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THESIS

JOBS AND WORKFORCE SCHEDULING FOR FLOW SHOPS. A CASE STUDY IN THE METAL CANS MANUFACTURE

PRAVEENA IN-YIM

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the Requirements for the Degree of
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The purpose of this thesis is to investigate the effect of skill differentiation on the assignment of flow shop scheduling in a two-stage parallel machine shop. The case study is a can manufacturing company with simple machines for pre-assembly line. There are 6 classes of products constitutes to 27 different types of part. Each part has a different processing time and each is allocated to a particular machine and one worker to each machine. There are high number of orders and presumably there are not enough number of machines to fulfill the orders. The objective is to minimize the maximum completion time of all the tasks and to improve effectiveness of production planning and reduced missing deliveries.

A simple heuristic approach is used by taking into consideration a two-step approach. The first step is assigning jobs to machines using 4 different dispatching rules, FIFO, EDD, SPT and LPT. The second step is to assign workers to different tasks by assuming that there is a differentiation in the work force. A variation from 0 to 80% in the ratio of multiple skill workers in the group is used to test the effects of skill differentiation. There are three heuristics of assigning skill workers to tasks, single skill first, multiple skill first and randomly assigned. The effect of learning curve is also taken into consideration by applying various degrees of penalty rates to the unmatched workers.

The results show that differentiation in the skill level of work group will take effects on the total completion time as soon as the ratio of multiple skill workers is less than 80%. The effect is higher when not assigning the single skill workers first. The effect remains even in the low penalty rate of 25%. The results from the new heurist is reduce the number of carry over jobs by 96.66% and able to achieve 98.85% of delivery due dates. Therefore, it is important that workers in the production line be trained even in simple tasks and assigned right skill to the right task.

Praveena In-Yim
Student's signature

R. Kanjanapanyakom 27/10/06
Thesis Advisor's signature

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Finally, the author would like to acknowledge the encouragement the constantly supporting by her parents. This thesis is proudly dedicated to her parents.

Praveena In-Yim

September 2006

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JOBS AND WORKFORCE SCHEDULING FOR FLOW SHOPS. A CASE STUDY IN THE METAL CANS MANUFACTURE

INTRODUCTION

Small and medium enterprises (SME) play a crucial part in the development of Thai economy. The thriving of large manufacturing companies relies very much on the support of parts and components such as packaging from these companies. However while SME helps deliver parts and supplies at low cost to large companies, they also face the competition in terms of labour wages and availability of skill labour with large manufacturing companies.

Thus, SME manufacturing firms have to improve themselves to survive in the world of competition amid rising pressure from fluctuating economic situation. They have to apply innovation to improve the manufacturing flexibility, reduce production / cost, enhance production quality and control the delivery schedules. Some persisting problems encountered by SMEs are

1. Consistency in product and service quality,
2. shortage of reliable raw material and supplier sources,
3. shortage of labour, high turn over and low skill labour,
4. competitive pricing and cost controlling,
5. competitive management skill,
6. meeting customers' expetations, etc.

In Thailand the definition of a SME company is defined by the number of employees which is less than 200. The nature of production system in SMEs is typified by human-centered manufacturing systems so that skill operators are very important to the productivity of the business (Figure 1). However with high labour turnover and pressing delivery due dates, most SME companies have to utilise their available labours in most efficient way by rotating them to any job positions at hand, regardless

of their skill levels. In doing so may improve labour productivity but may not be effective in term of meeting target deliveries especially if there exists the difference in the skill levels among workers.

Figure1 The workers have different skills.

This study will demonstrate that by assigning the right skill workers to the right job assignments can actually improve the scheduling of a simple flow shop production and thus meeting the delivery due dates.

A pioneer in field of metal packaging company located in the Bangkok industrial zone is one example of such problem. The company manufactures can containers for paint and chemical products. Production process involves printing a pattern on a flat tin sheet, cut and stamp the metal sheet into the desired shapes, then piecing the components together to make the different can sizes. The environment is referred to as a 2 stage parallel flow shop (Pinedo,1995) where a number of operations have to be done on each job. Often these operations are done on all jobs in the same sequences implying that the jobs have to follow the same route and machines are set up in series.

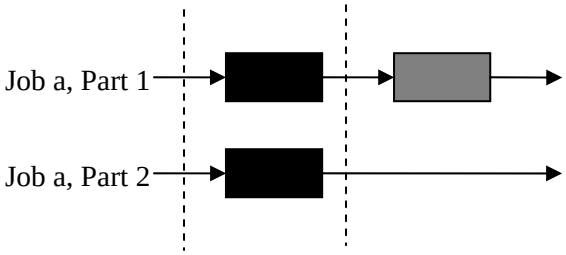


Figure 2 A typified flow shop where jobs follow the same route

Although production process can be grouped into three simple operations namely; body forming, part stamping and final assembly, but with high number of jobs and size varieties to be scheduled to a limited number of machines, this is then turned into a classic sequencing and scheduling problem.

At present, a software program is used to assist production planning of final assembly. However problem exists in the pre-assembly stage where parts are made through various stages of sequencing machines. Due to high number of customer orders and various can sizes, the planning for pre-assembly section is done manually through joint meeting of pre-assembly supervisors and final assembly manager on a daily basis. Daily production plan for pre-assembly line is adjusted to support the final assembly master plan. This often results in missing delivery due dates and leaving some machines idle in the part stamping stage.

The assignment of operators to each machines are random although it is apparent that some operators have higher skill and experience than others. The questions is arise as whether assigning the right operator to the machine will significantly reduce the amount of operation and improve production planning.

A two-step scheduling approach is then used to investigate the improvement on production planning in such situation.

The purpose of this research is to use a two-step flow shop scheduling approach to the assignment of jobs and workforce with skill differentiation for a production line using a pre-assembly line of a can manufacturing company as case study. This research will demonstrate the applicability of proposed dispatching rules for job scheduling and heuristics for workforce assignments to improve production planning.

The Problem Statement

The study of a production scheduling of a small metal forming company using two-step scheduling method and heuristics approach for dispatching rules to minimize the maximum completion time and meeting delivery targets.

Research objectives

The main objective of this research is to propose a production scheduling method for a can manufacturing company in order to minimize time loss in the production. The study aims at the following objectives:

1. Investigate various dispatching rules for a two stage flow shop scheduling.
2. Investigate the effect of skill levels on the assignment of workforce.
3. Propose a heuristic rule for workforce scheduling.
4. Test the result of model to justify the proposed method
5. An effective heuristic solving programs to shorten the planning time.

Conceptual Research Model

This model is base on jobs and workforce scheduling for flow shops at pre-assembly line or two-step scheduling that using dispatching rules for job scheduling and heuristics solutions approach for workforce scheduling. This scheduling can lead to improve machine utilization and reduce waiting job assignments by minimizing maximum completion time of each job. Conceptual Research model is presented as shown.

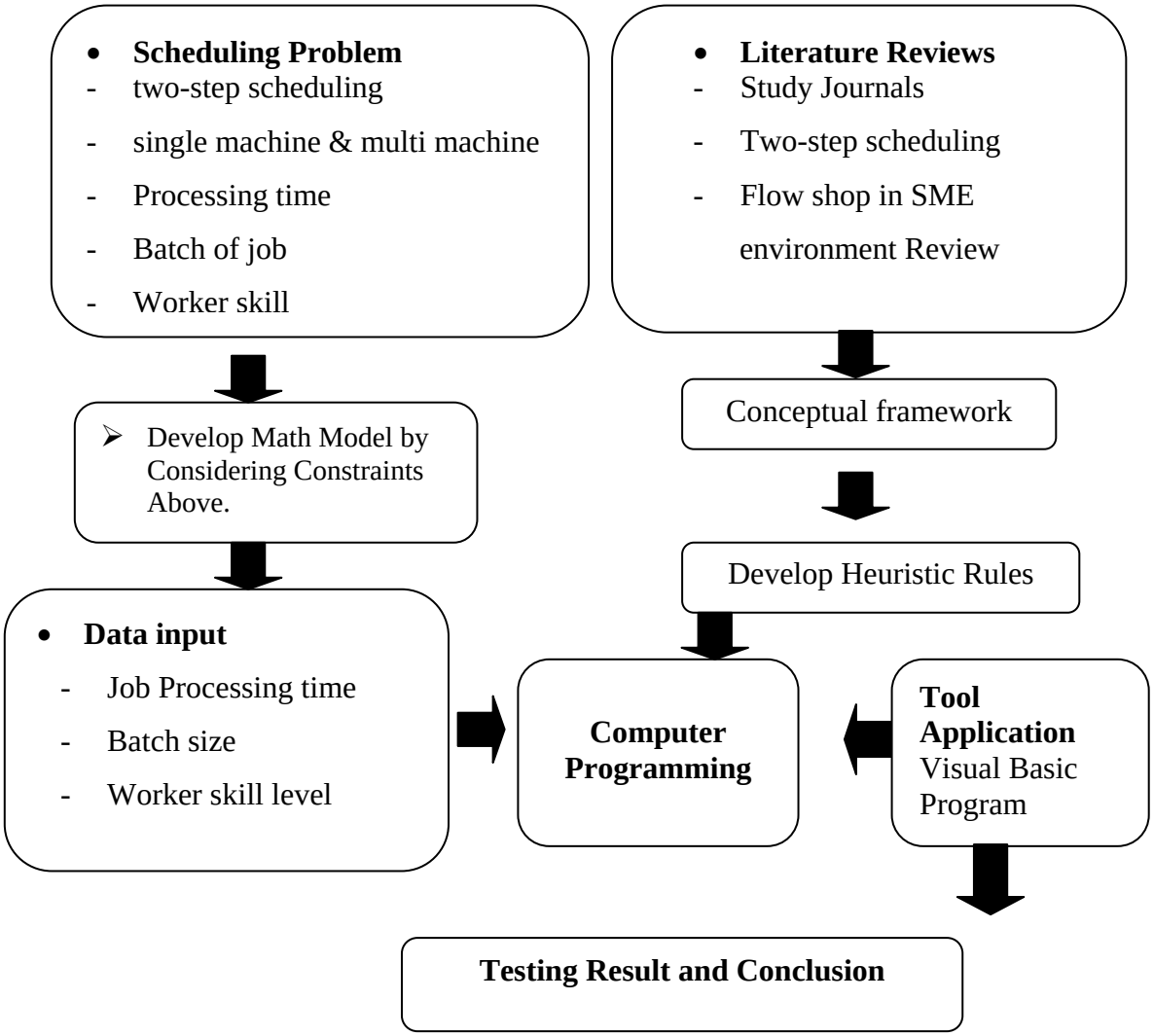


Figure 3 Conceptual Model

Scope and Limitation of Research

The scope of the study is limited to the pre-assembly line of the case study company which is a two stage parallel flow shop problem with numerous similar machines at each stage. All jobs can be processed on any machine and each job will follow a similar route. Other assumptions and limitations are;

- There are limited number of available workers and machines.
- There is differentiation in the skill levels of workers.
- Preemption on any machine is not allowed and all jobs are considered to be of same priority.
- No machine can handle more than one job at a time.
- Setup time at each machine is considered negligible compared to the processing time.

LITERATURE REVIEWS

There have been publications and research on scheduling problem at the beginning of this century with the work of Henry Gantt and other pioneers (Pinedo, 1995). The theory of scheduling has received a lot attention from Operations Research practitioners, management scientists, production and operations research workers and mathematicians. Some of the first publications appeared in Naval Research Logistics Quarterly in the early 1950s about “Johnson 's Problem”.

After Richard Karp's famous paper on complexity theory, the research in the 1970s focused mainly on the complexity hierarchy of scheduling problems. In the 1980s several different directions were pursued in academia and industry with an increasing amount of attention paid to stochastic. However, recent research papers are more concern on the cases of flow shop scheduling. The Scheduling literature ranges from the study of deterministic cases to stochastic cases, from single machine problem to the multi-machine problem and from static to dynamic problems (Nagar et al., 1995).

Scheduling problems can be classified as deterministic or stochastic, static or dynamic. An excellent classification of scheduling problem was provided by Reisman et al., in 1997, Figure 4

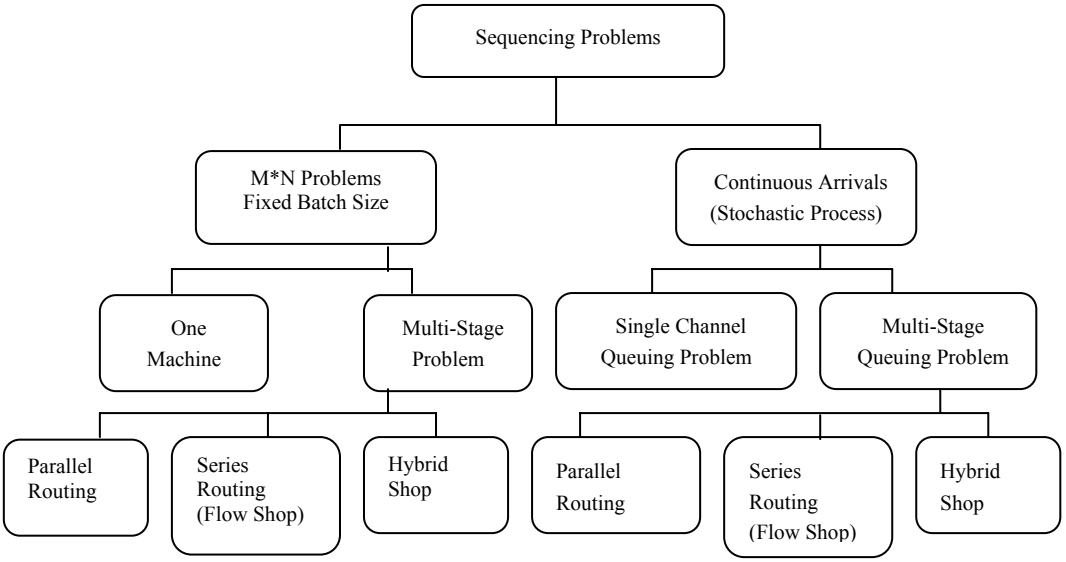


Figure 4 A classifications of Scheduling Problems

Scheduling Procedures

Some of the scheduling problems are inherently easy to solve because many of those can be formulated as linear programs, and that can be solved with using the existing efficient algorithms. Other easy problems can be solved by different algorithms that are also efficient. These efficient algorithms are referred to as polynomial time algorithms. These problems can be solved with short time by computer even if that problem has thousand of jobs, Pinedo and Chao (1990)

However, many more scheduling problems are very hard to solve. These problems are called NP-hard. They cannot be formulated as linear programs, and no simple rules or algorithms yield optimal solutions in a limited amount of computer time. For these problems, it may be possible to formulate them as integer or disjunctive program, but it requires too much computing time to get optimal solutions.

Then it is usually considered the "acceptable" feasible solutions that satisfy them, and those solutions are not far from optimal.

The following table 1 shows the relationship between data, objectives and basic dispatching rules those are one of the general-purpose techniques that have proven in industrial scheduling systems.

Table 1 Basic Dispatching Rules

Condition	Rule	Data	Objective
Rules dependent	ERD	r_i	Variance in throughput times
on release date	EDD	d_i	Maximum lateness
and due dates	MS	d_i	Maximum lateness
Rules dependent	LPT	p_i	Load balancing over parallel machines
on processing time	SPT	p_i	Sum of completion times, WIP
	WSPT	p_i, w_i	Weighted sum of completion times, WIP
	CP	p_i, precedences	Makespan
	LNS	p_i, precedences	Makespan
Miscellaneous	SIRO	--	Ease of implementation
	SST	s_{ik}	Makespan and throughput
Miscellaneous	LFJ	M_i	Makespan and throughput
	SQNO	--	Machine idleness

Notations; ERD = Earliest release date first rule.

EDD = Earliest due date first rule.

MS = Minimum slack first rule.

LPT = Longest processing time first rule.

SPT = Shortest processing time first rule.

WSPT = Weighted shortest processing time first rule.

CP = Critical path rule.

LNS = Largest number of successors rule.

SIRO = Service in random order rule.

SST = Shortest setup time first rule.

LFJ = Least flexible job first rule.

SQNO = Shortest queue at the next operation rule.

Heuristics for flow shop scheduling with multiple operations and time lags.
By Riezebos and Gaalman (1996).

This paper considers a multistage flow shop where jobs require multiple operations at each stage and a finish-to-start time lag between any two consecutive operations of a job the next operation of a job cannot start until the time lag after the former operation of that job has elapsed. Since the problem of minimizing the make span is shown to be NP-hard even for the two-stage case, It present a lower bound based heuristic approach that is used to construct several heuristic procedures. These heuristics use lower bounds on the minimum make span to solve the problem. The effectiveness of these heuristics is empirically evaluated by solving a large number of randomly generated problems. The use of these lower bounds in the construction of heuristics results in an improvement of the make span performance of up to 50% as compared with the performance of some simple dispatching heuristics that take the presence of multiple operations and time lags into account. Furthermore, It show that the relative performance of the heuristics depends on the size of the time lag. If the ratio of mean time lag and mean processing time is 20% or more, heuristics that construct an active schedule perform less well than heuristics that construct a non-delay schedule. The opposite holds true if this ratio is smaller.

The performance of the widely used Shortest Processing Time heuristic (SPT) deteriorates quickly if the size of the time lags increases. It propose instead to use the Earliest Finish Time heuristic (EFT) in case time lags are present. EFT performs much better in this case and is identical to SPT if all time lags are zero.

Integrated project task and manpower scheduling.

By Alfares and Bailey (1997).

This paper present personnel scheduling, It is to determine how many workers must be assigned to each feasible days-off tour to satisfy a given labor-demand profile with minimum labor cost. The objective of project task scheduling is to determine task start dates and durations to complete a project on time with the minimum cost of performing tasks plus overhead. By assumption of altering task start dates and durations, the daily labor-demand profile can be changed. Integrating these two problems permits the simultaneous determination of start dates, durations, labor levels and required tours for a minimum-cost and on-time schedule. Both integer programming and heuristic solution procedures to solve the integrated problem are presented., the heuristic procedure outperformed the traditional two-step scheduling procedure by a project scheduling algorithm first determines the start time and duration, which is a function of labor level, for each task.

The task and personnel scheduling problems have been integrated in a model that seems to offer substantial savings in the overall cost of a project. The savings come as a result of selecting a start time and labor level for each task that reduces labor cost. The integer programming optimization formulation is, however, large for realistic problems. A much more efficient heuristic approach based on dynamic programming was presented and tested. The heuristic procedure produced near-optimal solutions in terms of total cost, labor cost, and labor productivity, while providing significant savings in computation time. Yet although the heuristic solution is easily obtained for real-world problems, the optimal solution is currently impracticable. When compared with the traditional two-stage approach, the heuristic procedure provided notable savings in total cost and labor cost, and substantial gains in labor productivity. In a series of 20 test problems, The heuristic solution procedure yielded an 8.6% reduction in total cost compared with the traditional two-step procedure. In the test cases, this percentage saving tended to increase as the average number of options for start time and labor level grew. By using the heuristic

procedure, labor productivity was increased in the test cases by 14% to 98%. Relative to the integer programming procedure, the heuristic procedure reduced the computational time by 58%. The primary conclusion is that integrating the solutions of project task and personnel scheduling problems is both feasible and wise. Future research extensions include considering stochastic elements and sensitivity analysis of the solution. Although there are standard estimates for most construction tasks, equipment breakdowns, cost increases, and labor shortages can never be ruled out. Other reasonable follow-up efforts would be to explore refinements to the heuristic procedure presented here and to program user-friendly decision support tools for this scheduling activity.

A multiple-shift workforce scheduling model under annualized hours.

By Hung (1999).

Many manufacturing and service organizations in Europe have used annualized hours, also known as flexiyear, to successfully tackle seasonal demand. Under annualized hours, the employer has a certain number of labor hours available in a year and the employer can allocate the hours over the year according to manpower need. A problem in planning for annualized hours is the scheduling of the workforce over the year. This paper presents an algorithm to generate an annual schedule for a scenario in which a facility operates one or more shifts and manpower need may vary from week to week.

Assigning students to course sections using tabu search.

By Ramon ,Crespo and Tamarit (2000).

This paper describe a new student registration system which has been developed at the University of Valencia, Spain. The system has two steps. First, the students make a computer-aided course selection from the courses available at the University. Thereafter, an assignment procedure allocates students to sections in order

to respect two criteria: to provide the students with satisfactory schedules and to get balanced section enrollments. The assignment process has two phases. In Phase I, obtain a set of the best solutions for each student. The algorithm is based on the construction of maximum cardinality independent sets. In Phase II, these solution sets are put together and a tabu search algorithm to obtain good feasible solutions for the balancing problem, and use tabu search combined with strategic oscillation in a way similar to that proposed looks for a satisfactory balance between course sections without causing the solution obtained for each student to worsen significantly. The system was used at the beginning of the academic year 1996/97 in the Faculty of Mathematics and could be extended in the near future to the rest of the University.

The results of the registration will be evaluated by the University in order to decide if the system will be extended beyond the Faculty of Mathematics. Some preliminary conclusions may be drawn at this moment. First, some kind of computer aided registration is necessary for large universities to speed up the process and reduce the staff requirements. The first phase of our procedure has shown to be well suited to the type of registration and the existing computer network. Second, the algorithm of Phase II produced good solutions which are currently being used by the Faculty. The course offer has been adjusted to the students' demands before assigning them to sections.

Finally, the results show that the quality of students' timetables depends critically on the structure of the master schedule. It would therefore be very useful to develop an algorithm to build the schedule. The new and the existing algorithms could be imbedded in a package for academic management.

An algorithms for workforce scheduling and shift design optimization.

By Gärtner ,Musliu and Slany (2001).

The typical process of planning and scheduling a rotating workforce in an organization consists in designing shifts and then assigning employees to these shifts

and to periods of rest (days-off). Successfully solving these problems has high practical relevance. Results from ergonomics indicate that shift schedules have a profound impact on the health and satisfaction of employees as well as on their performance at work. The solutions must also satisfy legal requirements and should meet the objectives of the employing organization. In the research project , undertaken by the Database and Artificial Intelligence Group at the Vienna University of Technology in cooperation with Ximes Corp., systems for the design of shifts and assignment of employees to shifts and days-off were developed.

Complexity of Workforce Scheduling in Transfer Lines.

By Vairaktarakis and Xiaoqiang. (2003).

This paper consider a production system that consists of m assembly stations arranged in series. All jobs enter the assembly line at station 1 and proceed with subsequent stations in the same order as in a flow shop. Each job spends a fixed amount of time c in each station, known as the production cycle. This production system is synchronous or paced because jobs move one station forward synchronously, every c time units. To ensure that all required work is performed in precisely *c* periods, the appropriate number of workers is assumed to be known for every task in each station. Hence, each job is specified by an m-tuple of workforce requirements. There are interested in "level"' workforce schedules where workforce size fluctuations are minimal during the production horizon. In this article It define level workforce scheduling objectives and analyze the complexity status of the associated problems. That find that most of these problems are NP-complete even when m=2.

In this article defined a variety of objective functions for the workforce planning problem on synchronous production systems and determined the complexity status of the corresponding problems. All other problems are strongly NP-complete even for 2-station paced assembly lines. This means that workforce leveling is a very hard problem. Hence, increased effort is required to find reasonable solutions for such problems. In addition to the basic problems formulated in this article, future research

should address cross-training issues in synchronous production systems. In this setting, workers are not trained to work on every single station of the assembly system, but only on a small subset of stations as dictated by the nature of the work. Evidently, this article also provides a complexity classification for many cross-training problems. Namely, if there is a skill with 3 or more stations, then the workforce planning problem is NP-complete for any objective f . Research on cross-training issues is important not only for tactical decision making but also for gaining insight on effective ways to form skill vectors (i.e., determine the stations on which workers of a particular skill are trained) so as to minimize cross-training costs.

Multi-Skilled Workforce Optimisation.

By Guy and Pantonand (2004).

This paper describes a problem faced by CS Energy's Swanbank Power Station in the Australian state of Queensland. It involved the personnel scheduling (rostering) of staff with multiple skill levels at the power station. Such a problem can be classified using the six stage construction process proposed by Ernst et al. It assume that the three processes of 'demand modeling,' 'shift starting times' and 'task scheduling' are specified. It are concerned with the essential processes of 'day off scheduling,' 'line of work construction' and 'shift assignment to staff' with requirements to maintain multiple skills. Several other authors have reported results for staff with hierarchical skills while the methods proposed in this paper are for non-hierarchical skill sets. The paper describes a set covering approach to the multi-skilled rostering problem. It proposes a number of solution strategies for the set covering approach and gives a comparison of the results.

Each of the three solution methods discussed have been based on a set covering model in which 'tours of duty' are generated so as to implicitly account for all workforce constraints. Problems involving workforces of a realistic size and skill-level combination are combinatorially complex and require considerable time and effort to find good or optimal solutions. Indeed the number of possible tours for such problems

may exceed memory capacity requirements, let-alone our capacity to compute a feasible solution. In such cases It must be content to compute good feasible solutions and trade-off solution quality with the time taken for this computation. For these reasons have presented three alternative approaches which might be used to compute good feasible solutions to such problems. It have shown that the reduced column subset and column expansion methods, while not guaranteeing optimal solutions, are capable of providing acceptable solutions in a reasonable time. On the other hand, the method of branch and price has been shown to generate more cost effective solutions, but will generally involve more computing time.

Learning Curve Calculator,

By Milligan (2002).

The concept of the learning curve was introduced to the aircraft industry in 1936 when T. P. Wright published an article in the February 1936 *Journal of the Aeronautical Science*. Wright described a basic theory for obtaining cost estimates based on repetitive production of airplane assemblies. Since then, learning curves (also known as progress functions) have been applied to all types of work from simple tasks to complex jobs like manufacturing a Space Shuttle.

The theory of learning is simple. It is recognized that repetition of the same operation results in less time or effort expended on that operation. For the Wright learning curve, the underlying hypothesis is that the direct labor man-hours necessary to complete a unit of production will decrease by a constant percentage each time the production quantity is doubled. If the rate of improvement is 20% between doubled quantities, then the **learning percent** would be 80% (100-20=80). While the learning curve emphasizes time, it can be easily extended to cost as well.

The learning percent is usually determined by statistical analysis of actual cost data for similar products. Lacking that, you may use the following guidelines from "Cost Estimator's Reference Manual- 2nd Ed.," by Rodney Stewart:

- 75% hand assembly/25% machining = 80% learning
- 50% hand assembly/50% machining = 85%
- 25% hand assembly/75% machining = 90%

Piece rates and learning:understanding work and production in the New England textile industry a century ago.

By Leunig. (2006).

This paper shows that workers' earning increased over time, and that this increase was caused by learning rather than by poor workers leaving the mill more quickly thatn the more able. The data are drawn from the records of Lyman Mills and covered the period 1903 – 1912. Productivity plots over the period shows that experienced workers produced more than inexperienced ones. Even simple task like ring spinning, the skill appears to have taken two years to master fully. The effect of experience on worker output could increase the labour productivity to as much as 15% to 125%. Although such simple skill takes up to two year to master and in some case can double the output, once learnt the ability does not appear to have been forgotten.

Incremental changes in the workforce to accommodate changes in demand

By Bard. and Purnomo (2006).

In many service organizations, rosters must be constructed weekly or monthly as demand and available personnel change. Once the permanent workforce is fixed, it may not be possible to alter its composition easily, implying that expensive contract labor may be the only option to cover shortages. With respect to nursing resources, this means calling in part-timers, casuals, or agency nurses on a daily basis, or hiring travelers for up to several months at a time. This paper addresses the latter option and presents two models that can be used to solve what It call the nurse addition problem. The first was originally developed to solve the midterm preference scheduling problem and is based on a pattern-view formulation. The second is derived from a shift-view formulation and is solved with a branch-and-price algorithm. In either case, the

objective is to hire up to some predetermined number of nurses and assign them midterm schedules that minimize the maximum amount of uncovered shifts per day in the planning horizon. Each roster selected for a new nurse must satisfy a set of hard constraints related to the total working hours, work stretches, time between shifts, and weekend requirements, and a set of soft constraints related to days-on and days-off patterns and transitions from one shift type to another. Extensive testing with data provided by a 400-bed hospital indicated that most instances could be solved in a matter of minutes. In the face of rising healthcare costs and a growing nursing shortage, hospitals are constantly reexamining their staffing needs to determine the optimal mix of full-timers, part-timers, and temporary personnel. As demand fluctuates over the year, it often makes better economic sense to hire nonpermanent staff for weeks or months at a time, rather than rely on expensive agency nurses to handle the peaks on a daily basis.

In this paper, It proposed two models to help nurse managers make temporary hiring decisions. Extensive testing was done on the second model using a modified version of a branch-and-price algorithm originally developed to solve a related cyclic scheduling problem. The results showed that high quality solution could be obtained quickly for the most difficult instances. This is especially important in an environment in which scenario analysis is an integral part of the planning process.

Literature Review Summary

From the literature reviews above, conclusion can be made about the work done related to this study with regard to this point.

Table 2 Literature Review Summary

Year	Heuristic Rule			Detail
	Job scheduling	Workforce scheduling	Skill level	
1990	●			Basic Dispatching Rules
1996	●			Heuristics for flow shop
1997	●	●		Task and manpower scheduling
1999		●		Multiple-shift workforce
2001		●		Shift design optimization
2000		●		Assigning students using tabu search
2003		●	●	Complexity of Workforce Scheduling for flow shop
2004		●	●	Scheduling of staff with multiple skill levels (non-hierarchical skill)
2006		●	●	The nurse addition problem
2006			●	Piece rates and learning

Most of the studies were done on jobs scheduling or workforce scheduling in both of industrial and service system. Only one paper present two-step scheduling procedure by Integrated project task and manpower scheduling (Alfares K.H**.**, 1997). The problem are presented heuristic solution procedures to solve the integrated problem but not interested in the workers skill. It is reducing the cost of labor and overhead. Until 2003, Vairaktarakis L. and X. Cai defined a variety of objective functions for the workforce planning problem on synchronous production systems and determined the complexity status of the corresponding problems. In 2006,from the study of Piece Rate and Learning found that experienced workers can have % increase in output ranging from 15% - 123%. The assumption that all workers have the same skill level is certainly a misconception.

To the best of the knowledge no other leveling objectives have been presented before in the literature for day-to-day tactical scheduling operations. They survey of related literature shows that there is very little research done on workforce measures even though leveling issues are of practical importance in manufacturing settings.

Independently, most of the previous researches for workforce scheduling are based on the assumption that all workers have unified skill level and most of the jobs scheduling researches for flow shop are focused on the method to solve the optimize solution of other criteria. Hence a jobs scheduling considering differentiation in workforce skill levels is a relatively new problem and not yet understudied.

MATERIAL AND METHODS

Materials

The material and resources of this thesis can be categorized into three groups; Hardware, Software, and Data input. Detail information regarding each group is listed as below:

1. Hardware

1.1 Personal computer: Computer Pentium III 700 with 640 MB Ram
It is necessary to choose a computer with a proper specification.

1.1.1 Window 95/98 or window NT
1.1.2 CPU 80486 or Pentium 166 or more
1.1.3 Ram 16 MB
1.1.4 VGA monitor of higher resolution
1.1.5 CD-ROM
1.1.6 Free hard disk spaces at least 512 MB

1.2 Printer Black & white or color

2. Software

2.1 Program Microsoft Excels version 2000
2.2 Program Microsoft Word is used to create this research document.
2.3 Visual Basic

3. Data Input

3.1 Standard time for each operation
3.2 Number of jobs to be processed on machine
3.3 Manpower requirement for each machine
3.4 Number of machines in production environment
3.5 Number of batch size of jobs
3.6 Number of workers available

Methods

The method employed is based on the problem solving process as follows;

1. Problem formulation.
2. Data collection.
3. Proposed dispatching rules for job scheduling.
4. Heuristics rules for workforce scheduling.
5. Solving the heuristic algorithm.
6. Analysis of output.
7. Conclusion and recommendation.

1. Problem formulation

This research was conducted using data from a metal can manufacturing company which designs and manufactures several kinds of cans over decades of accumulated experience. Although the company produces many types of product such as aerosol cans, food can, all-purpose round cans, rectangular can, pails and cups, etc., but the highest volume of sales are mainly concentrate in the general round can and rectangular cans which constitute to around 80% of the total production.

Table 3 8 Main Product Ranges.

Types of product	
1. Aerosol cans	
2. General round cans	
3. Food can	
4. Rectangular can	
5. Gallon pail	

Table 3 (Cont'd)

Types of product	
6. Cup	
7. Rectangular pails	
8. Top accessories	

All products go through similar processes although somewhat different in minor details. The overall process can be divided into three main production processes as follows;

1. Printing and body forming process: to print logo and patterns onto a flat sheet of tin and cutting into can body. The body is then formed into a cylindrical shape before sending it to the final assemble.

2. Pre-assembly process: cutting and stamping the metal sheet into the desired shapes to become lids, bottom, rings and handles.

3. Final assembly process: piecing the components together into final products.

The printing process is a sophisticate fully automated process which can accommodate numerous orders in daily production. The final assembly process is also a continuous production line which employs a software for production planning and control in order to meet the daily customer orders. Hence problem lies in the pre-assembly process where there are only two types of machines, press and seal, both are manually operated and need a worker for each machine. There are 40 press machines and 15 seal machines available for all jobs, but there are not enough workers for all the machines.

From the observation, the workers in pre-assembly department are allocated to each machine on a random basis and assumed that each worker can work in all machines. The worker duties are not only to operate on the machine but also to check quality of parts while working. There is a high variation in operation time due to different levels of skill of workers.

The production planning in this company employs a backward scheduling approach that is plan from the final assembly stage to meet delivery due dates and send the plan to pre-assembly department. However due to high variation in the processing time and high number of jobs in the pre-assembly, the production of parts are always delay and thus plans do not meet targets. Problems in the delay of production in the pre-assembly department are due to;

1. There are not enough number of workers for all the jobs and machines.
2. There is no differentiation in the skill levels of each worker while there are different types of machine.
3. There are high turnover ratios of worker causing further problem in the productivity drop due to learning cycle of new workers.
4. The processing time used in the planning of pre-production is a single value from an estimate and does not represent the actual production of different product parts or different operations.

The problem in the pre-assembly department of this company is a classic 2 steps scheduling situation. Step one is the scheduling of jobs to machines and step two is the scheduling of workers to the allocated jobs. This thesis will investigate the effects of skill levels on the improvement of production schedule using heuristic rules.

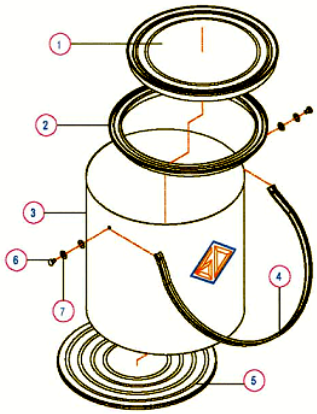
2. Data gathering

There are 4 main groups of data to be used as input and testing of the 2-step scheduling method as follow;

2.1 Product data
2.2 Production Process data
2.3 Types of Machine
2.4 Standard time for each production process

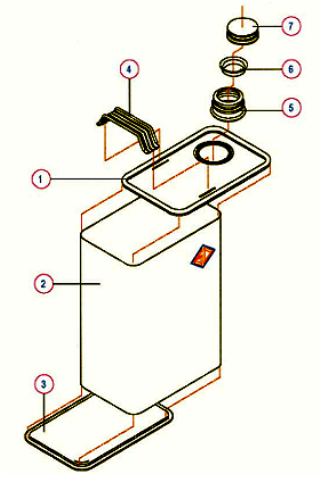
2.1 Product Data

The products which pass through pre-assembly process can be generalized into two types namely; general round cans and rectangular cans. Details of part assembly for both general round cans and rectangular cans are shown in figure 5 and 6.



No.	Details
1	**Cover:** a can's lid or closure and some type of cover have **Curl:** area of tin turned in on itself to provide a safe, finished curved edge
2	**Multiple or single friction (Ring) :** a plug closure fits into a "well" of a seamed-on ring. The plug is pressed into the ring and the two surfaces (the outside and inside edge) come into contact with the ring, creating multiple sealing surfaces on the plug/ring combination
3	**Body:** a can without a cover (lid); the base of a container
4	**Handle**
5	**Bottom or can end**
6	**Nut**
7	**Attach ear**

Figure 5 General Round Can.



No.	Details
1	**Cover:** a can's lid or closure
2	**Body:** a can without a cover (lid); the base of a container
3	**Bottom**
4	**Handle**
5	**Thread**
6	**Inner-cap**
7	**Cap**

Figure 6 Rectangular Can.

Although both products has numerous parts, but there are only 4 parts which are made in the pre-assembly lines, namely lid, bottom, ring and handle. There are also various sizes and height of round and rectangular cans which can be grouped into 6 family codes, each code has different production process and different processing time. For the purpose of the study, all the product information are classified into 6 family codes as follows:

Table 4 Products in the 6 Family Groups.

Group	Product Code	Type	Height	Size	Parts for Pre-Assm.
1	2GC1 , 2GC6-1	General Round Cans	Low	1 Gallon	4
2	2GC5 , 2GC6-5	General Round Cans	High	1 Gallon	3
3	2GC2L ,2GC6-2L	General Round Cans	Low	1/4 Gallon	3
4	2GC2H , 2GC6-2H	General Round Cans	High	1/4 Gallon	3
5	2GR3	Rectangular Cans	-	1 Gallon	3
6	2GR4	Rectangular Cans	-	1/4 Gallon	3

2.2 Production Process data

The pre-assembly line consists of two simple processes namely pressing and sealing.

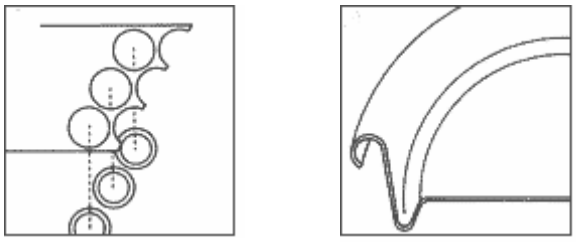


Figure 7 Press process of lid.

Sheet metal passes through the press machine in the first process and cut the metal into desire shape while in the mean time curl the edge of the piece as shown.

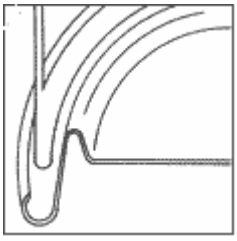


Figure 8 Sealing with rubber compound.

The newly formed ends the are passed through the second stage, sealing where a lining machine applies a very precise bead of compound sealant around the inside of the curl.

All classes of product family can be grouped into three production processes as follows;

Production process 1

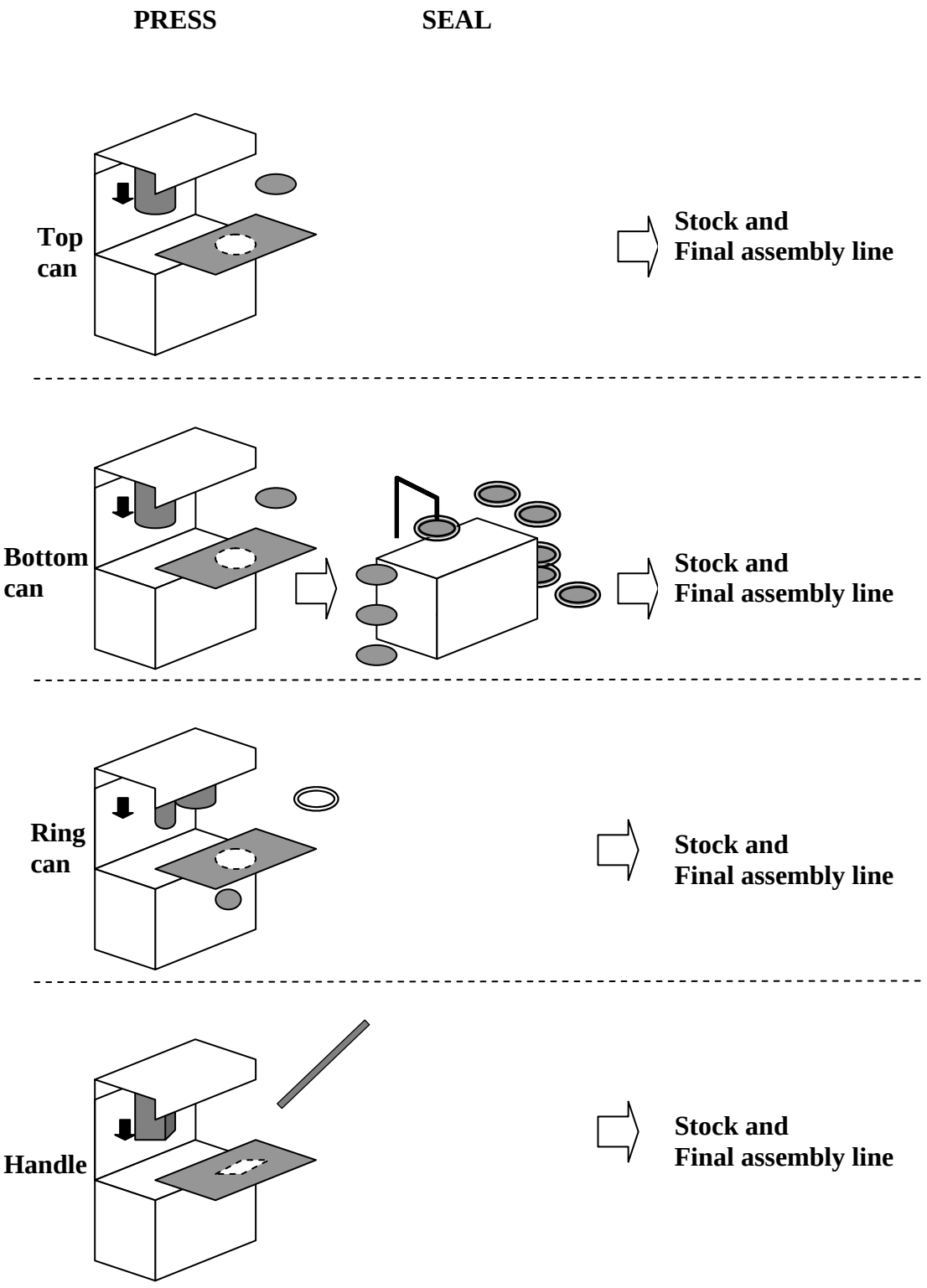


Figure 9 Production Process for Product Class 1- General Round Cans.

Production process 2

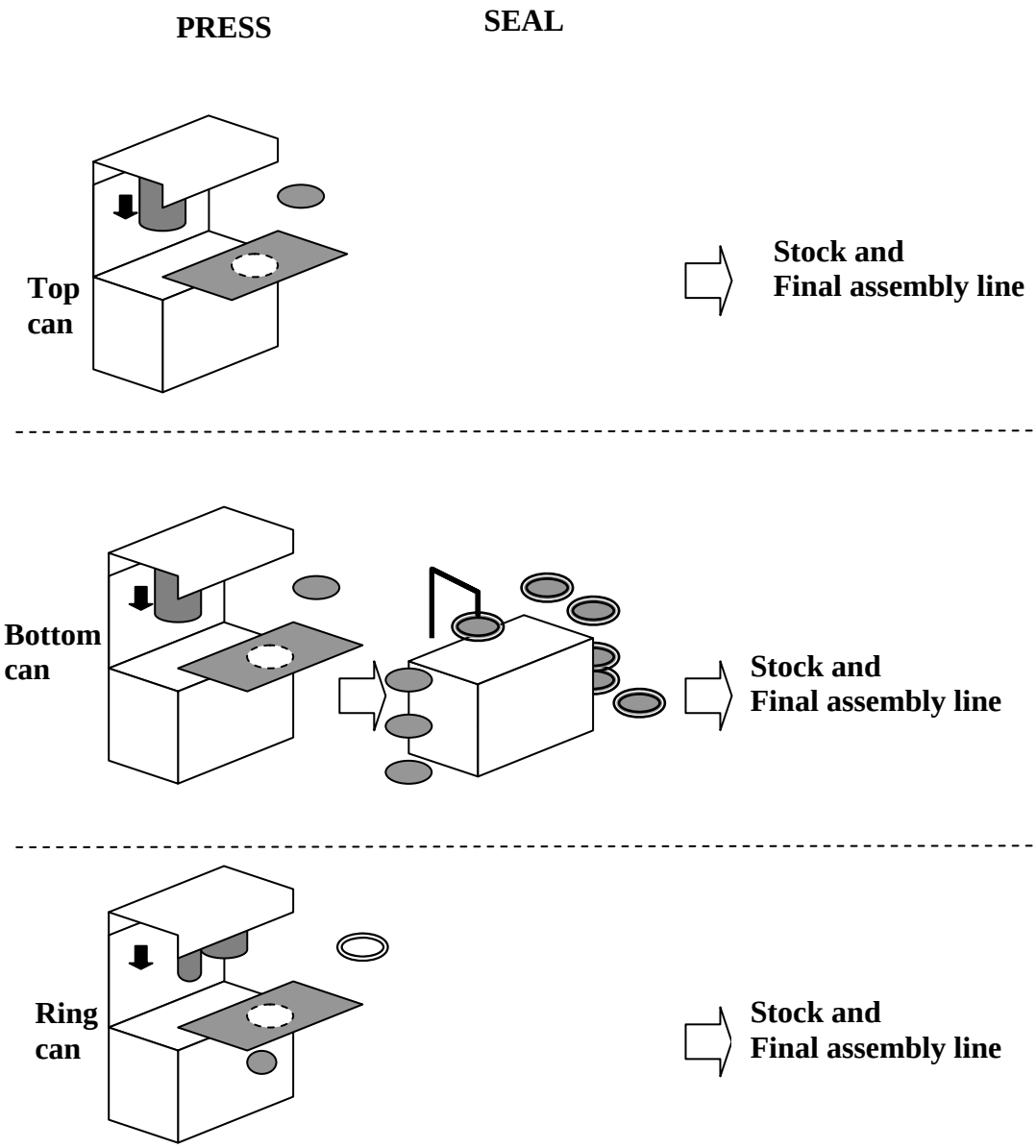


Figure 10 Production Process for Product Class 2-4 General Round Cans

The processes of class 2-4 are the same with exception of some processes are performed with different type of machines.

Production process 3

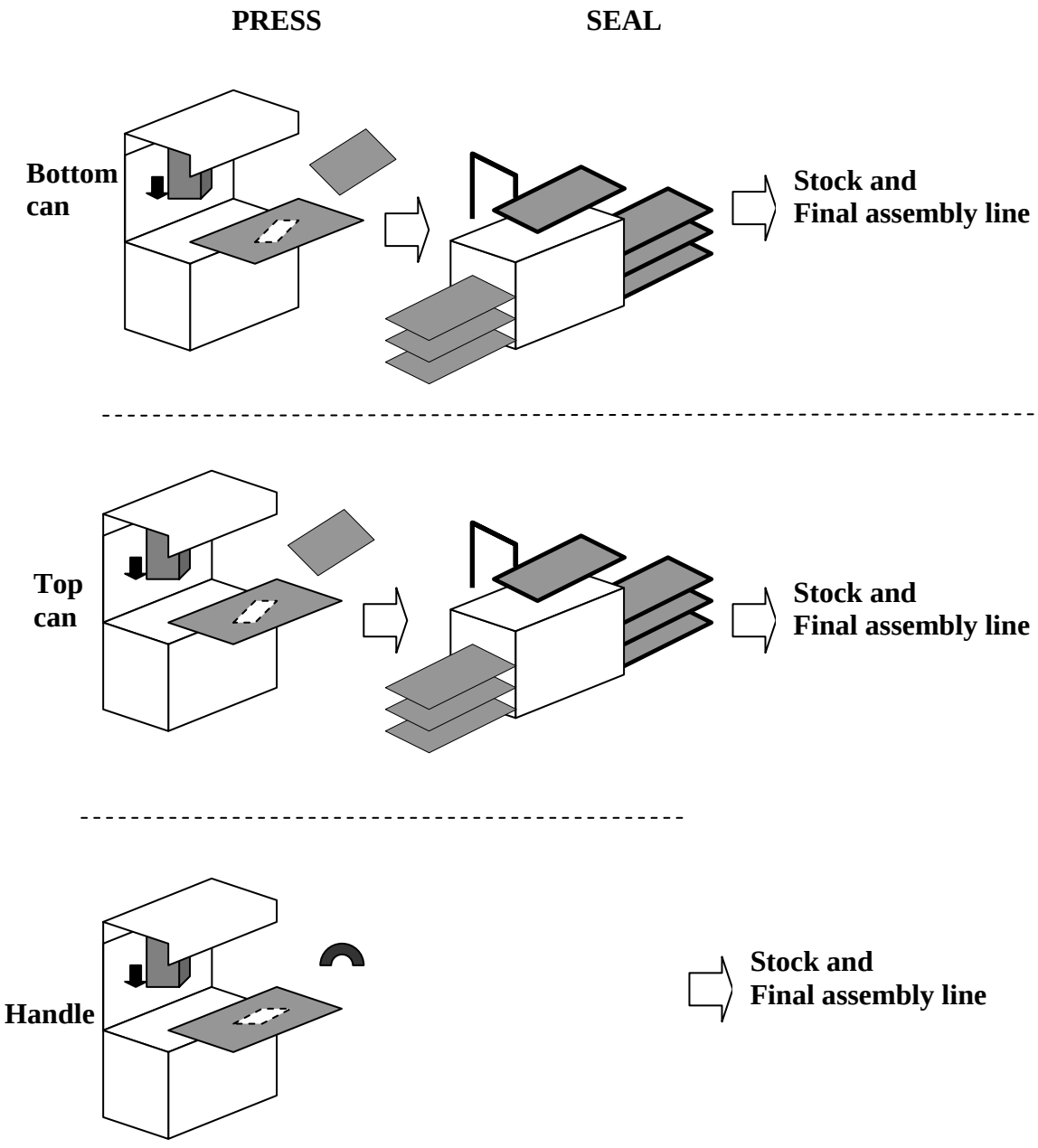


Figure 11 Production Process for Product Class 5-6 Rectangular Cans

The processes of class 5-6 (Rectangular Cans size 1 and ¼) Gallon are the same but using different type of machines.

2.3 Types of Machine

Although there are 40 press machines and 15 seal machines available for all jobs, but each machine is set up for one product part in order to reduce set up time. Hence it needs only 27 machines for the parts under this study. For simplification, machine codes will be allocated as shown in the table 5.

Table 5 List of machines for general round can and rectangular can.

Machine Code	Types of machines	Product Type	Height	Size	Part
pt1	Press	General Round Cans	Low	1 Gallon	Top
pb1					Bottom
pr1					Ring
ph1					Handle
pt2	Press	General Round Cans	High	1 Gallon	Top
pb2					Bottom
pr2					Ring
pt3	Press	General Round Cans	Low	1/4 Gallon	Top
pb3					Bottom
pr3					Ring
pt4	Press	General Round Cans	High	1/4 Gallon	Top
pb4					Bottom
pr4					Ring
pt5	Press	Rectangular Cans	-	1 Gallon	Top
pb5					Bottom
ph5					Handle
pt6	Press	Rectangular Cans	-	1/4 Gallon	Top
pb6					Bottom
ph6					Handle

Table 5 (Cont'd)

Machine No.	Types of machines	Type	Height	Size	Part
sb1	Seal	General Round Cans	Low	1 Gallon	Bottom
sb2		General Round Cans	High	1 Gallon	Bottom
sb3		General Round Cans	Low	1/4 Gallon	Bottom
sb4		General Round Cans	High	1/4 Gallon	Bottom
st5		Rectangular Cans	-	1 Gallon	Top
sb5					Bottom
st6		Rectangular Cans	-	1/4 Gallon	Top
sb6					Bottom

2.4 Standard time

Processing time for each production process is collected by using the method of time study. Each operation is timed for 20 cycles and relative accuracy is calculated to be ± 10% within 95 % of confidence intervals.

Standard time is calculated as follows;

Standard time = (Average time x Rating factor) + Allowances

where Average time is calculated from 20 observations. A 15% allowance is applied throughout.

Since one operator is allowed to operate on one machine, there are assumed that 27 operators are to be used.

Table 6 Summary of Standard Times for each Operation

Class	Press (M1)	Std. time	Seal (M2)	Std. time	Part
Class1	Top	2.97			Top
	Bottom	4.12	Bottom	3.79	Bottom
	Ring	5.67			Ring
	Handle	6.58			Handle
Class2	Top	3.42			Top
	Bottom	3.93	Bottom	2.91	Bottom
	Ring	4.14			Ring
Class3	Top	3.77			Top
	Bottom	3.52	Bottom	2.76	Bottom
	Ring	4.99			Ring
Class4	Top	3.85			Top
	Bottom	2.84	Bottom	2.09	Bottom
	Ring	5.28			Ring
Class5	Top	3.28	Top	5.00	Top
	Bottom	4.11	Bottom	4.72	Bottom
	Handle	6.16			Handle
Class6	Top	4.3	Top	6.62	Top
	Bottom	4.68	Bottom	4.60	Bottom
	Handle	5.78			Handle
Total	**19 Press machines**		**8 Seal machines**		**19 parts**

3. Phase I : Job Sequencing

Since there more machines than operators available for the jobs, it is logical to assign jobs to machines first and then assign operators to machines. This problem will be divided into two phases namely; job scheduling and worker scheduling. The first phase will consider job scheduling by considering different dispatching rules in a two stage parallel machines with the objective of minimizing maximum completion time of all jobs.

Proposed dispatching rules for job scheduling

In a sequencing and scheduling problem, dispatching rules set priority to all the jobs that are waiting for processing on any machine. Whenever a machine is available, a dispatching rule inspects the waiting jobs and selects the job with the highest priority. There had been several studies in dispatching rules in the past, the related rules to the completion time constraints can be described as below;

1. First-In-First-Out (FIFO): Selects the jobs in the order of their arrival times; very simple and robust; it is the most commonly used rule by workflow systems.

2. Earliest Due date (EDD): Selects the job with the nearest due date; it is known to be effective in minimizing the system's mean total tardiness.

3. Shortest Processing Time (SPT): This rule schedules the jobs in the order of increasing processing time. Whenever a machine is free, the shortest job available at the time will begin processing first. This algorithm is optimal for finding the minimum total completion time and weighted completion time.

4 Longest processing time (LPT): This rule schedules the jobs in the order of decreasing processing times. Whenever a machine is free, the largest job ready at the time will begin processing first.

5 Johnson's algorithm: This algorithm minimizes the makespan in a flow shop, given all job are available at the beginning and non-preemption. In a two-stage flow shop, this rule looks at all jobs on both stages at the same time and set priority based on the shortest processing time. It is based on the rule that says job i should precede before job j if min $\{ t_{i1}, t_{j2} \} <= \{ t_{i2}, t_{j1} \}$, where t_{i1} is the processing time of job i on machine 1, t_{j2} is the processing time of job j on machine 2. The rule sets for the shortest processing time to be processed first in stage 1, and the shortest processing time to be processed last if in stage 2.

Johnson's rule is not applicable in the situation where number of machines in two stages are not equal.

6 Genetic Algorithms: This algorithms as a search process at each iterative step, a number of different schedules are generated and carried over to the next step by combining with the sequence of operations on another machine in another parent schedule. Actually, the genetic algorithm can be applied to problem without having to know much about the structural properties of problem. However, the amount of computation time needed to obtain the solution can be relatively long in comparative with the more rigorous problem specific approaches such as dispatching rules.

In this study basic concept of dispatching rules is used for single machine. In the first phase, several dispatching rules are proposed such as ; FIFO , SPT , EDD, and LPT. This is a 2 stage parallel flow shop and the objective is to minimize the maximum total production time of stage 1 and stage 2 (M1+M2) for each parts in class.

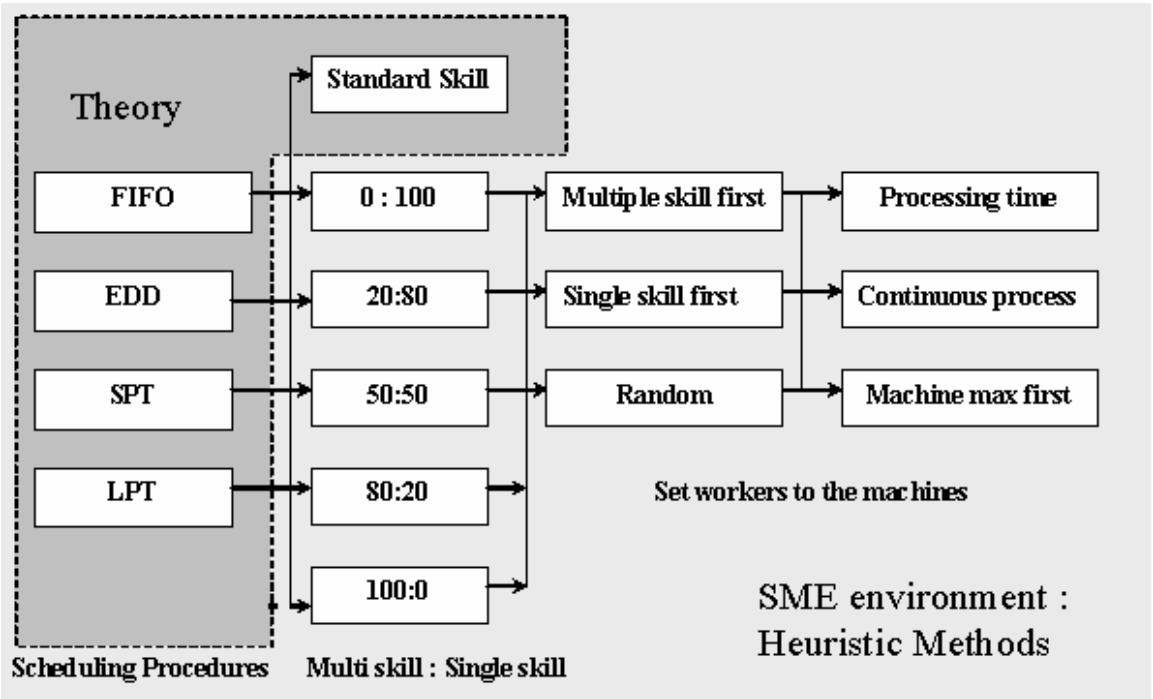


Figure 12 The concept and scope of the thesis

Before starting the job sequencing on the machines, there are certain assumptions to be made.

- Processing time for each job is standard time for experienced workers
- Since each machine is a simple process machine, thus set up time is considered to be negligible.
- There are more jobs than the number of machines
- Each job can be assign to only one machine and one operator to one machine at a time.
- All jobs are of same priority.

The problem can be stated as follows. A set of n jobs is available at time 0 to be processed by two machines where each job is processed on machine 1 first and then on machine 2. All jobs follow the same unidirectional flow pattern through the shop.

Hence the objective function is as follow:

$$\text{Min. } C_{max} = \text{Min} \sum_{j=1}^{n} C_{2,j}$$

Subject to the following constraints,

$$C_{1,j} \geq P_{k,j} \qquad \forall j, \qquad (1)$$

$$C_{2,j} \geq C_{1,j} + P_{2,j} \qquad \forall j, \qquad (2)$$

$$C_{1,j} - P_{1,j} \geq C_{1,j} \vee C_{1,j} - P_{1,j} \geq C_{1,j} \qquad \forall i, j, i \neq j, \qquad (3)$$

$$C_{2,j} - P_{2,j} \geq C_{2,j} \vee C_{2,j} - P_{2,j} \geq C_{2,j} \qquad \forall i, j, i \neq j, \qquad (4)$$

where,

$C_{k,j}$ be the completion time of job j on machine k.

$P_{k,j}$ the processing time of job j on machine k (for $j = 1, \ldots, n$ and $k = 1,2$)

(1) means there is no jobs being processed on machine 1 before time 0,

(2) requires for each job must complete the first stage before it can go through the second stage,

(3) and (4) indicates that machine in both stages can not process more than one job at a time.

In order to explain how the dispatching rules are applied in the job scheduling in this phase, a step by step example will be presented as follows.

1) Considering the case of a general round can product class2 where there are 3 pieces to be manufactured lid , bottom and handle, while a rectangular can line of class5 also consists of 3 parts; lid , bottom and handle. The processing time of each part are listed on table 7 and table 8.

Table 7 General round can line data.

M 1		M2		Part of general round can
press-top Std. time = 3 second.			→	TOP CAN
press-bottom Std. time = 4 second.	→	sealing-bottom Std. time = 3 second.	→	BOTTOM CAN
press-ring (pr1) Std. time = 4 second.			→	RING CAN

Table 8 Rectangular can line data.

M 1		M2		Part of rectangular can
press-top Std. time = 3 second.	→	sealing-top Std. time = 5 second.	→	TOP CAN
press-bottom Std. time = 4 second.	→	sealing-bottom Std. time = 5 second.	→	BOTTOM CAN
press- handle Std. time = 6 second.			→	RING CAN

2) Let's assume a list of jobs in a month which consisted of different product orders and quantity and different due dates to test different dispatching rules.

Table 9 Example data from sale department and for calculation dispatching rules

Job	Class	Q'ty	Max{M1 + M2}	Total	Due date	
				Prod. Time	Date	Mth.
A_0	A_1	A_2	A_3	A_4	A_5	A_6
1	5	5	9	45	15	1
2	5	10	9	90	25	1
3	2	15	7	105	20	1
4	5	20	9	180	20	1
5	5	25	9	225	14	1
6	2	20	7	140	15	1
7	2	10	7	70	8	1
8	5	5	9	45	8	1
9	2	20	7	140	24	1
10	5	10	9	90	12	1

Testing the data from the above table by using different dispatching rules as follows;

1. First Come First Serve (FCFS): Considering queue of job in column A_0 by scheduling list of jobs in the order of job come first, done first. Thus, using this rule the job in table 9 will be scheduled for round can line as (3, 6, 7, 9) and rectangular can line is (1, 2, 4, 5, 8, 10)

2 Earliest Due Date (EDD): Considering due date of job in column A_5 and A_6. The earliest due date rule orders the sequence of jobs to be done from the job with the earliest due date to the job with the latest due date. Let $d_{[i]}$ denote the due date of the i th job in the ordered sequences job such that the following in equality holds,

$$d_{[i]} \leq d_{[2]} \leq \ldots \leq d_{[n]}$$

Thus, using this rule the round can job in previous example can be scheduled as (7, 6, 3, 9) and rectangular can line is (8, 10, 5, 1, 4, 2). If the condition of early due date is equal, chose to the first priority the maximum of sum production time.

3. Shortest Processing Time Rules (SPT): Considering production time of job in column A_4 by scheduling list of jobs in the order of increasing processing time. Whenever a machine is freed, Let $t_{[i]}$ denote the processing time of the i th job in the order of the shortest job available at the time will begin processing that the following in equality holds,

$$t_{[i]} \leq t_{[2]} \leq \ldots \leq t_{[n]}$$

Thus, using this rule the job of round can line in previous example can be scheduled as (7, 3, 6, 9) or (7, 3, 9, 6) and rectangular can line is(8, 1, 10, 2, 4, 5), (8, 1, 2, 10, 4, 5), (1, 8, 10, 2, 4, 5) or (1, 8, 2, 10, 4, 5)

In the condition where sum of production time is equal, chose early due date (minimum of A_5 and A_6) to be first priority. Thus, this example can be scheduled round can line as (7, 3, 6, 9) and rectangular can line as (8, 1, 10, 2, 4, 5)

4. Longest Processing Time Rules (LPT): Consider production time of job in column A_5 by scheduling list of jobs in the order of decreasing processing time. Whenever a machine is freed, the largest job ready at the time will begin processing. Thus, using this rule the job in previous example can be scheduled round can jobs as (6, 9, 7, 3) or (9, 6, 7, 3) and rectangular can line is (5, 4 , 10 , 2 , 8, 1) , (5, 4 , 10 , 2 , 1, 8), (5, 4 , 2 , 10 , 8, 1) or (5, 4 , 2 , 10 , 1, 8)

In the condition where sum of the production time is equal, choose early due date (minimum of A_5 and A_6) to be first priority. Thus, this example, round can line can be scheduled as (6, 9, 3, 7) and rectangular can line as (5, 4, 10, 2, 8, 1).

It can be seen from the example above that different dispatching rules yield different job assignments and different completion time. In this test data the best dispatching rule is SPT as summarized in table 10.

Table 10 Conclusion of job sequencing by using dispatching rules.

Dispatching Rules		Job Sequencing Order
	Line : Round can	
1)	FIFO	3 → 6→ 7→ 9
2)	EDD	7→ 6→ 3→ 9
3)	SPT	7→ 3→ 6→ 9
4)	LPT	6→ 9→ 3→ 7
	Line : Rectangular can	
5)	FIFO	1→ 2→ 4→ 5→ 8→ 10
6)	EDD	8→ 10→ 5→ 1→ 4→ 2
7)	SPT	8→ 1→ 10→ 2→ 4→ 5
8)	LPT	5→ 4→ 10→ 2→ 8→ 1

Table 11 The comparison C_{max} in phase I by using dispatching rules

	C_{max}

Job no. (Ao)	FCFS	EDD	SPT	LPT
1	45	310	70	475
2	110	460	180	425
3	105	225	145	265
4	240	410	300	325
5	365	285	450	225
6	200	180	240	140
7	230	70	70	295
8	390	45	45	450
9	320	320	320	220
10	450	110	130	375
Total: Round can	855	795	775	920
Total: Rectangular can	1600	1620	1175	2275

4. PhaseII Workforce scheduling

The second phase of the problem is to assign workers to machines by using a set of heuristic rules in order to minimize the maximum completion time of all tasks.

In addition, the following assumptions are made:

1. There is a certain ratio of skill workers among the work force.
2. If the worker skill does not match with the machine, there is a penalty on the completion time. No penalty is applied when the skill of operator matches with the machine.
3. There are equal numbers of workers to the number of machines.

Heuristics rules for workforce scheduling

1. Skill levels of workforce

In the situation where manual works involve the skill of individual operator, skill levels will have a significant impact on the productivity of the production line. From the study of Piece Rate and Learning[1] found that experienced workers can have an increase in output ranging from 15% - 123%. The assumption that all workers have the same skill level is certainly a misconception. Phase II will look into the effect of different skill levels of workforce on the scheduling problems. The assumption used in the study is that workers have differentiation in skills, in this case, single or multi-skill. The study will investigate the case of different ratio of multi-skill workers in the workforce ranging from 0% to 100%. The ratio of multi-skill to single-skill are in 5 different sets ranging from 0-100, 20-80, 50-50, 80-20 and 100-0.

2. Assignment rules.

There are three methods for assigning workers to machines namely;

- Assigning single skill workers first (S)
- Assigning multi-skill workers first (M)
- Random allocation. (R)

3. Machine priority rules

Since the machines in each stage are not of equal number and parts do not go through the same numbers of process, there is an interest to see if machine priority may have the effects on the completion time. The heuristic rules for machine priority setting are:

- Priority to machines with highest processing time first (processing),
- Priority to sequential machines first(continuous), and

[1] Timothy Leunig, Piece Rate and Learning, Working paper No. 72/03, XIV International Economic of Congress, Helsinki 2006.

- Priority to machines with higher number of available machines first(maximum).

All heuristic rules in Phase II have to combine with those in Phase I .

To give some example of how the different heuristic rules operate in phase II, let's take the previous case example from Phase I and apply workforce assignment with different skills. The workforce required in this case is 12. If the workforce consisted of 20% multi-skill and 80% are single skill, this means there are 3 multi-skill workers and 9 single skill workers.

Table 12 Identify skill to the worker

Skill number	Number of worker	Press	Seal
1	4	✓	
2	5		✓
3	3	✓	✓

Testing of assignment rules:

1. Random Allocation

This rule is to assign workers to jobs and machines in random order regardless of their skill levels. Neither does it is consider whether the skill of worker matches with the machine. If the worker skill does not match with the machine, there is a penalty on the completion time. No penalty is applied when the skill of operator matches with the machine.

Figure13 Random Allocation

2. Allocate Workers with Multi-skill First

This rule is to assign multi-skill workers to machines first until no multi-skill workers left before assigning single-skill workers into machines. There is also penalty for unmatched skills.

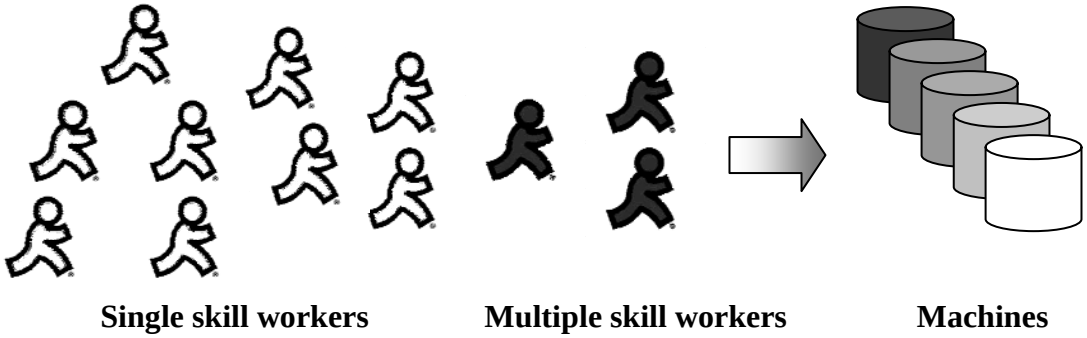


Figure14 Allocate Workers with Multi-skill First

3. Allocate Workers with Single-skill First

This rule allows workers with single-skill to select the machines first until no single-skill worker left and then select multi-skill workers into machines. Penalty rate is applied.

Figure15 Allocate Workers with Single-skill First

Testing of machine priority rules:

There are 3 types of machine priority rule; maximum processing time first, sequential machines first, and higher number of available machines first.

1. Maximum processing time

Set priority of machine by assigning the maximum processing time first. This method can prevent the worker who does not have skill matching run into the high processing time machines and eventually increase the overall completion time.

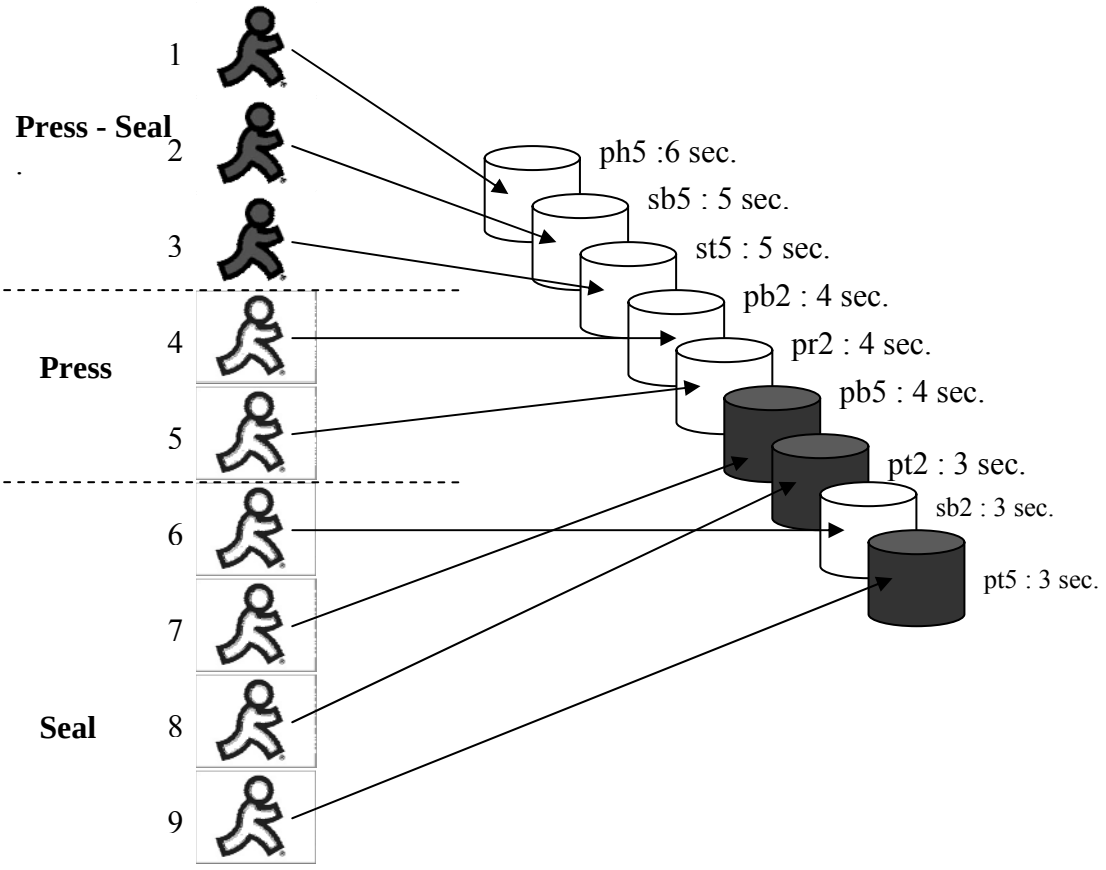


Figure 16 Maximum processing time

From example the data come from table 7,8 and 12, sequencing the worker by using multiple skill first and then worker select the machine by order of decreasing processing time machine. In this case 3 workers from the last worker have to do the job which does not match his skill.

2. Sequential machines

Set priority of machine by assigning workers to sequential machines first. This method can prevent the single-skill workers run into the long process machines and unmatched skill which will affect the overall completion time.

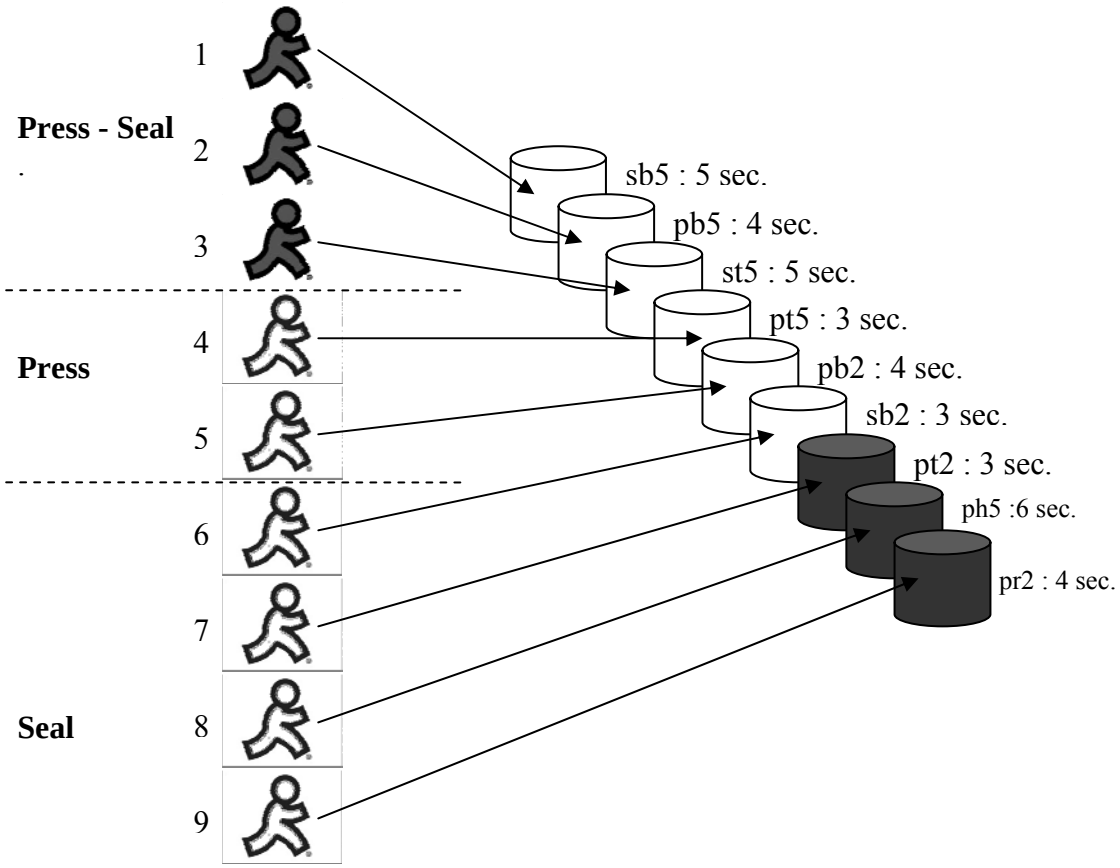


Figure17 Sequential machines

Following the same example from table7,8 and 12, after sequencing the worker by using multiple skill first, then set priority to sequential machines. The result in this case will leave the last 3 workers to work on press top M1 with processing time of 3 sec, press handle M2 with processing time of 6 sec and press ring M1 with processing time of 4 sec.

3. Higher number of available machines

Set priorities of machine to higher number of machines first. This method can prevent the company from having more unmatched jobs towards the end.

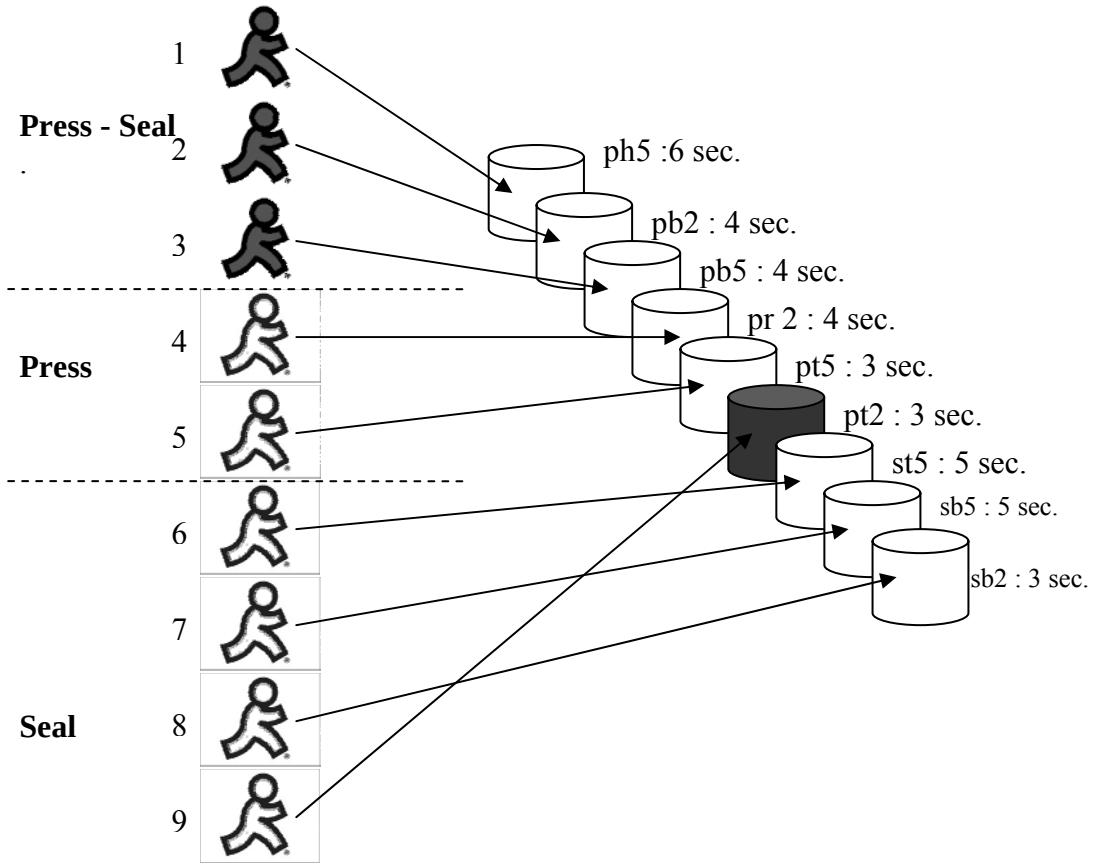


Figure18 Higher number of available machines

Using same data from table7,8 and 12, sequencing the worker by using multiple skill first and then worker select the machine from group with higher number of machines. The result in this case is worker number 9 have to do the unmatched-skill job which is Press top M1 with processing time of 3 sec.

Table 13 The comparison $C_{max,SPT}$ by multi-skill First at 20:80 arrangement rule

Job no.	C_{max}		
	Maximum processing time	**Sequential machines**	**Higher number of available machines**
1	450	600	315
2	130	120	90
3	150	200	145
4	340	360	300
5	565	660	525
6	270	360	240
7	60	80	70
8	420	560	295
9	390	520	320
10	510	680	370
Total: Round can	870	1160	775
Total: Rectangular can	2415	2980	1895

Thus, it can be concluded that the case of multi-skill first at 20:80 arrangement rule that C_{max} from higher number of available machines is better than other machine priority rules.

Penalty rate

There is a penalty for all the unmatched skill allocated. The penalty rate is the increase in the processing time on the assigned unmatched job. Three values of penalty rates are used in order to see the effects on the results.

- Standard time is increased by 100 %
- Standard time is increased by 50 %
- Standard time is increased by 25 %

5. Solving the heuristic algorithm

In order to solve this scheduling problem, Visual Basic 6 was chosen as the application tool to develop a program for solving the problem.

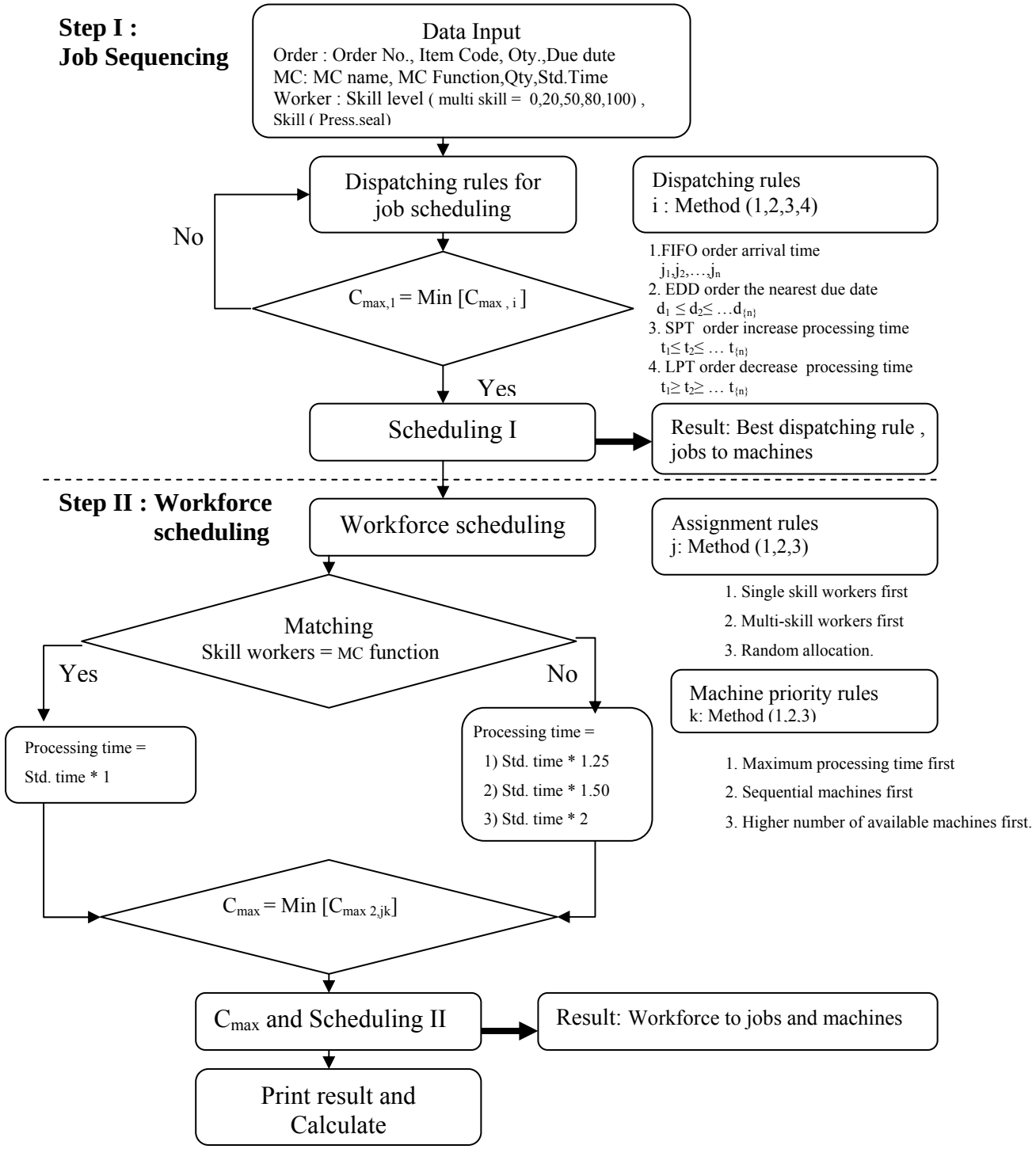


Figure 19 Heuristic Flow Chart

The program has been tested by using a small set of data as shown in the earlier example for its reliability. Finally the full data set has been used for the final testing and conclusion.

RESULT AND DISCUSSION

Analysis of output

The program is then tested with a set of 6 months data from a can manufacturing company. There exists an average of 300 jobs to be scheduled in each month. Each job consists of an order of product which is classified into 6 product class as mentioned earlier with associate due dates. Actual production time of each job is converted into $C_{max, act}$ as shown in Appendix A. A summary of the number of jobs in each month and total number of production are shown in the following tables.

Table 14 Number of Jobs and Number of Production in pieces within 6 months.

	No. of Job						
	Month 1	**Month 2**	**Month 3**	**Month 4**	**Month 5**	**Month 6**	Total
Class 1	70	56	69	72	74	55	396
Class 2	62	66	71	68	71	78	416
Class 3	72	51	75	72	83	89	442
Class 4	12	16	18	19	19	26	110
Class 5	105	87	58	59	77	62	448
Class 6	71	56	59	60	62	65	373
Total	392	332	350	350	386	375	**2185**

	No. of Production(pieces)						
	Month 1	**Month 2**	**Month 3**	**Month 4**	**Month 5**	**Month 6**	**Total**
Class 1	89283	96581	94381	96390	118281	64779	559695
Class 2	109416	102296	102252	105020	97868	99917	616769
Class 3	179931	224157	227650	279767	257450	175189	1344144
Class 4	47000	40468	38340	37384	34670	41675	239537
Class 5	144921	134588	126557	106180	141677	102346	756269
Class 6	176922	115133	110790	117210	89470	121557	731082
Total	747473	713223	699970	741951	739416	605463	**4247496**

The output data from the program is show in appendix B.

Result from heuristic algorithm can be discussed 3 steps as follow;

1. Comparison of C_{max} from simple dispatching rule.
2. Consider $C_{max,heuristic}$ when there is skill differentiation among workers and apply heuristic rules to assigning workers to each machine.
3. Comparison of $C_{max,heuristic}$ to those of the actual assign schedules of the company and conclusion of the best heuristic methods.

1. Comparison C_{max} from simple dispatching rule

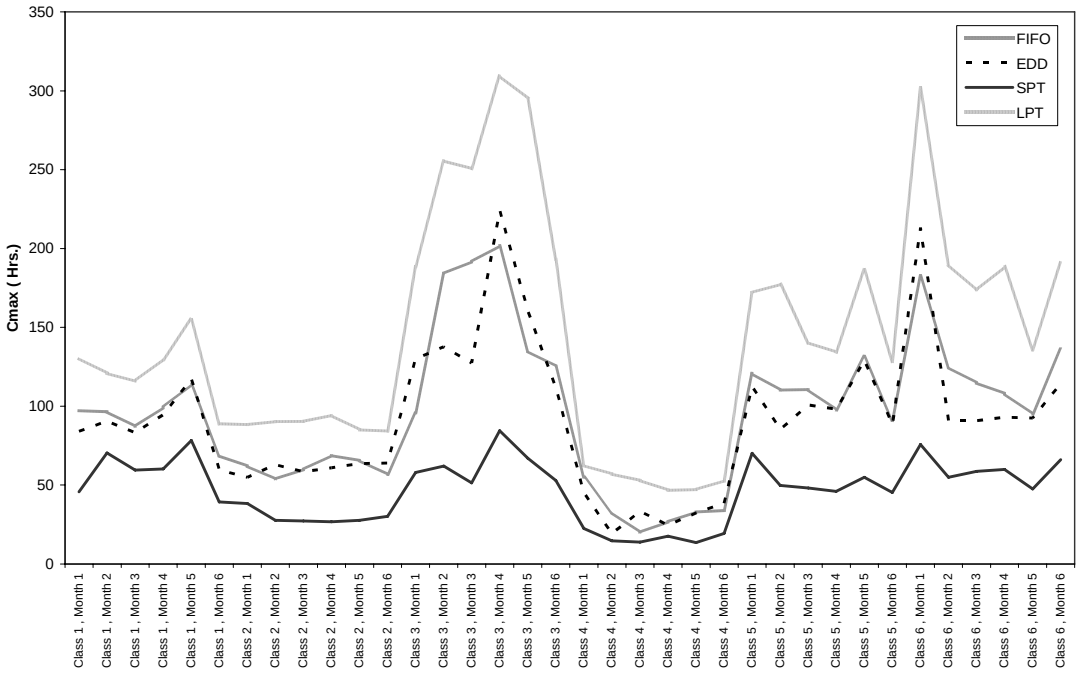


Figure 20 The completion time from the simple dispatching rule.

The result from the simple dispatching rule shown clearly indicates that in all situations shortest processing time (SPT) is the best dispatching rule for simple one or two stage parallel sequencing jobs. However in such situation, it is assumed that all operators are of the skillful and there is no differentiation in the skill of workers and the effects on the operation.

Therefore in condition 1,

$$C_{max} = C_{max,1}$$

2. Consider $C_{max,heuristic}$ when there is skill differentiation

In step two, assigning workers to each job where there is a skill differentiation. The ratio of multi-skill operators ranging from 0 to 80 (100 is omitted because this would be the same as considering a simple scheduling problem where there is no differentiation in the skill levels. A penalty is allocated where the worker skill does not match with that of the assigned machine, using a penalty rate of 25%, 50% and 100%.

Step2: Skill differentiation in the group ranging from 0 – 80.
Heuristic rule for workers allocation;

Rule 1 – Single skill workers first
Rule 2 – Multiple skill workers first
Rule 3 – Random skill allocation

Where skill does not match with those of assigned jobs , a penalty is applied. The penalty rate varies from 25%, 50% and 100% on the standard time is added to each unmatched job assignment.

When skill matches,

$$C_{max,2} = C_{max}$$

However if not match , $C_{max,2} > C_{max}$,

$$C_{max,2} - C_{max} = \Delta t$$

Calculate $\Sigma \Delta t$ of all products in each month. Results of the calculation are shown.

Table 15 Penalty rate 25%

Skill		heuristic rules	Month					
			1	2	3	4	5	6
80	S	Processing	0.005	0.003	0.005	0.005	0.005	0.005
80	S	Continuous	0.004	0.002	0.003	0.004	0.004	0.003
80	S	Maximum M/C	0.005	0.003	0.005	0.005	0.005	0.005
50	S	Processing	0.545	0.312	0.454	0.518	0.508	0.445
50	S	Continuous	0.404	0.231	0.337	0.384	0.376	0.329
50	S	Maximum M/C	0.562	0.322	0.469	0.535	0.524	0.459
20	S	Processing	0.648	0.371	0.540	0.616	0.603	0.529
20	S	Continuous	0.480	0.275	0.400	0.456	0.447	0.392
20	S	Maximum M/C	0.669	0.383	0.557	0.635	0.623	0.545
0	S	Processing	1.409	0.807	1.174	1.339	1.312	1.149
0	S	Continuous	1.043	0.598	0.870	0.992	0.972	0.851
0	S	Maximum M/C	1.453	0.832	1.212	1.381	1.353	1.186
80	M	Processing	0.230	0.132	0.192	0.218	0.214	0.188
80	M	Continuous	0.170	0.097	0.142	0.162	0.159	0.139
80	M	Maximum M/C	0.237	0.136	0.198	0.225	0.221	0.194
50	M	Processing	22.806	13.060	19.011	21.675	21.236	18.601
50	M	Continuous	16.893	9.674	14.082	16.055	15.730	13.778
50	M	Maximum M/C	23.530	13.475	19.614	22.363	21.910	19.191
20	M	Processing	27.108	15.524	22.597	25.763	25.242	22.109
20	M	Continuous	20.080	11.499	16.738	19.084	18.698	16.377
20	M	Maximum M/C	27.968	16.016	23.314	26.581	26.043	22.811
80	R	Processing	0.326	0.186	0.271	0.309	0.303	0.266
80	R	Continuous	0.241	0.138	0.201	0.229	0.225	0.197
80	R	Maximum M/C	0.336	0.192	0.280	0.319	0.313	0.274
50	R	Processing	32.301	18.498	26.926	30.699	30.077	26.345
50	R	Continuous	23.926	13.702	19.945	22.740	22.280	19.515
50	R	Maximum M/C	33.326	19.085	27.781	31.673	31.032	27.181
20	R	Processing	38.394	21.987	32.005	36.489	35.751	31.314
20	R	Continuous	28.440	16.286	23.707	27.029	26.482	23.196
20	R	Maximum M/C	39.612	22.685	33.021	37.648	36.886	32.308
0	R	Processing	83.464	47.797	69.575	79.325	77.719	68.074
0	R	Continuous	61.825	35.405	51.537	58.759	57.570	50.425
0	R	Maximum M/C	86.114	49.315	71.784	81.843	80.186	70.235

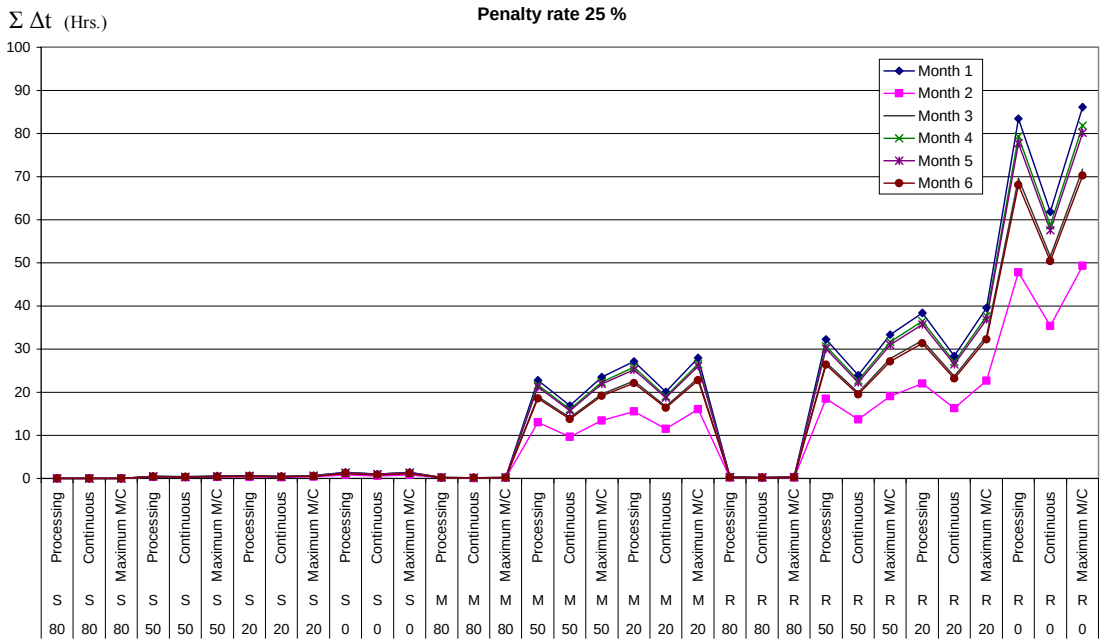


Figure 21 Skill effects at 25% penalty rate.

Table 16 Penalty rate 50%

Skill		heuristic rules	Month					
			1	2	3	4	5	6
80	S	Processing	0.006	0.003	0.005	0.005	0.005	0.005
80	S	Continuous	0.005	0.002	0.004	0.004	0.004	0.004
80	S	Maximum M/C	0.006	0.003	0.005	0.006	0.005	0.005
50	S	Processing	0.603	0.345	0.503	0.573	0.561	0.492
50	S	Continuous	0.462	0.264	0.385	0.439	0.430	0.377
50	S	Maximum M/C	0.620	0.355	0.517	0.589	0.577	0.506
20	S	Processing	0.768	0.440	0.640	0.730	0.715	0.626
20	S	Continuous	0.600	0.344	0.500	0.570	0.559	0.489
20	S	Maximum M/C	0.789	0.452	0.657	0.749	0.734	0.643
0	S	Processing	1.707	0.977	1.423	1.622	1.589	1.392
0	S	Continuous	1.342	0.768	1.118	1.275	1.249	1.094
0	S	Maximum M/C	1.752	1.003	1.460	1.665	1.631	1.429
80	M	Processing	0.242	0.139	0.202	0.230	0.225	0.197
80	M	Continuous	0.182	0.104	0.152	0.173	0.170	0.149
80	M	Maximum M/C	0.249	0.143	0.208	0.237	0.232	0.203
50	M	Processing	25.219	14.442	21.023	23.968	23.483	20.569
50	M	Continuous	19.307	11.056	16.094	18.349	17.978	15.747
50	M	Maximum M/C	25.943	14.857	21.626	24.657	24.157	21.159
20	M	Processing	32.128	18.398	26.781	30.534	29.916	26.204
20	M	Continuous	25.100	14.374	20.923	23.855	23.372	20.472
20	M	Maximum M/C	32.988	18.891	27.499	31.352	30.718	26.905
80	R	Processing	0.343	0.196	0.286	0.326	0.319	0.280
80	R	Continuous	0.258	0.148	0.215	0.246	0.241	0.211
80	R	Maximum M/C	0.353	0.202	0.294	0.336	0.329	0.288
50	R	Processing	35.719	20.455	29.775	33.947	33.260	29.132

Table 16 (Cont'd)

Skill		heuristic rules	Month					
			1	2	3	4	5	6
50	R	Continuous	27.344	15.659	22.794	25.988	25.462	22.302
50	R	Maximum M/C	36.744	21.042	30.630	34.922	34.215	29.969
20	R	Processing	45.503	26.058	37.932	43.247	42.371	37.113
20	R	Continuous	35.550	20.358	29.634	33.787	33.103	28.994
20	R	Maximum M/C	46.722	26.756	38.948	44.405	43.506	38.107
0	R	Processing	101.129	57.913	84.300	96.113	94.168	82.481
0	R	Continuous	79.490	45.521	66.262	75.548	74.018	64.832
0	R	Maximum M/C	103.778	59.430	86.509	98.632	96.635	84.642

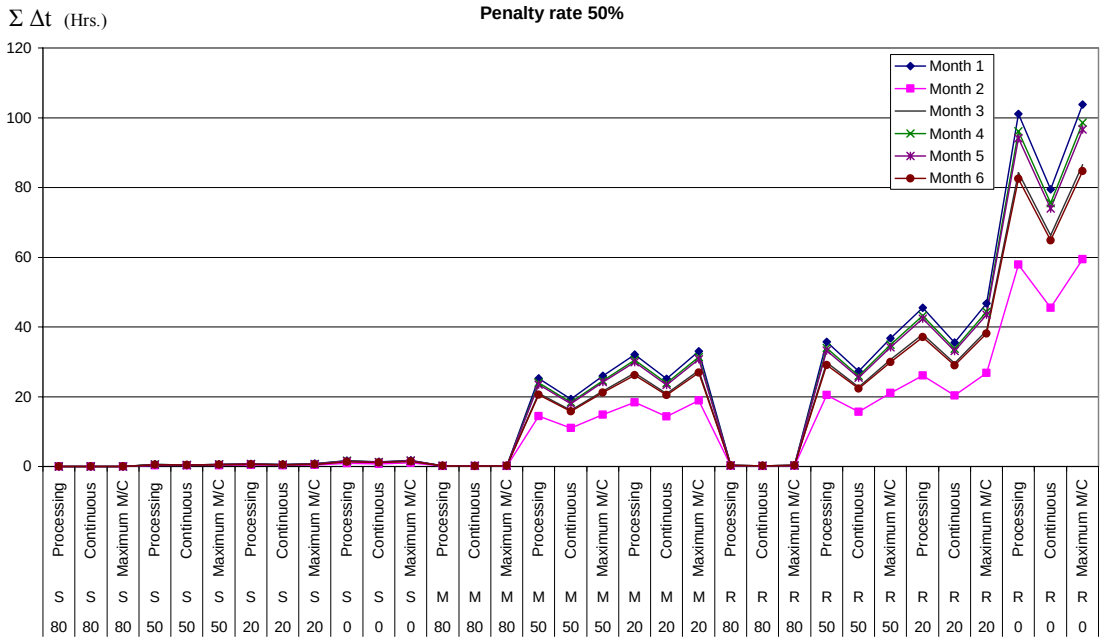


Figure 22 Skill effects at 50% penalty rate.

Table 17 Penalty rate 100%

Skill		heuristic rules	Month					
			1	2	3	4	5	6
80	S	Processing	0.008	0.005	0.007	0.008	0.007	0.007
80	S	Continuous	0.007	0.004	0.006	0.006	0.006	0.006
80	S	Maximum M/C	0.008	0.005	0.007	0.008	0.007	0.007
50	S	Processing	0.805	0.461	0.671	0.765	0.749	0.656
50	S	Continuous	0.663	0.380	0.553	0.631	0.618	0.541
50	S	Maximum M/C	0.822	0.471	0.685	0.781	0.765	0.671
20	S	Processing	0.974	0.558	0.812	0.925	0.907	0.794
20	S	Continuous	0.806	0.461	0.672	0.766	0.750	0.657
20	S	Maximum M/C	0.994	0.569	0.829	0.945	0.926	0.811
0	S	Processing	2.139	1.225	1.783	2.033	1.992	1.745
0	S	Continuous	1.774	1.016	1.479	1.686	1.652	1.447
0	S	Maximum M/C	2.184	1.251	1.820	2.076	2.034	1.781
80	M	Processing	0.337	0.193	0.281	0.320	0.314	0.275
80	M	Continuous	0.277	0.159	0.231	0.264	0.258	0.226
80	M	Maximum M/C	0.344	0.197	0.287	0.327	0.320	0.281
50	M	Processing	33.666	19.279	28.064	31.996	31.348	27.458
50	M	Continuous	27.753	15.893	23.135	26.377	25.843	22.636
50	M	Maximum M/C	34.390	19.694	28.667	32.684	32.023	28.048
20	M	Processing	40.733	23.327	33.955	38.713	37.929	33.222
20	M	Continuous	33.705	19.302	28.097	32.034	31.385	27.490
20	M	Maximum M/C	41.594	23.819	34.672	39.531	38.731	33.924
80	R	Processing	0.477	0.273	0.398	0.453	0.444	0.389
80	R	Continuous	0.393	0.225	0.327	0.373	0.366	0.320
80	R	Maximum M/C	0.487	0.279	0.406	0.463	0.454	0.398
50	R	Processing	47.682	27.306	39.747	45.317	44.400	38.890
50	R	Continuous	39.308	22.510	32.767	37.358	36.602	32.060
50	R	Maximum M/C	48.707	27.893	40.602	46.292	45.355	39.726
20	R	Processing	57.692	33.038	48.092	54.831	53.721	47.054
20	R	Continuous	47.738	27.338	39.794	45.371	44.452	38.935
20	R	Maximum M/C	58.911	33.736	49.108	55.989	54.856	48.048
0	R	Processing	126.742	72.581	105.652	120.456	118.018	103.371
0	R	Continuous	105.103	60.189	87.614	99.891	97.869	85.723
0	R	Maximum M/C	129.392	74.098	107.860	122.975	120.485	105.532

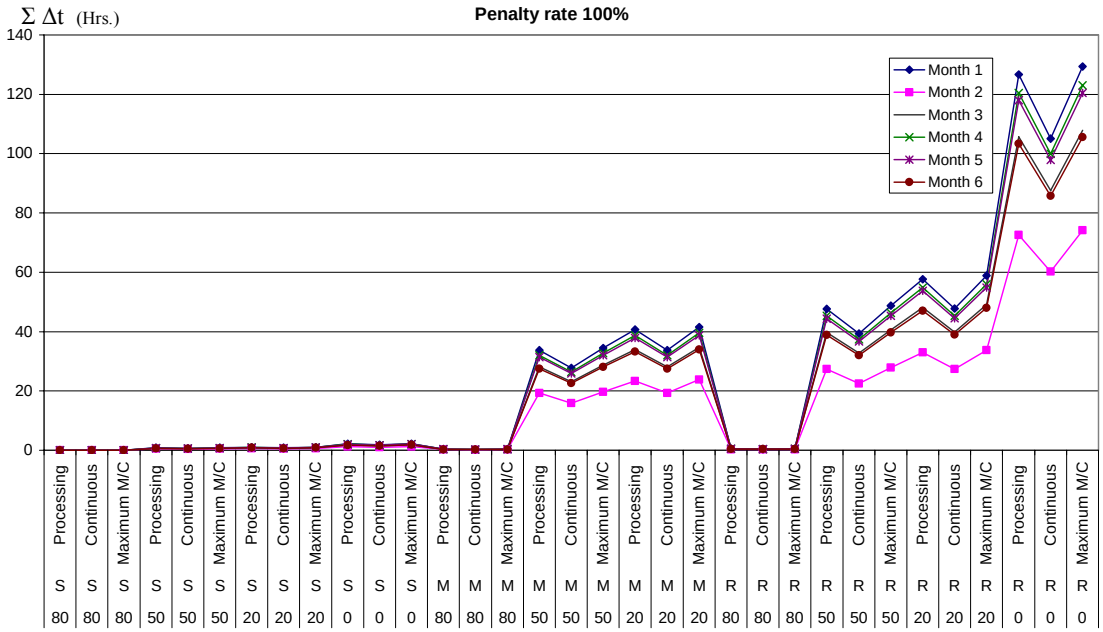


Figure 23 Skill effects at 100% penalty rate.

From results shown in figure 21, 22, 23, it is shown that skill has effects highly in the case where using heuristic of multiple skill and random skill allocation. The impact is higher with the diminishing of ratio of multiple skill workers in the group. Such effects to the completion time (C_{max}) take place even when penalty rate is as low as 25%. The cumulative of delay time is worsening with the higher number of jobs in each month.

Machine priority rule has little or no impact on the completion time where there is a high ratio of skill workforce and allocate single skill workers first. However with other skill allocation rules, multiple and random, machine priority rule has effects on the completion time at the low ratio of skill workforce.

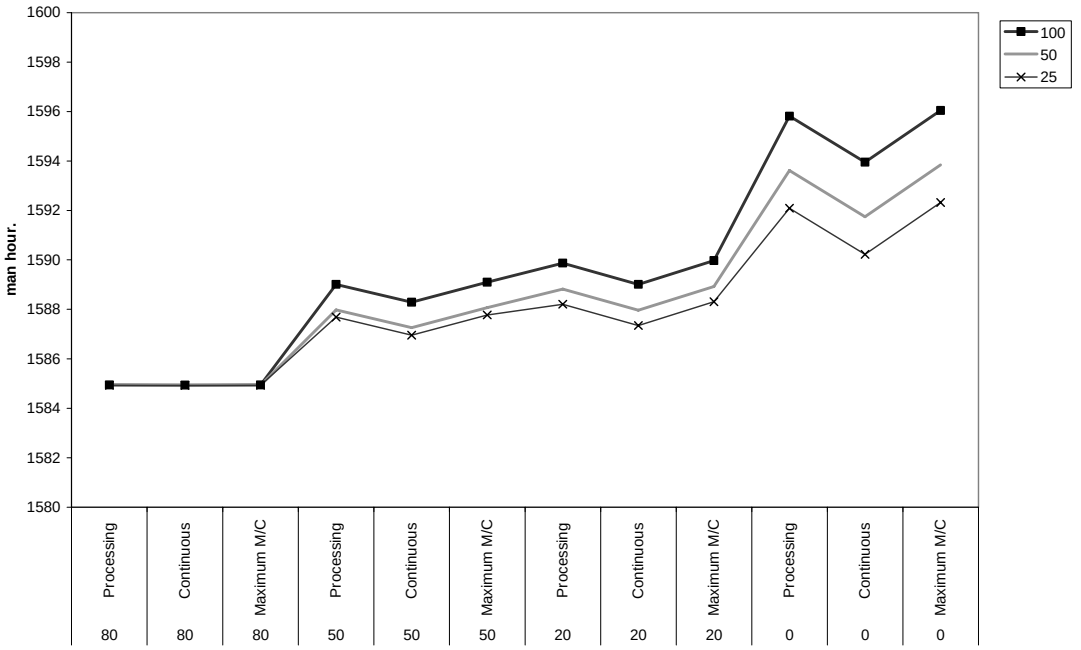


Figure 24 Skill effects at different penalty rates using heuristic rule 1 Single skill first.

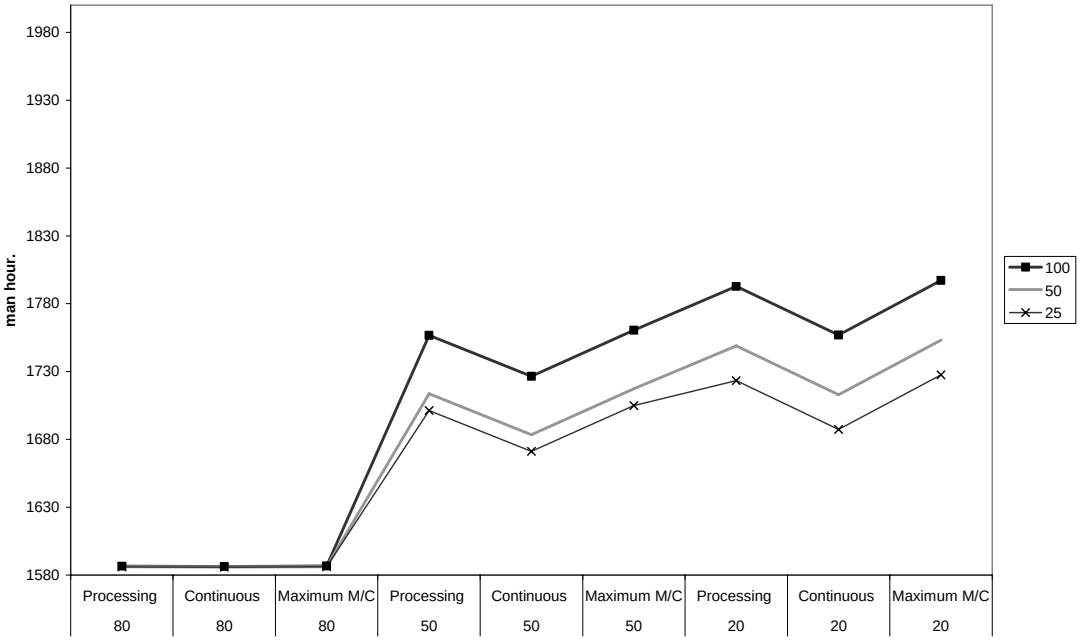


Figure 25 Skill effects at different penalty rates using heuristic rule 2 Multiple skill first.

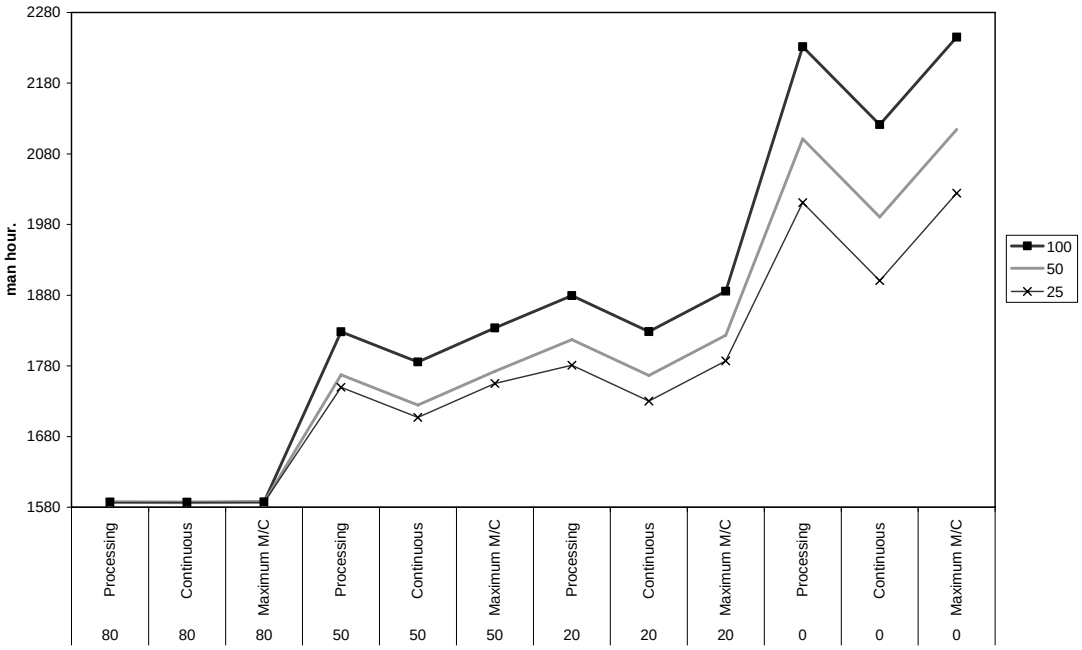


Figure 26 Skill effects at different penalty rates using heuristic rule 3- Random skill

When considering the effects of different penalty rates using different heuristic rules of workers allocation. From figure 24, 25, and 26, it can be seen clearly that the effects of skill differentiation will have impact on the total completion time when the ratio of skill workers in the group is less than 80%. The effects remain high even when the penalty rate is only 25%. When using the single skill allocation rule, this will reduce the impact of penalty. However in the worst case situation, the penalty increases with lower ratio of skill operators and maximum machines priority.

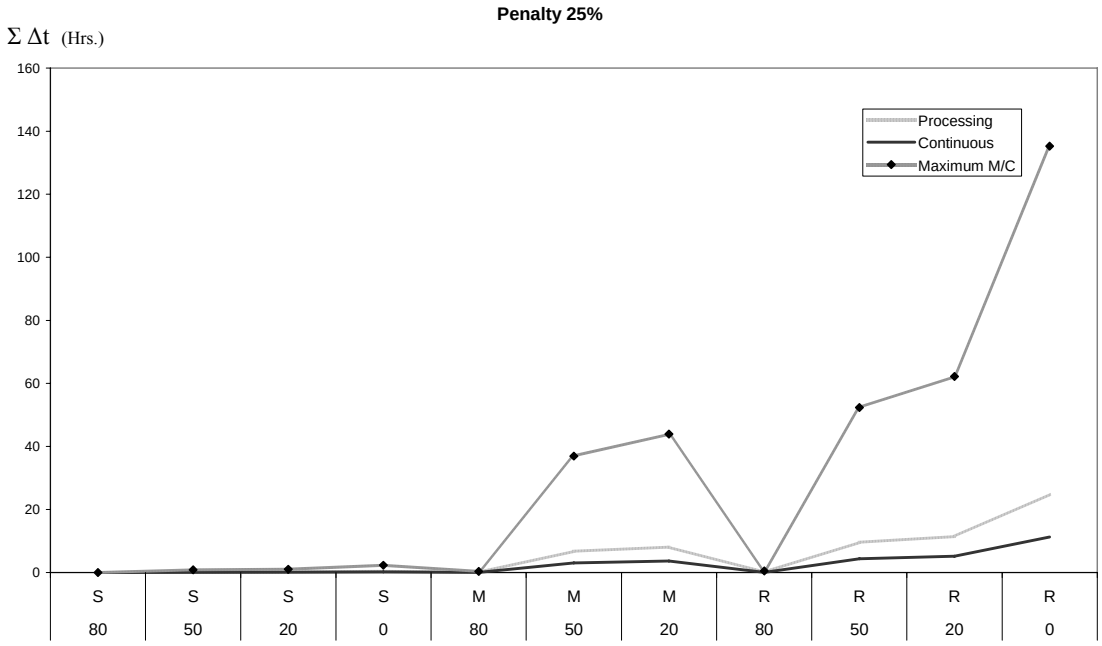


Figure 27 Effects of different machine priority rules at 25% penalty rates

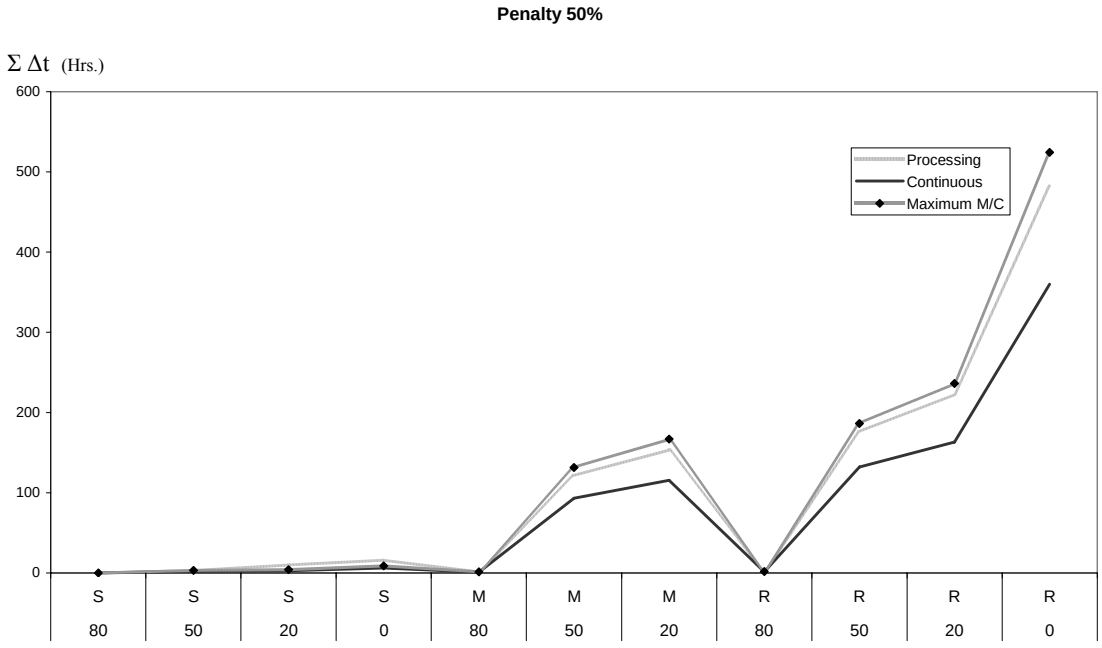


Figure 28 Effects of different machine priority rules at 50% penalty rates

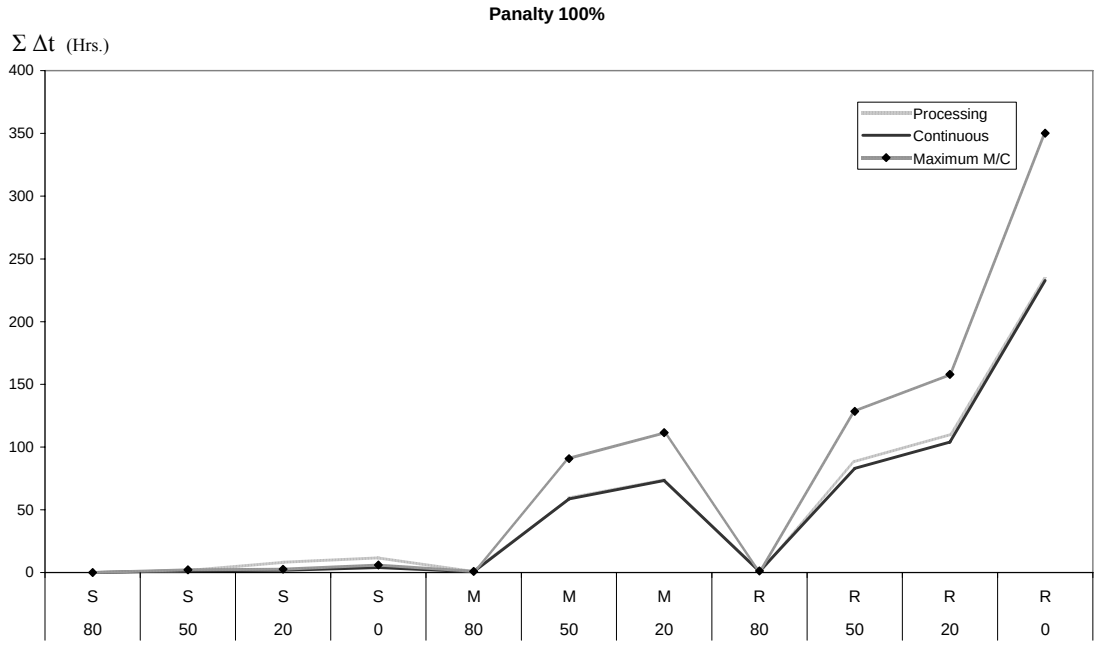


Figure 29 Effects of different machine priority rules at 100% penalty rates

From figure 27, 28, and 29, it can be seen clearly that machine priority rules will have more impact in the worst case situation where there are low ratio of skill work force and higher penalty rates.

3. Comparison of $C_{max,heuristic}$ to those of the company

With the tested heuristic rules, the results are then compared with those from the company. Using the following heuristic rules;

1) Assigning jobs to machines by using SPT
2) Assigning operators to tasks using skill allocation rules as follows;
    - Single skill workers first
    - Continuous machine has priority first

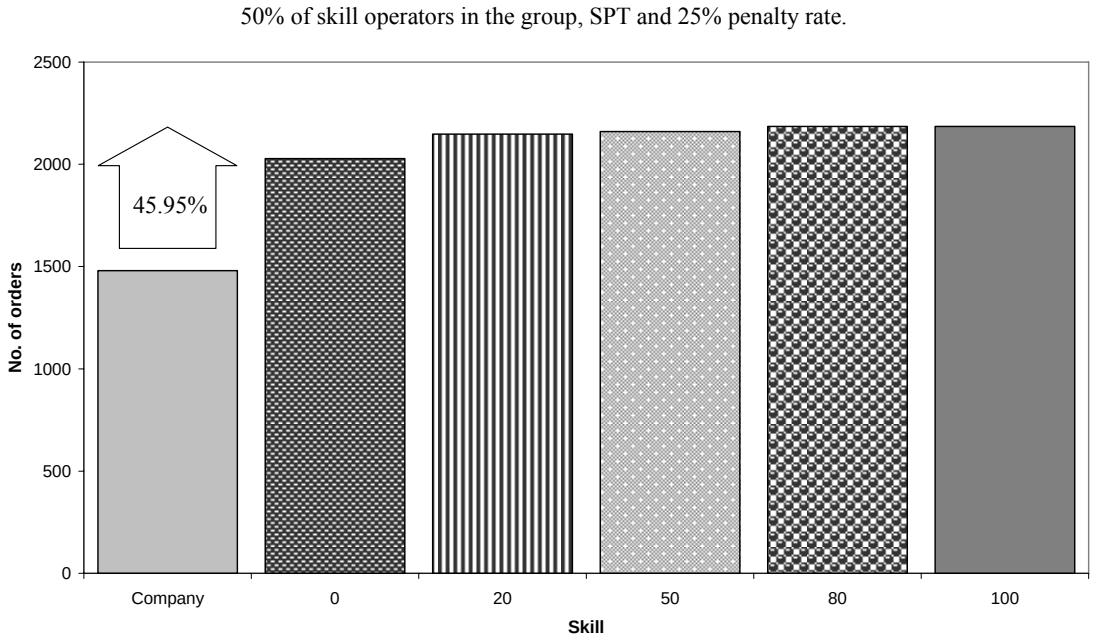


Figure 30 The number of orders meet due date.

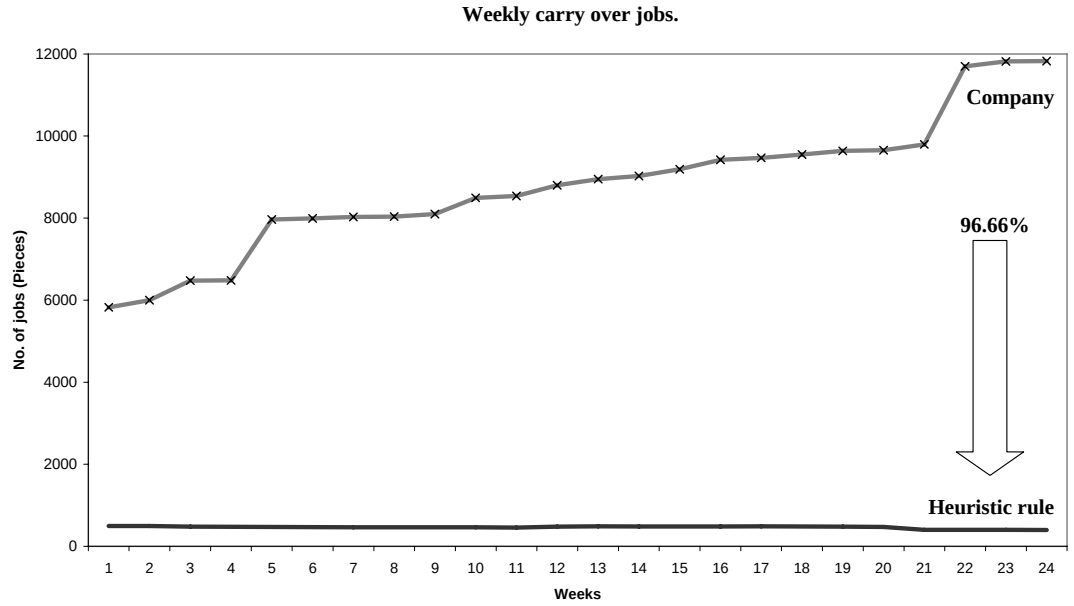


Figure 31 Weekly carry over jobs.

At the minimum penalty rate of 25%, it can be seen from Figure 30 that the new heuristic rule can improve the number of orders meeting due dates from 35% to 46%. In the mean time it also reduces throughput time and reduces number of weekly carry over jobs by 96.66 %.

From the comparison of results, it is obvious that the company is using a random skill allocation with first-come-first-serve rule for their job scheduling. The total number of orders meeting due date over the last 6 months period is only 1480 orders which is only 67.7% of the total order of 2185. By using a two-step heuristic scheduling method as proposed in this study, the optimal solution is using a skill ratio of 50%, and a minimum 25% penalty rate will give the result of 2160 orders meeting the target due dates. This is 98.85% achievement. comparing to 67.7% of the original result.

DISCUSSION

With no proper guidance, the method which is commonly employed by any scheduling jobs is FIFO and random assignment of workers. As can be seen from the comparison of heuristic rules in this study that such case yields the worst result of overall completion time and hence the cumulative of carry over unfulfilled orders (Appendix C).

The best heuristic rules derived from the study can be concluded as follows;

1) Scheduling jobs to machines first using simple SPT rule
2) Assigning single skill workers to tasks first before multiple skill workers.
3) Where there are uneven number of machines in the two stage flow shop, assign job to the longer sequential machine first before single machines.

CONCLUSION AND RECOMMENDATION

Conclusion

The study is to develop a heuristic set of rules for scheduling of a two-step flow shop assignment. The objectives is to minimize the maximum completion time of jobs by consider worker skills. Previously, there are no algorithms available for the scheduling in this case. Using a two-step approach and simple heuristic rules for the assignment of jobs in a can manufacturing, it can improve the overall completion time of the jobs, reduce tardiness and hence meeting delivery due dates.

From this thesis, it can be concluded that

1) The worker skills have influence over completion time especially where there is more than one skill needed for the operation. The company has to maintain the multiple skill workers at least 50 % in the work group in order to get the best results.

2) SPT rule gives the best solution for simple jobs scheduling. On the other hand, other rules as EDD, FIFO and LPT can also give better results when combined with right skill allocations.

3) Machine priority rules such as sequential machines, maximum processing time and higher number of machines will be considered only with low ratio of skill operators in the work group.

4) Effects of skill differentiation remain high even when there is a low learning curve, in this case represented by low penalty rate.

5) The new heuristic not only decrease the completion time but can improve the productivity, reduce throughput time and reduce number of weekly carry over jobs by 96.66%

Recommendation

Recommendation for application to real world situation;

1. Classification of worker skill according to each type of work.
2. Training of workers to the standard skill level using standard time as a milestone.
3. Allocate each worker to the appropriate task.
4. Scheduling jobs to machines and workers to task using heuristic rules of single skill first.
5. Where there are multiple tasks and skills in operation, a minimum ratio of 50% of multi-skill in the work group is suggested.
6. Follow up on standard time for improve and managing production plan.

Recommendation for future study

This study is based on the objective function of minimize the maximum completion time using a two-step schedule approach in a two stage parallel flow shop. For future study, addition situations might be included, such as;

- multiple stages hybrid flow shop,
- differentiation in the skill preference of operators,
- incentive effects on the assignment of skill operators.

LITERATURE CITED

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APPENDIX

Appendix A

The number of order jobs and completion time for six data.

Appendix Table A1 The number of order jobs and completion time for DATA 1.

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
1	6	22	01	2006	1000	1603908
2	2	06	01	2006	1005	41200
3	2	14	01	2006	1000	233780
4	5	15	02	2006	2000	1452210
5	1	20	01	2006	1000	311898
6	2	12	01	2006	1000	178780
7	5	06	01	2006	3000	159950
8	6	07	01	2006	1000	493368
9	6	28	01	2006	900	1729908
10	3	08	01	2006	1000	117450
11	6	19	01	2006	200	1443908
12	2	29	01	2006	5000	439530
13	3	04	01	2006	1000	15000
14	2	10	01	2006	1000	106280
15	5	17	01	2006	1500	668110
16	3	24	01	2006	1500	758655
17	6	20	01	2006	1000	1483908
18	5	06	01	2006	800	110380
19	5	01	02	2006	500	1364410
20	3	19	01	2006	600	610700
21	2	10	01	2006	1000	111280
22	4	13	01	2006	10000	96000
23	5	15	01	2006	1000	548110
24	6	31	01	2006	5000	1839908
25	4	14	01	2006	1000	100000
26	1	13	01	2006	4500	194898
27	6	10	01	2006	500	595668
28	6	11	01	2006	300	644668
29	6	17	01	2006	2000	1371908
30	3	14	01	2006	500	414200
31	2	01	02	2006	1000	444530
32	2	25	12	2006	2390	547080
33	6	21	01	2006	2000	1573908
34	1	07	01	2006	875	25728
35	5	15	01	2006	1500	583110
36	2	10	01	2006	3000	136280
37	2	09	01	2006	1000	93780
38	5	07	12	2005	1500	43000
39	5	14	01	2006	2600	418750
40	3	11	01	2006	50	271700
41	5	17	01	2006	1000	643110
42	3	01	01	2006	2000	12000
43	3	13	01	2006	1000	411700
44	2	17	01	2006	1000	271280
45	3	05	01	2006	5000	60000
46	1	27	01	2006	300	410298
47	1	27	01	2006	1000	419298
48	2	08	01	2006	1000	83780
49	6	08	01	2006	3000	590368
50	2	05	01	2006	700	31175

Appendix Table A1 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
51	2	11	01	2006	500	163780
52	5	11	01	2006	1000	206950
53	1	31	01	2006	2000	493698
54	2	29	01	2006	4200	414530
55	2	10	01	2006	500	96280
56	1	15	01	2006	6000	274698
57	1	20	01	2006	1000	317898
58	6	17	01	2006	1000	1331908
59	3	14	01	2006	2000	437700
60	1	07	01	2006	1000	31728
61	3	29	01	2006	2000	849655
62	1	14	01	2006	2500	232698
63	3	10	01	2006	2000	241450
64	5	01	02	2006	1260	1395410
65	5	21	01	2006	420	1050210
66	6	29	01	2006	3000	1789908
67	6	10	01	2006	600	601668
68	5	20	01	2006	1000	906010
69	2	19	01	2006	2000	298780
70	6	07	01	2006	1000	503368
71	3	21	01	2006	2000	712155
72	6	08	01	2006	500	548368
73	5	12	01	2006	1200	289350
74	6	17	01	2006	1000	1341908
75	3	06	01	2006	630	64365
76	3	28	01	2006	7000	834655
77	1	10	01	2006	5000	118794
78	5	19	01	2006	2000	794010
79	3	08	01	2006	500	109950
80	3	14	01	2006	700	417700
81	6	17	01	2006	1000	1351908
82	3	20	01	2006	2000	630200
83	2	10	01	2006	500	98780
84	6	14	01	2006	19008	1084548
85	1	06	01	2006	120	5568
86	6	11	01	2006	1720	668868
87	5	12	01	2006	1000	267350
88	1	29	01	2006	600	478098
89	5	14	01	2006	840	392750
90	5	24	01	2006	5000	1247410
91	5	19	01	2006	3200	846010
92	5	18	01	2006	900	725010
93	5	18	01	2006	3000	774010
94	3	24	01	2006	1000	751155
95	2	06	01	2006	1000	36175
96	2	06	01	2006	1016	46280
97	1	20	01	2006	1000	323898
98	5	18	01	2006	500	699010
99	1	14	01	2006	300	196698
100	3	22	01	2006	1000	742155

Appendix Table A1 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
101	5	28	01	2006	500	1338410
102	6	01	02	2006	1000	1863308
103	5	06	01	2006	600	102380
104	2	29	01	2006	1500	393530
105	3	10	01	2006	500	221450
106	3	10	01	2006	1200	231450
107	6	20	01	2006	1000	1493908
108	6	18	01	2006	5000	1441908
109	2	25	01	2006	1000	340280
110	6	06	01	2006	1000	466368
111	5	18	01	2006	900	734010
112	3	17	01	2006	1000	507700
113	5	17	01	2006	500	628110
114	6	07	01	2006	1000	513368
115	5	28	12	2005	1000	53000
116	2	24	01	2006	1000	335280
117	5	15	01	2006	1000	558110
118	5	14	01	2006	3168	506430
119	4	22	01	2006	10000	170000
120	3	20	01	2006	5391	702155
121	3	17	01	2006	500	500200
122	2	28	01	2006	1000	381030
123	5	17	01	2006	200	615110
124	1	10	01	2006	4551	88794
125	5	18	01	2006	500	704010
126	1	04	02	2006	1000	529698
127	6	14	01	2006	19008	1274628
128	1	10	01	2006	500	51888
129	6	12	01	2006	2592	752068
130	1	24	01	2006	500	372498
131	1	28	01	2006	4000	467298
132	3	07	01	2006	5117	107450
133	5	19	01	2006	2000	814010
134	5	06	01	2006	1957	129950
135	1	10	01	2006	1000	61488
136	6	17	01	2006	2000	1391908
137	3	08	01	2006	500	112450
138	5	06	09	2005	1000	18000
139	6	07	01	2006	1000	523368
140	5	18	01	2006	200	686010
141	5	12	01	2006	1000	277350
142	1	03	02	2006	1000	520698
143	5	07	01	2006	500	167950
144	5	11	01	2006	1000	216950
145	2	15	01	2006	1500	266280
146	6	01	02	2006	840	1853308
147	3	18	01	2006	4000	607700
148	3	24	01	2006	500	746155
149	6	24	01	2006	1000	1613908
150	5	05	01	2006	878	81780

Appendix Table A1 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
151	5	25	01	2006	500	1254410
152	5	20	01	2006	1000	916010
153	5	08	01	2006	600	183950
154	1	19	01	2006	2000	290898
155	2	12	01	2006	2000	193780
156	1	22	01	2006	1000	365898
157	3	07	01	2006	2000	81865
158	3	10	01	2006	300	218950
159	1	06	01	2006	400	9768
160	1	14	01	2006	500	199698
161	3	29	01	2006	1000	839655
162	2	13	12	2006	10120	535130
163	2	27	01	2006	2000	356030
164	5	17	01	2006	1500	683110
165	2	05	01	2006	500	27675
166	1	19	01	2006	500	278898
167	2	01	02	2006	2000	454530
168	1	06	01	2006	300	7368
169	6	21	01	2006	2000	1593908
170	6	19	01	2006	3000	1473908
171	5	12	01	2006	840	257350
172	1	24	01	2006	1000	378498
173	2	10	01	2006	500	101280
174	2	10	01	2006	5000	161280
175	2	28	12	2005	1000	15000
176	2	04	01	2006	35	15175
177	3	31	01	2006	1000	869655
178	2	07	01	2006	2000	61280
179	6	20	01	2006	5000	1553908
180	3	24	01	2006	2000	768655
181	5	20	01	2006	5000	996010
182	5	11	01	2006	1200	248950
183	2	03	11	2006	2000	479530
184	5	20	01	2006	1000	926010
185	4	18	12	2005	1000	6000
186	2	18	01	2006	500	288780
187	4	1	02	2006	10000	225000
188	5	27	01	2006	1000	1265410
189	3	12	01	2006	2000	286700
190	5	18	01	2006	600	710010
191	1	04	02	2006	500	523698
192	5	15	01	2006	1000	568110
193	5	17	01	2006	300	620110
194	5	14	01	2006	3168	538110
195	6	15	01	2006	3000	1321908
196	3	18	01	2006	1000	587700
197	3	01	02	2006	2000	879655
198	5	20	01	2006	5000	1046010
199	2	10	01	2006	2000	121280
200	5	17	01	2006	1000	653110

Appendix Table A1 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
201	5	21	01	2006	2400	1118410
202	6	05	01	2006	27648	450368
203	6	01	02	2006	500	1844908
204	5	24	01	2006	3500	1197410
205	6	10	01	2006	2000	621668
206	2	21	01	2006	300	330280
207	5	18	01	2006	300	691010
208	5	21	01	2006	420	1054410
209	3	07	01	2006	500	66865
210	5	18	01	2006	1000	744010
211	3	20	01	2006	3000	675200
212	2	14	01	2006	1000	238780
213	6	11	01	2006	700	651668
214	6	16	12	2005	2000	32000
215	5	06	01	2006	500	96380
216	4	5	01	2006	8000	52000
217	1	24	01	2006	300	367698
218	5	15	01	2006	1500	598110
219	6	05	02	2006	1000	1873308
220	3	20	01	2006	1000	620200
221	5	01	02	2006	1000	1382810
222	5	19	01	2006	5000	896010
223	1	04	01	2006	508	3048
224	1	29	01	2006	400	469698
225	5	25	01	2006	200	1249410
226	1	29	01	2006	600	481698
227	5	11	01	2006	1000	226950
228	2	12	01	2006	2000	203780
229	6	08	01	2006	1200	560368
230	2	20	01	2006	1000	303780
231	1	20	01	2006	4500	356898
232	1	24	01	2006	300	369498
233	6	28	01	2006	500	1715908
234	5	02	02	2006	1000	1422210
235	4	3	02	2006	500	227500
236	6	12	01	2006	1000	678868
237	2	14	01	2006	1000	243780
238	1	19	01	2006	2500	305898
239	1	31	01	2006	2500	508698
240	2	07	01	2006	3500	78780
241	2	25	01	2006	1000	345280
242	6	12	01	2006	1000	688868
243	5	20	01	2006	1000	936010
244	6	07	01	2006	1000	533368
245	5	17	01	2006	200	617110
246	1	07	01	2006	485	20478
247	4	18	01	2006	1000	115000
248	6	08	02	2006	380	1887108
249	1	29	01	2006	400	472098
250	3	20	01	2006	300	615200

Appendix Table A1 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
251	5	18	01	2006	90	684010
252	5	01	01	2006	1000	63000
253	5	17	01	2006	500	633110
254	5	12	01	2006	2000	309350
255	4	20	01	2006	1000	120000
256	3	21	01	2006	3000	737155
257	3	28	01	2006	700	789655
258	6	14	01	2006	3000	864468
259	2	04	01	2006	2000	25175
260	5	10	01	2006	1000	196950
261	2	11	12	2005	2000	12000
262	2	17	01	2006	2000	286280
263	1	11	01	2006	300	120594
264	1	12	01	2006	1000	138384
265	6	06	01	2006	1200	478368
266	3	12	01	2006	1000	276700
267	3	07	01	2006	1000	71865
268	5	27	01	2006	100	1255410
269	5	29	01	2006	1200	1359410
270	3	12	01	2006	2000	296700
271	5	04	01	2006	1000	73000
272	5	01	02	2006	840	1372810
273	2	02	02	2006	1000	469530
274	6	13	01	2006	2000	782068
275	5	12	01	2006	3500	344350
276	3	10	01	2006	6000	271450
277	5	05	01	2006	960	91380
278	6	10	01	2006	2000	641668
279	5	13	01	2006	1000	354350
280	2	27	01	2006	150	346030
281	1	14	01	2006	1500	217698
282	1	08	01	2006	1000	37728
283	6	07	01	2006	1000	543368
284	1	12	01	2006	300	132384
285	5	06	09	2005	1000	28000
286	1	10	01	2006	600	55488
287	5	25	12	2006	500	1457210
288	3	05	01	2006	4000	36000
289	6	15	01	2006	1728	1291908
290	3	29	01	2006	3000	864655
291	6	14	01	2006	1500	817068
292	3	20	01	2006	2000	640200
293	1	29	01	2006	400	474498
294	5	21	01	2006	2400	1142410
295	1	11	01	2006	1665	130584
296	1	27	01	2006	500	413298
297	1	18	01	2006	200	275898
298	6	07	01	2006	500	483368
299	1	10	01	2006	300	46488
300	2	17	01	2006	1000	276280

Appendix Table A1 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
301	5	14	01	2006	2800	446750
302	5	14	01	2006	2800	474750
303	1	06	01	2006	600	13368
304	1	06	01	2006	700	17568
305	3	03	02	2006	2000	889655
306	6	06	01	2006	600	456368
307	3	14	01	2006	1000	422700
308	6	28	01	2006	500	1720908
309	2	12	01	2006	5000	228780
310	5	29	01	2006	900	1347410
311	1	08	01	2006	1000	43728
312	3	24	01	2006	300	743655
313	3	20	01	2006	2000	650200
314	5	18	01	2006	300	694010
315	3	19	01	2006	600	613700
316	6	13	01	2006	1000	762068
317	1	05	01	2006	300	4848
318	5	20	01	2006	1000	946010
319	3	08	01	2006	20000	217450
320	5	15	01	2006	1500	613110
321	5	18	01	2006	600	716010
322	5	18	01	2006	200	688010
323	6	12	01	2006	2000	726148
324	5	02	02	2006	1000	1432210
325	1	14	01	2006	500	202698
326	2	25	12	2006	1000	484530
327	6	29	02	2006	3600	1923108
328	2	08	01	2006	1000	88780
329	1	22	01	2006	500	359898
330	3	17	01	2006	500	502700
331	3	21	01	2006	2000	722155
332	2	20	01	2006	5000	328780
333	1	10	01	2006	400	48888
334	5	11	01	2006	1000	236950
335	4	29	01	2006	1000	175000
336	5	24	01	2006	1000	1152410
337	4	3	02	2006	1500	235000
338	1	10	01	2006	160	44688
339	6	10	01	2006	30	590668
340	1	28	01	2006	3000	443298
341	6	27	01	2006	9700	1710908
342	1	01	02	2006	1000	514698
343	5	17	01	2006	300	623110
344	3	24	01	2006	3500	786155
345	2	12	01	2006	1000	183780
346	5	27	01	2006	6800	1333410
347	3	03	02	2006	2000	899655
348	6	13	01	2006	2000	802068
349	3	06	01	2006	243	61215
350	6	29	01	2006	1000	1739908

Appendix Table A1 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
351	6	20	01	2006	1000	1503908
352	6	14	01	2006	1740	834468
353	3	14	01	2006	7000	482700
354	6	12	01	2006	1728	706148
355	3	10	01	2006	800	225450
356	2	27	01	2006	4000	376030
357	3	20	01	2006	2000	660200
358	6	29	01	2006	1000	1749908
359	5	24	01	2006	1000	1162410
360	3	14	01	2006	2000	447700
361	1	14	01	2006	1000	208698
362	1	15	01	2006	1000	238698
363	5	07	01	2006	300	162950
364	3	17	01	2006	10000	582700
365	3	12	01	2006	20000	406700
366	2	01	02	2006	2000	464530
367	3	14	01	2006	1000	427700
368	6	14	01	2006	3000	894468
369	5	10	01	2006	300	186950
370	1	05	02	2006	1000	535698
371	3	12	01	2006	2000	306700
372	1	12	01	2006	4919	167898
373	5	21	01	2006	2000	1074410
374	5	01	02	2006	1680	1412210
375	1	25	01	2006	3000	408498
376	1	20	01	2006	1000	329898
377	4	14	01	2006	2000	110000
378	3	15	01	2006	3000	497700
379	5	13	01	2006	3000	384350
380	6	05	02	2006	1000	1883308
381	2	14	01	2006	3000	258780
382	2	28	01	2006	1000	386030
383	2	07	01	2006	1000	51280
384	1	24	01	2006	1000	384498
385	5	21	01	2006	2000	1094410
386	1	27	01	2006	1000	425298
387	2	11	01	2006	2000	173780
388	1	25	01	2006	1000	390498
389	3	28	01	2006	2000	799655
390	6	29	01	2006	1000	1759908
391	5	07	01	2006	1000	177950
392	3	17	01	2006	5000	532700

Appendix Table A2 The number of order jobs and completion time for DATA 2

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
1	2	8	12	2004	100	117950
2	1	20	12	2004	2800	338180
3	4	17	12	2004	250	35800
4	5	24	12	2004	1200	801850
5	5	30	12	2004	120	928080
6	6	23	01	2005	10500	1157330
7	1	20	12	2004	2464	286180
8	4	29	12	2004	1200	79800
9	2	22	12	2004	3000	438690
10	2	05	01	2005	400	493540
11	1	24	12	2004	370	369930
12	3	22	12	2004	12000	808285
13	2	11	12	2004	3000	178200
14	4	8	12	2004	1000	6000
15	1	17	12	2004	2000	229408
16	3	22	12	2004	500	662785
17	3	8	12	2004	9000	214285
18	5	3	12	2004	600	67700
19	5	17	12	2004	400	624650
20	1	03	12	2004	2200	30402
21	5	17	12	2004	380	620650
22	2	8	12	2004	280	119350
23	6	23	12	2004	750	542130
24	5	11	12	2004	500	321200
25	1	20	12	2004	1590	273860
26	5	9	12	2004	600	293200
27	5	4	12	2004	600	103900
28	2	07	01	2005	500	496680
29	1	15	12	2004	1170	186358
30	5	28	12	2004	800	822880
31	6	17	12	2004	500	397430
32	4	16	12	2004	160	31550
33	4	9	12	2004	550	23100
34	5	15	12	2004	550	389800
35	2	18	12	2004	2000	305690
36	5	17	12	2004	1000	639150
37	3	22	12	2004	600	665785
38	6	23	11	2004	1000	16000
39	5	11	12	2004	4000	379200
40	2	4	12	2004	1000	67450
41	6	16	12	2004	600	352430
42	2	3	12	2004	400	46000
43	1	18	12	2004	1500	239958
44	5	4	12	2004	1000	128400
45	6	17	12	2004	3000	462430
46	1	2	12	2004	1500	11322
47	1	15	01	2005	2700	482904
48	1	4	12	2004	1300	41552
49	3	14	01	2005	25000	1120785
50	2	24	12	2004	1000	445440

Appendix Table A2 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
51	3	30	12	2004	2000	984285
52	5	22	12	2004	1200	755150
53	1	13	12	2004	2830	160456
54	2	3	12	2004	700	49500
55	6	27	12	2004	500	775330
56	5	5	01	2005	8000	1120580
57	1	27	12	2004	2900	409930
58	2	22	12	2004	2600	423690
59	3	3	12	2004	800	71535
60	3	9	12	2004	4000	250785
61	2	25	12	2004	900	456440
62	2	11	12	2004	300	139850
63	6	25	12	2004	1000	720330
64	2	25	12	2004	1000	461440
65	5	26	11	2004	3500	53700
66	6	15	12	2004	2500	292430
67	1	4	12	2004	930	35052
68	2	4	12	2004	540	58200
69	6	9	12	2004	3000	234130
70	2	18	12	2004	1000	290190
71	2	8	12	2004	1800	138350
72	2	15	12	2004	750	256350
73	1	13	12	2004	300	139807
74	3	25	12	2004	1200	874285
75	3	3	12	2004	14000	161535
76	1	18	12	2004	1690	248410
77	1	15	01	2005	1300	469404
78	2	22	12	2004	700	407190
79	5	4	12	2004	1000	138400
80	6	25	11	2004	1200	28000
81	1	10	12	2004	1135	126807
82	2	11	12	2004	800	153200
83	5	8	12	2004	620	204200
84	5	3	12	2004	200	55700
85	5	5	01	2005	7000	1040580
86	6	16	12	2004	2000	372430
87	3	26	11	2004	500	47800
88	5	11	12	2004	800	329200
89	1	23	12	2004	900	368080
90	2	4	12	2004	850	62450
91	4	30	12	2004	8500	127340
92	1	7	12	2004	1300	64502
93	4	16	12	2004	600	34550
94	6	17	12	2004	2800	432430
95	6	29	12	2004	500	790330
96	5	15	12	2004	250	381700
97	5	15	12	2004	2000	431800
98	1	22	12	2004	2000	363580
99	3	29	12	2004	8500	974285
100	5	29	12	2004	5500	926880

Appendix Table A2 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
101	1	28	12	2004	1840	424129
102	3	24	12	2004	1000	838285
103	2	29	12	2004	500	488940
104	5	24	12	2004	500	775350
105	6	25	12	2004	2000	740330
106	1	22	12	2004	1800	353580
107	2	15	01	2005	2060	511480
108	6	9	12	2004	1480	184130
109	5	4	12	2004	650	110400
110	5	15	12	2004	700	396800
111	3	17	12	2004	1200	350285
112	5	30	12	2004	1200	951580
113	6	27	12	2004	900	784330
114	1	7	12	2004	3005	79527
115	6	3	12	2004	5000	110330
116	3	30	12	2004	2300	995785
117	5	24	12	2004	450	770350
118	5	3	12	2004	400	61700
119	2	4	12	2004	400	51500
120	1	7	12	2004	1000	58002
121	1	11	12	2004	2300	138307
122	5	24	12	2004	500	780350
123	2	25	12	2004	3000	486440
124	2	17	08	2004	2000	12000
125	3	25	12	2004	3000	901785
126	1	18	12	2004	610	232458
127	6	17	12	2004	700	404430
128	5	28	12	2004	1500	846880
129	3	22	12	2004	7000	708285
130	5	17	12	2004	5000	699150
131	1	20	12	2004	1300	265910
132	2	22	12	2004	700	410690
133	5	15	12	2004	4000	501800
134	2	25	12	2004	800	451940
135	5	22	12	2004	700	743150
136	3	22	12	2004	8000	748285
137	2	17	12	2004	800	261850
138	1	13	12	2004	3500	177956
139	6	30	12	2004	3000	902330
140	1	20	12	2004	2500	298680
141	5	9	12	2004	700	306200
142	3	15	12	2004	1200	266785
143	1	18	12	2004	2200	259410
144	2	18	12	2004	180	277750
145	2	11	12	2004	5000	203200
146	6	29	12	2004	500	795330
147	6	16	12	2004	2000	392430
148	1	28	12	2004	1000	414929
149	2	11	12	2004	670	145700
150	3	19	11	2004	7800	46800

Appendix Table A2 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
151	1	17	12	2004	1790	219408
152	1	15	12	2004	2300	197858
153	2	25	12	2004	1000	466440
154	2	8	12	2004	500	121850
155	5	15	12	2004	260	384300
156	3	9	12	2004	1000	219285
157	2	17	12	2004	3000	276850
158	5	8	12	2004	530	198000
159	5	28	12	2004	600	814880
160	5	15	12	2004	1500	411800
161	2	18	12	2004	2700	319190
162	5	23	12	2004	620	762850
163	1	5	01	2005	3145	462904
164	2	29	12	2004	520	491540
165	6	29	12	2004	3800	863330
166	1	2	12	2004	300	2922
167	5	9	12	2004	1000	316200
168	4	30	12	2004	1008	84840
169	2	18	12	2004	288	279190
170	5	4	12	2004	3500	189400
171	1	8	12	2004	1100	85027
172	6	8	12	2004	900	129330
173	6	15	12	2004	1680	267430
174	5	8	12	2004	2000	247200
175	5	30	12	2004	450	932580
176	3	24	12	2004	4000	858285
177	5	16	12	2004	300	604800
178	6	8	12	2004	3000	169330
179	3	1	12	2004	1000	59000
180	1	25	12	2004	2100	395430
181	2	15	12	2004	500	252600
182	4	30	12	2004	15000	202340
183	3	23	12	2004	2500	833285
184	6	3	12	2004	1000	50200
185	5	8	12	2004	100	190400
186	5	8	12	2004	230	192700
187	6	29	12	2004	1000	805330
188	6	23	12	2004	1500	557130
189	5	16	12	2004	505	614850
190	3	8	12	2004	1000	169285
191	6	7	12	2004	500	115330
192	5	28	12	2004	203	803880
193	2	26	11	2004	800	19000
194	3	3	12	2004	1000	76535
195	5	3	12	2004	1200	89700
196	4	9	12	2004	700	26250
197	5	29	12	2004	700	853880
198	6	3	12	2004	500	40200
199	1	15	12	2004	510	180508
200	5	4	12	2004	800	118400

Appendix Table A2 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
201	5	17	12	2004	200	616850
202	1	25	12	2004	1500	377430
203	2	18	12	2004	700	285190
204	6	23	12	2004	500	534630
205	6	16	12	2004	200	346430
206	2	4	12	2004	5000	92450
207	3	8	12	2004	250	162785
208	3	17	12	2004	10000	435285
209	2	27	11	2004	5000	45200
210	5	16	12	2004	500	609800
211	2	11	12	2004	500	142350
212	5	11	12	2004	1000	339200
213	1	8	12	2004	2500	97527
214	4	23	12	2004	1000	42800
215	2	18	12	2004	9400	403690
216	4	17	12	2004	400	37800
217	5	15	12	2004	3000	461800
218	3	16	12	2004	5000	341785
219	6	22	12	2004	3000	529630
220	3	16	12	2004	1000	311785
221	6	2	12	2004	720	35200
222	6	13	12	2004	450	238630
223	6	9	12	2004	2000	204130
224	3	17	12	2004	45000	660285
225	6	22	12	2004	1000	499630
226	3	25	12	2004	1000	863285
227	6	23	12	2004	6000	645330
228	5	21	12	2004	2000	732150
229	5	30	12	2004	1900	970580
230	5	15	12	2004	5000	551800
231	2	07	01	2005	900	501180
232	5	12	1	2005	7000	1280580
233	6	23	12	2004	2820	585330
234	6	7	12	2004	500	120330
235	1	22	12	2004	1280	344580
236	6	25	12	2004	3000	770330
237	6	3	12	2004	1013	60330
238	3	15	12	2004	1000	255785
239	1	25	12	2004	1500	384930
240	1	20	12	2004	2500	311180
241	3	16	12	2004	1000	316785
242	6	24	12	2004	500	650330
243	6	15	12	2004	5200	344430
244	3	17	12	2004	7000	385285
245	5	21	12	2004	800	712150
246	5	23	12	2004	150	756650
247	2	4	12	2004	400	53500
248	2	25	12	2004	200	446440
249	3	15	12	2004	1000	260785
250	4	23	12	2004	4200	63800

Appendix Table A2 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
251	5	8	12	2004	800	212200
252	4	9	12	2004	900	30750
253	2	18	12	2004	500	281690
254	2	24	12	2004	350	440440
255	5	21	12	2004	500	704150
256	3	29	12	2004	5000	931785
257	3	25	12	2004	1000	868285
258	2	15	12	2004	380	250100
259	5	29	12	2004	1800	871880
260	5	28	12	2004	500	808880
261	5	5	01	2005	9000	1210580
262	4	8	12	2004	3000	22000
263	2	8	12	2004	1500	129350
264	3	26	11	2004	2500	54000
265	2	18	12	2004	1100	295690
266	5	12	01	2005	8000	1360580
267	6	4	01	2005	15000	1052330
268	6	20	12	2004	220	464630
269	5	17	12	2004	1000	649150
270	5	24	12	2004	950	789850
271	1	4	12	2004	2290	53002
272	5	26	11	2004	400	6000
273	6	29	12	2004	100	785330
274	3	17	12	2004	500	344285
275	5	4	12	2004	120	90900
276	2	11	12	2004	1000	158200
277	4	25	12	2004	2000	73800
278	3	23	12	2004	1500	820785
279	5	3	12	2004	1000	77700
280	6	30	12	2004	200	865330
281	3	25	12	2004	2500	886785
282	3	22	12	2004	1500	673285
283	2	11	12	2004	9000	248200
284	3	29	12	2004	1000	906785
285	5	22	12	2004	400	736150
286	5	4	12	2004	200	92900
287	2	4	12	2004	400	55500
288	2	4	12	2004	5000	117450
289	2	17	12	2004	300	257850
290	6	29	12	2004	2000	825330
291	1	20	12	2004	2600	324180
292	2	25	12	2004	1000	471440
293	1	28	12	2004	1900	433629
294	5	3	12	2004	200	57700
295	5	15	12	2004	5000	601800
296	1	2	12	2004	1800	19402
297	6	24	12	2004	6000	710330
298	2	11	12	2004	700	149200
299	5	9	12	2004	600	299200
300	5	17	12	2004	450	629150

Appendix Table A2 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
301	5	28	12	2004	900	831880
302	1	9	12	2004	300	99027
303	1	5	01	2005	1510	447179
304	2	18	12	2004	7500	356690
305	6	30	12	2004	700	872330
306	2	11	12	2004	1000	163200
307	3	1	12	2004	1707	67535
308	3	15	12	2004	8000	306785
309	1	9	12	2004	1320	105630
310	1	13	12	2004	1300	146307
311	5	8	12	2004	1500	227200
312	2	07	01	2005	128	494180
313	2	25	12	2004	300	447940
314	3	9	12	2004	1300	230785
315	1	5	01	2005	1200	439629
316	6	15	12	2004	1000	250630
317	6	21	12	2004	2500	489630
318	5	8	12	2004	4000	287200
319	2	25	11	2004	1000	15000
320	1	15	12	2004	2520	210458
321	5	4	12	2004	500	97900
322	6	8	12	2004	1000	139330
323	3	23	12	2004	1000	813285
324	3	8	12	2004	300	164285
325	5	30	12	2004	700	939580
326	6	15	12	2004	200	240630
327	3	9	12	2004	1000	224285
328	3	3	12	2004	3000	91535
329	1	2	12	2004	280	1683
330	1	9	12	2004	3100	121130
331	5	4	12	2004	1600	154400
332	5	24	12	2004	300	765850

Appendix Table A3 The number of order jobs and completion time for DATA 3

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
1	1	27	11	2005	1500	429006
2	6	3	11	2005	500	22100
3	5	8	12	2005	1260	1315970
4	2	25	11	2005	1000	394160
5	3	3	11	2005	21000	155200
6	3	3	11	2005	900	10500
7	2	19	11	2005	100	331860
8	5	12	11	2005	3000	600400
9	3	25	11	2005	26000	753450
10	3	16	11	2005	800	493250
11	4	7	12	2005	2000	191700
12	3	6	11	2005	400	214500
13	6	5	11	2005	500	122100
14	1	29	11	2005	1480	476166
15	2	12	11	2005	100	112150
16	3	13	11	2005	4000	383750
17	3	13	11	2005	1000	324250
18	2	26	11	2005	850	405410
19	6	22	10	2005	1000	16800
20	1	12	11	2005	1000	114780
21	1	27	11	2005	1200	420006
22	6	12	11	2005	3000	176100
23	3	13	11	2005	20000	483750
24	2	5	11	2005	200	28900
25	1	5	11	2005	2000	74940
26	5	5	11	2005	10000	395400
27	2	18	11	2005	9000	331360
28	5	25	11	2005	1000	937600
29	5	26	11	2005	2000	1032600
30	3	26	11	2005	500	761750
31	2	16	11	2005	2500	244300
32	6	16	11	2005	2000	430700
33	2	5	11	2005	1000	34900
34	2	27	11	2005	1400	481160
35	2	29	11	2005	1000	490260
36	6	25	11	2005	1000	804700
37	1	18	11	2005	1700	205146
38	2	26	11	2005	800	401160
39	5	5	11	2005	300	215400
40	5	6	11	2005	1000	410400
41	3	26	11	2005	400	757250
42	4	3	11	2005	200	3500
43	3	13	11	2005	330	316850
44	4	18	11	2005	1000	106700
45	2	6	11	2005	1100	76650
46	2	18	11	2005	1800	256300
47	6	25	11	2005	1000	814700
48	3	16	11	2005	600	489250
49	3	25	11	2005	500	599450
50	2	3	11	2005	2500	27900

Appendix Table A3 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
51	6	24	11	2005	15000	794700
52	2	5	11	2005	1200	40900
53	3	5	11	2005	1000	157200
54	3	6	11	2005	480	216900
55	5	18	11	2005	1000	706800
56	5	18	11	2005	3200	758800
57	1	27	11	2005	2000	451806
58	3	26	11	2005	3000	805750
59	3	3	12	2005	10000	1010250
60	1	6	11	2005	1000	84180
61	1	25	11	2005	1570	370506
62	1	18	11	2005	300	182280
63	3	26	11	2005	4500	867750
64	2	3	11	2005	600	15400
65	5	26	11	2005	1000	992600
66	3	27	11	2005	10000	960250
67	3	19	11	2005	300	528250
68	3	5	11	2005	9000	212500
69	6	25	11	2005	1000	824700
70	3	27	11	2005	400	892250
71	1	25	11	2005	2000	382506
72	2	20	11	2005	540	358060
73	3	26	11	2005	400	759250
74	1	18	11	2005	1111	194946
75	2	26	11	2005	600	397160
76	2	29	11	2005	120	481760
77	4	25	11	2005	500	179200
78	1	24	11	2005	1000	319686
79	6	25	11	2005	1000	834700
80	6	7	12	2005	1000	1112700
81	2	26	11	2005	2000	425410
82	1	7	12	2005	2700	566286
83	6	24	11	2005	2000	584700
84	5	20	11	2005	500	763800
85	6	20	11	2005	2000	514700
86	5	26	11	2005	2400	1056600
87	3	26	11	2005	1500	781250
88	3	5	11	2005	3200	167500
89	6	3	11	2005	1500	57100
90	2	20	11	2005	200	352860
91	1	24	11	2005	350	311286
92	3	26	11	2005	1900	790750
93	4	18	11	2005	500	98200
94	1	27	11	2005	1800	439806
95	5	13	11	2005	1000	616400
96	2	16	11	2005	520	223050
97	1	6	11	2005	540	78180
98	5	29	11	2005	6800	1283800
99	5	20	11	2005	8500	875600
100	5	6	11	2005	5000	520400

Appendix Table A3 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
101	6	26	11	2005	500	869700
102	5	18	11	2005	2000	726800
103	3	6	11	2005	480	219300
104	1	29	11	2005	600	455406
105	6	26	11	2005	5000	939700
106	3	3	11	2005	200	4000
107	5	5	11	2005	2000	265400
108	3	3	11	2005	1200	16500
109	1	3	11	2005	1000	8040
110	6	3	11	2005	1000	32100
111	1	20	11	2005	1900	309186
112	1	5	11	2005	1000	52140
113	3	26	11	2005	4000	845250
114	6	3	11	2005	1000	42100
115	5	26	11	2005	1000	1002600
116	5	3	11	2005	9600	212400
117	4	12	11	2005	720	88200
118	2	24	11	2005	1000	371660
119	2	26	11	2005	2000	435410
120	3	12	11	2005	2500	298700
121	2	3	11	2005	200	5700
122	1	25	11	2005	500	351486
123	6	3	11	2005	30	17100
124	2	24	11	2005	2500	384160
125	4	16	11	2005	1000	95700
126	1	29	11	2005	1330	467286
127	6	13	11	2005	700	188100
128	5	3	11	2005	1000	28000
129	4	3	11	2005	220	4600
130	3	24	11	2005	2000	583950
131	3	27	11	2005	2000	910250
132	2	13	11	2005	5860	185950
133	2	3	11	2005	200	6700
134	5	24	11	2005	300	878600
135	6	12	11	2005	1000	146100
136	1	20	11	2005	1330	297786
137	2	13	11	2005	500	125650
138	2	16	11	2005	750	226800
139	1	25	11	2005	2500	397506
140	2	26	11	2005	1000	410410
141	4	25	11	2005	500	181700
142	3	27	11	2005	400	894250
143	3	3	11	2005	400	6000
144	3	6	11	2005	4400	277800
145	3	13	11	2005	300	315200
146	1	16	11	2005	600	165480
147	3	20	11	2005	420	530350
148	3	20	11	2005	1600	538350
149	1	28	10	2005	340	2040
150	3	3	12	2005	25600	1138250

Appendix Table A3 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
151	5	6	11	2005	2000	430400
152	6	13	11	2005	500	181100
153	5	25	11	2005	600	927600
154	5	5	11	2005	1000	225400
155	3	12	11	2005	330	281200
156	1	3	12	2005	2520	550086
157	3	24	11	2005	300	569850
158	1	25	11	2005	1100	361086
159	1	12	11	2005	700	108780
160	1	12	11	2005	1600	124380
161	5	13	11	2005	600	606400
162	1	29	11	2005	2900	516966
163	1	29	11	2005	2100	499566
164	4	18	11	2005	700	101700
165	2	20	11	2005	1000	363060
166	3	13	11	2005	480	319250
167	2	27	11	2005	1000	474160
168	3	24	11	2005	400	571850
169	2	26	11	2005	2000	445410
170	6	12	11	2005	900	136100
171	5	6	11	2005	5000	570400
172	6	25	11	2005	1000	844700
173	6	24	11	2005	1000	564700
174	3	12	11	2005	3000	313700
175	3	26	11	2005	3900	825250
176	2	3	11	2005	200	7700
177	3	5	11	2005	1000	159200
178	3	24	11	2005	420	573950
179	6	3	11	2005	2000	77100
180	6	20	11	2005	1000	494700
181	6	27	11	2005	1000	949700
182	5	24	11	2005	1000	897600
183	2	8	12	2005	4200	511260
184	1	18	11	2005	2500	220146
185	2	24	11	2005	500	366660
186	5	27	11	2005	5520	1200800
187	6	27	11	2005	1000	959700
188	2	13	11	2005	2500	144150
189	5	5	11	2005	1000	235400
190	2	3	11	2005	200	8700
191	1	25	11	2005	300	348486
192	2	6	11	2005	450	63650
193	6	16	11	2005	300	378500
194	6	24	11	2005	2000	604700
195	6	18	10	2005	200	3200
196	1	24	11	2005	1000	325686
197	3	13	11	2005	1300	330750
198	1	13	11	2005	1000	144480
199	1	12	11	2005	1700	134580
200	3	6	11	2005	2400	235800

Appendix Table A3 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
201	2	6	11	2005	4500	111650
202	3	26	11	2005	260	755250
203	2	27	11	2005	850	469160
204	2	6	11	2005	2500	89150
205	3	18	11	2005	4400	526750
206	5	25	11	2005	1000	947600
207	4	13	11	2005	500	90700
208	4	18	11	2005	9000	151700
209	4	12	11	2005	700	85680
210	5	5	11	2005	1000	245400
211	5	24	11	2005	2400	921600
212	6	29	11	2005	600	1005700
213	1	19	11	2005	1500	246246
214	1	24	11	2005	1500	334686
215	2	21	10	2005	300	4700
216	2	20	11	2005	500	355360
217	6	5	11	2005	500	127100
218	2	13	11	2005	2500	156650
219	2	26	11	2005	1000	415410
220	5	24	11	2005	900	887600
221	6	3	12	2005	9700	1102700
222	6	13	11	2005	1000	198100
223	4	6	11	2005	300	84280
224	6	3	11	2005	2000	97100
225	5	25	11	2005	1500	982600
226	1	16	11	2005	300	159480
227	2	25	11	2005	500	389160
228	3	26	11	2005	1000	766750
229	5	7	12	2005	1957	1303370
230	1	29	11	2005	1800	486966
231	2	3	11	2005	240	9900
232	3	18	11	2005	2000	504750
233	4	3	11	2005	10000	83680
234	5	25	11	2005	1000	957600
235	6	13	11	2005	1740	225500
236	4	24	11	2005	5000	176700
237	1	16	11	2005	1000	171480
238	3	30	8	2005	600	3600
239	6	25	11	2005	2000	864700
240	6	24	11	2005	2000	624700
241	3	25	11	2005	3600	623450
242	6	13	11	2005	2000	245500
243	2	27	11	2005	350	464910
244	1	19	11	2005	1600	264846
245	2	24	11	2005	220	364160
246	1	13	11	2005	2200	157680
247	5	20	11	2005	1000	773800
248	6	13	11	2005	1000	208100
249	6	20	11	2005	4000	554700
250	2	13	11	2005	1200	131650

Appendix Table A3 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
251	2	19	11	2005	4000	351860
252	6	16	11	2005	380	382300
253	2	18	11	2005	100	244800
254	3	26	11	2005	1400	773750
255	2	11	8	2005	640	3840
256	4	3	11	2005	5000	33680
257	6	13	11	2005	3000	295500
258	2	27	11	2005	250	463160
259	1	19	11	2005	500	225246
260	2	5	11	2005	200	29900
261	2	12	11	2005	2000	123150
262	2	5	11	2005	4100	61400
263	1	19	11	2005	2500	279846
264	5	16	11	2005	5000	691800
265	1	5	11	2005	1800	62940
266	3	18	11	2005	300	494750
267	3	3	11	2005	4000	37200
268	1	5	11	2005	350	46140
269	2	12	11	2005	200	113150
270	3	12	11	2005	220	279550
271	2	6	11	2005	1000	71150
272	3	26	11	2005	4500	890250
273	6	26	11	2005	1000	879700
274	5	27	11	2005	900	1115600
275	5	16	11	2005	200	633400
276	1	13	11	2005	650	138480
277	3	16	11	2005	200	484750
278	1	27	11	2005	550	412806
279	3	6	11	2005	4000	255800
280	6	18	11	2005	3000	484700
281	3	24	11	2005	2600	596950
282	2	3	11	2005	500	12400
283	2	13	11	2005	6900	220450
284	1	19	11	2005	1000	231246
285	6	16	11	2005	840	390700
286	5	29	11	2005	500	1205800
287	5	3	11	2005	2600	74000
288	1	19	11	2005	1500	255246
289	2	26	11	2005	3300	461910
290	6	18	11	2005	2400	454700
291	1	24	11	2005	2000	346686
292	1	25	11	2005	500	354486
293	6	26	11	2005	1000	889700
294	3	27	11	2005	800	900250
295	5	26	11	2005	1000	1012600
296	5	6	11	2005	500	400400
297	1	26	11	2005	2000	409506
298	5	13	11	2005	1500	631400
299	1	6	11	2005	3400	104580
300	1	3	11	2005	2500	23040

Appendix Table A3 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
301	2	18	11	2005	6012	286360
302	5	5	11	2005	3000	295400
303	5	18	10	2005	1000	18000
304	6	13	11	2005	2000	265500
305	6	13	11	2005	5000	375500
306	5	18	11	2005	300	696800
307	1	29	11	2005	650	459306
308	2	16	11	2005	1000	231800
309	1	19	11	2005	1000	237246
310	6	16	11	2005	1000	400700
311	2	25	11	2005	400	386660
312	1	16	11	2005	1500	180480
313	6	13	11	2005	3000	325500
314	1	3	11	2005	3500	44040
315	2	6	11	2005	500	66150
316	3	12	11	2005	1000	286200
317	2	29	11	2005	700	485260
318	1	16	11	2005	400	161880
319	1	20	11	2005	460	282606
320	3	12	11	2005	130	278450
321	3	25	11	2005	1200	605450
322	6	3	11	2005	2000	117100
323	5	20	11	2005	1680	790600
324	6	27	11	2005	3000	999700
325	2	25	11	2005	100	384660
326	5	29	11	2005	1000	1215800
327	5	18	11	2005	200	693800
328	6	27	11	2005	1000	969700
329	1	19	11	2005	350	222246
330	3	6	11	2005	900	223800
331	2	18	11	2005	500	247300
332	6	16	11	2005	1000	410700
333	1	29	11	2005	3000	534966
334	3	26	11	2005	100	753950
335	1	20	11	2005	1200	289806
336	5	26	11	2005	5000	1106600
337	5	25	11	2005	1000	967600
338	5	3	11	2005	2000	48000
339	3	16	11	2005	300	486250
340	3	13	11	2005	3600	363750
341	4	17	9	2005	500	3000
342	3	13	11	2005	3000	345750
343	3	27	11	2005	400	896250
344	6	24	11	2005	2000	644700
345	5	16	11	2005	840	641800
346	1	18	11	2005	1000	188280
347	5	6	11	2005	4000	470400
348	1	24	11	2005	400	313686
349	3	20	11	2005	6000	568350
350	5	27	11	2005	3000	1145600

Appendix Table A4 The number of order jobs and completion time for DATA 4

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
1	1	1	10	2005	700	13500
2	6	30	10	2005	2300	925100
3	1	30	10	2005	1250	468075
4	2	15	10	2005	1000	266550
5	6	11	10	2005	1000	348900
6	3	28	10	2005	3000	1243250
7	4	9	10	2005	1500	52520
8	3	15	10	2005	2000	956750
9	3	28	10	2005	5117	1268835
10	3	12	11	2005	15000	1398835
11	6	20	10	2005	2500	553900
12	6	6	10	2005	5000	199000
13	2	6	10	2005	800	97550
14	5	14	10	2005	200	642800
15	1	22	10	2005	2000	431325
16	6	15	10	2005	200	475900
17	2	2	10	2005	400	14050
18	3	20	10	2005	500	979250
19	4	28	10	2005	550	131920
20	4	9	10	2005	204	45020
21	6	30	10	2005	2000	882100
22	5	30	10	2005	500	1021800
23	2	8	10	2005	600	134050
24	3	28	10	2005	500	1199250
25	3	14	10	2005	20000	938250
26	1	9	10	2005	1500	221000
27	2	30	10	2005	4500	521100
28	5	24	9	2005	2000	30000
29	1	6	10	2005	4100	178000
30	6	9	10	2005	1000	327600
31	3	30	10	2005	2000	1288835
32	5	2	10	2005	2000	95000
33	1	28	10	2005	600	443825
34	6	1	10	2005	3000	62000
35	3	2	10	2005	200	218500
36	5	9	10	2005	1000	291800
37	6	30	10	2005	500	837100
38	6	28	10	2005	1000	792100
39	2	14	10	2005	1000	220050
40	5	11	10	2005	3200	422800
41	3	1	10	2005	200	42400
42	4	28	10	2005	1000	136920
43	6	14	10	2005	1000	443900
44	1	20	10	2005	700	353650
45	3	20	10	2005	20000	1104250
46	1	8	10	2005	300	179500
47	6	6	10	2005	1000	149000
48	3	8	10	2005	50	470250
49	3	23	10	2005	700	1130750
50	6	23	10	2005	2000	754900

Appendix Table A4 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
51	3	14	10	2005	2000	702250
52	2	2	10	2005	400	16050
53	2	23	10	2005	1000	348750
54	4	20	10	2005	2000	99170
55	2	23	10	2005	10600	441750
56	1	20	10	2005	1500	361150
57	1	20	10	2005	2700	374650
58	5	11	10	2005	900	390800
59	2	8	10	2005	400	131050
60	6	8	10	2005	1000	280400
61	2	22	10	2005	500	312650
62	4	2	10	2005	700	23500
63	5	6	10	2005	5000	200000
64	4	8	10	2005	2000	44000
65	3	5	11	2005	3000	1323835
66	1	15	10	2005	2000	349250
67	6	11	10	2005	2000	368900
68	2	22	10	2005	5000	337650
69	5	20	10	2005	200	779100
70	5	2	10	2005	5000	145000
71	4	2	10	2005	1000	28500
72	3	14	10	2005	1000	692250
73	5	20	10	2005	300	782100
74	1	20	10	2005	3800	393650
75	6	22	10	2005	2000	573900
76	6	9	10	2005	720	317600
77	1	28	10	2005	2000	458325
78	5	15	10	2005	830	732100
79	6	1	10	2005	3000	92000
80	5	28	10	2005	200	992800
81	1	6	10	2005	2300	143000
82	6	9	10	2005	1000	337600
83	2	15	10	2005	500	258550
84	5	20	10	2005	2000	810100
85	5	9	10	2005	5000	381800
86	3	6	10	2005	3000	295000
87	5	15	10	2005	3000	777100
88	2	28	10	2005	3000	462850
89	5	11	10	2005	8000	640800
90	1	23	10	2005	700	434825
91	3	28	10	2005	1000	1208250
92	6	15	10	2005	2000	515900
93	6	8	10	2005	500	256000
94	2	28	10	2005	500	445350
95	1	9	10	2005	1500	228500
96	6	8	10	2005	840	270400
97	1	22	10	2005	1000	406325
98	1	22	10	2005	1500	413825
99	2	2	10	2005	1000	27050
100	1	1	10	2005	1000	18500

Appendix Table A4 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
101	6	2	10	2005	2000	139000
102	3	23	10	2005	5000	1196750
103	3	2	10	2005	7800	265000
104	1	15	10	2005	300	325750
105	1	23	10	2005	1200	440825
106	2	23	10	2005	1000	353750
107	5	30	10	2005	1000	1031800
108	6	23	10	2005	1000	683900
109	3	15	10	2005	500	940750
110	3	30	10	2005	2000	1298835
111	2	30	10	2005	1500	498600
112	5	9	10	2005	1000	301800
113	2	23	10	2005	4000	388750
114	1	9	10	2005	2050	248750
115	4	22	10	2005	4000	124170
116	5	5	11	2005	1000	1071800
117	2	20	10	2005	220	300150
118	3	11	10	2005	600	592250
119	4	14	10	2005	5000	80170
120	5	22	10	2005	500	815100
121	5	22	10	2005	2000	852100
122	1	14	10	2005	700	297750
123	6	23	10	2005	1000	693900
124	5	28	10	2005	1000	1006800
125	2	2	10	2005	500	18550
126	3	6	10	2005	2000	280000
127	1	2	10	2005	1000	99000
128	1	8	10	2005	1000	189000
129	6	22	10	2005	10000	673900
130	1	6	10	2005	700	111500
131	3	23	10	2005	700	1134250
132	1	30	10	2005	1475	475450
133	5	8	10	2005	1000	210000
134	1	22	10	2005	1500	421325
135	1	8	10	2005	2900	203500
136	3	15	9	2005	7000	42000
137	2	9	10	2005	400	156050
138	2	23	10	2005	520	343750
139	1	24	9	2005	300	1800
140	2	11	10	2005	200	177550
141	5	14	10	2005	900	651800
142	4	1	10	2005	1200	20000
143	6	1	10	2005	700	12000
144	5	23	10	2005	1000	990800
145	5	11	10	2005	7000	560800
146	4	22	10	2005	1000	104170
147	1	2	10	2005	300	86500
148	2	9	10	2005	400	158050
149	2	14	10	2005	6000	255050
150	3	9	10	2005	3000	587750

Appendix Table A4 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
151	5	15	10	2005	1500	747100
152	1	6	10	2005	2900	157500
153	3	23	10	2005	2000	1154250
154	1	30	10	2005	700	461825
155	5	11	10	2005	6800	490800
156	3	8	10	2005	4000	515250
157	1	2	10	2005	700	94000
158	1	5	11	2005	300	476950
159	6	8	10	2005	200	251000
160	2	22	10	2005	200	309150
161	2	8	10	2005	4000	154050
162	6	23	10	2005	1000	703900
163	6	8	10	2005	1000	290400
164	5	8	10	2005	2600	272800
165	6	2	10	2005	1000	109000
166	3	8	10	2005	2000	485250
167	1	15	10	2005	1800	339250
168	2	15	10	2005	600	261550
169	2	28	10	2005	220	442850
170	2	11	10	2005	500	180050
171	6	30	10	2005	2000	902100
172	6	23	10	2005	1000	713900
173	5	23	10	2005	570	980800
174	3	28	10	2005	2000	1218250
175	6	28	10	2005	1000	802100
176	5	14	10	2005	4000	721800
177	5	22	10	2005	500	820100
178	6	8	10	2005	1000	300400
179	3	22	10	2005	2000	1127250
180	1	2	10	2005	300	88000
181	3	14	10	2005	2000	712250
182	3	15	10	2005	2000	966750
183	1	15	10	2005	900	330250
184	2	28	10	2005	3000	477850
185	1	9	10	2005	1000	208500
186	3	1	10	2005	20000	217500
187	1	11	10	2005	1000	273250
188	3	1	10	2005	6000	67500
189	3	1	10	2005	10000	117500
190	3	22	10	2005	1000	1112250
191	4	23	10	2005	1000	129170
192	6	28	10	2005	3000	832100
193	4	15	10	2005	1800	89170
194	3	14	10	2005	6000	752250
195	3	28	10	2005	2000	1228250
196	5	14	10	2005	1000	661800
197	2	2	10	2005	700	22050
198	6	1	10	2005	1000	22000
199	2	15	10	2005	3500	299050
200	1	1	10	2005	2000	43500

Appendix Table A4 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
201	1	8	11	2005	1000	481950
202	1	14	10	2005	800	301750
203	6	30	10	2005	1500	862100
204	2	1	10	2005	110	12220
205	3	28	10	2005	800	1203250
206	3	20	10	2005	500	981750
207	6	15	10	2005	1000	485900
208	5	15	10	2005	200	723800
209	2	23	10	2005	200	338650
210	2	11	10	2005	6000	212550
211	3	9	10	2005	2000	572750
212	1	1	10	2005	4200	85000
213	6	28	10	2005	720	782100
214	4	28	10	2005	10000	186920
215	2	6	10	2005	2100	108050
216	6	11	10	2005	3500	433900
217	1	6	10	2005	500	108000
218	2	1	10	2005	300	12820
219	1	1	10	2005	1800	33500
220	3	23	10	2005	1000	1139250
221	6	11	10	2005	3000	398900
222	2	9	10	2005	700	161550
223	5	22	10	2005	5000	922100
224	3	14	10	2005	2000	722250
225	1	14	10	2005	1000	306750
226	5	20	10	2005	300	785100
227	5	28	10	2005	1000	1016800
228	3	14	10	2005	7000	787250
229	5	22	10	2005	2000	872100
230	3	23	10	2005	1000	1144250
231	2	11	10	2005	500	182550
232	1	2	10	2005	500	90500
233	3	11	10	2005	3000	607250
234	1	1	10	2005	600	7000
235	3	23	10	2005	3500	1171750
236	6	15	10	2005	1000	495900
237	5	9	10	2005	600	281800
238	1	14	10	2005	1500	314250
239	6	15	11	2005	10000	1175100
240	2	23	10	2005	3000	368750
241	3	15	10	2005	2000	976750
242	6	6	10	2005	5000	249000
243	2	9	10	2005	3000	176550
244	2	20	10	2005	700	308150
245	1	9	10	2005	3000	263750
246	1	6	10	2005	1500	124000
247	4	14	10	2005	530	55170
248	5	14	10	2005	2000	681800
249	2	22	10	2005	200	310150
250	3	15	10	2005	1200	946750

Appendix Table A4 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
251	5	8	10	2005	1000	220000
252	6	20	10	2005	300	518900
253	3	30	10	2005	1000	1273835
254	3	11	10	2005	300	589250
255	2	6	10	2005	4000	128050
256	3	22	10	2005	600	1107250
257	1	6	10	2005	300	105500
258	2	30	10	2005	600	483100
259	2	15	10	2005	1000	271550
260	6	1	10	2005	200	3200
261	1	8	10	2005	600	184000
262	5	8	10	2005	1680	246800
263	6	2	10	2005	1000	119000
264	3	20	10	2005	2000	994250
265	5	23	10	2005	300	975100
266	1	22	10	2005	785	401325
267	3	22	10	2005	1000	1117250
268	6	23	10	2005	1000	723900
269	6	20	10	2005	1000	528900
270	1	11	10	2005	900	268250
271	1	11	10	2005	2000	283250
272	2	15	10	2005	1000	276550
273	1	22	10	2005	750	397400
274	3	11	10	2005	4000	627250
275	2	20	10	2005	500	304650
276	1	9	10	2005	2000	238500
277	1	6	10	2005	1500	131500
278	2	30	10	2005	200	478850
279	3	11	10	2005	7000	687250
280	3	20	10	2005	500	984250
281	3	8	10	2005	9500	562750
282	3	20	10	2005	2000	1004250
283	2	30	10	2005	600	486100
284	6	8	10	2005	1000	310400
285	3	6	10	2005	25000	470000
286	6	23	10	2005	1100	734900
287	2	2	10	2005	8000	92050
288	2	30	9	2005	2000	12000
289	2	5	11	2005	800	525100
290	3	14	10	2005	10200	838250
291	6	23	10	2005	2000	774900
292	4	6	10	2005	1100	34000
293	1	2	10	2005	1000	104000
294	2	28	10	2005	500	447850
295	5	2	10	2005	1500	75000
296	4	30	9	2005	2000	12000
297	5	6	10	2005	500	150000
298	1	14	10	2005	2000	324250
299	5	22	10	2005	600	826100
300	3	8	10	2005	2000	495250

Appendix Table A4 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
301	2	23	10	2005	500	341150
302	1	9	10	2005	1000	213500
303	3	6	10	2005	1000	270000
304	3	1	10	2005	300	43000
305	1	1	10	2005	1200	24500
306	2	20	10	2005	400	302150
307	2	14	10	2005	500	215050
308	6	30	10	2005	1000	847100
309	5	22	10	2005	600	832100
310	2	14	10	2005	1000	225050
311	5	28	10	2005	400	996800
312	2	2	10	2005	4000	52050
313	5	9	10	2005	1000	311800
314	1	20	10	2005	180	350150
315	5	30	10	2005	3000	1061800
316	1	11	10	2005	2200	294250
317	5	8	10	2005	1000	230000
318	2	15	10	2005	1000	281550
319	6	14	10	2005	3000	473900
320	3	6	10	2005	10000	345000
321	5	1	10	2005	2000	60000
322	1	28	10	2005	900	448325
323	6	2	10	2005	700	99000
324	5	1	10	2005	1000	40000
325	1	1	10	2005	600	10000
326	3	2	10	2005	1500	226000
327	3	11	10	2005	5000	652250
328	1	6	10	2005	1000	116500
329	2	2	10	2005	1000	32050
330	5	22	10	2005	5000	972100
331	1	8	10	2005	300	181000
332	6	1	10	2005	1000	32000
333	3	30	10	2005	1000	1278835
334	5	9	10	2005	300	275800
335	6	11	10	2005	130	338900
336	6	8	10	2005	600	262000
337	3	30	10	2005	2000	1308835
338	2	30	10	2005	1000	491100
339	2	15	10	2005	200	256050
340	6	30	10	2005	15000	1075100
341	5	9	10	2005	1000	321800
342	2	8	10	2005	200	129050
343	2	30	10	2005	250	480100
344	2	6	10	2005	300	93550
345	1	24	9	2005	500	4200
346	5	9	10	2005	1000	331800
347	4	1	10	2005	800	14000
348	5	20	10	2005	500	790100
349	1	1	10	2005	4100	64000
350	3	8	10	2005	1000	475250

Appendix Table A5 The number of order jobs and completion time for DATA 5.

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
1	1	24	9	2004	700	483548
2	2	3	9	2004	800	19000
3	2	24	9	2004	1000	382600
4	1	15	9	2004	300	298860
5	1	25	9	2004	2100	577628
6	4	17	9	2004	2000	138850
7	5	21	9	2004	3000	1077870
8	3	27	9	2004	1600	1009250
9	4	6	9	2004	500	4600
10	2	21	9	2004	2600	358850
11	1	1	9	2004	1500	23160
12	3	25	9	2004	3600	880250
13	1	18	9	2004	3400	421418
14	1	4	9	2004	900	98820
15	3	29	9	2004	1900	1023750
16	2	9	9	2004	200	154900
17	2	9	9	2004	2000	168900
18	5	25	9	2004	250	1189470
19	4	10	9	2004	1000	34340
20	6	15	9	2004	200	412700
21	3	10	9	2004	2400	243550
22	4	27	9	2004	1000	162350
23	1	4	10	2004	1000	697688
24	6	17	9	2004	400	445200
25	2	24	9	2004	2000	411600
26	2	8	9	2004	3000	116000
27	4	15	9	2004	8000	123850
28	1	1	9	2004	1000	8160
29	3	10	8	2004	300	1800
30	2	6	9	2004	1600	66000
31	2	25	9	2004	7500	475990
32	5	17	9	2004	1000	666700
33	1	23	9	2004	3005	469448
34	2	3	9	2004	800	23000
35	5	25	9	2004	2600	1308670
36	2	15	9	2004	3000	281400
37	5	25	9	2004	2000	1262670
38	6	23	9	2004	3000	605000
39	2	29	9	2004	1000	482990
40	5	24	9	2004	500	1141970
41	5	21	9	2004	1260	1027870
42	3	21	9	2004	6000	731350
43	6	24	9	2004	100	656000
44	4	10	9	2004	2000	43850
45	1	30	9	2004	2500	676628
46	3	8	9	2004	400	171150
47	2	9	9	2004	2000	178900
48	3	4	10	2004	900	1281250
49	1	8	9	2004	1800	183480
50	5	4	9	2004	580	84700

Appendix Table A5 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
51	2	15	9	2004	300	243200
52	5	29	9	2004	840	1345870
53	6	17	9	2004	3000	486200
54	5	24	9	2004	1000	1156970
55	2	25	9	2004	350	414990
56	2	1	9	2004	1000	13500
57	6	25	9	2004	600	672100
58	3	24	9	2004	1500	798750
59	1	1	9	2004	1600	32760
60	6	10	9	2004	1000	340700
61	5	30	9	2004	300	1348870
62	2	17	9	2004	1000	291400
63	3	1	9	2004	4000	25200
64	5	25	9	2004	420	1193670
65	1	1	9	2004	360	2160
66	2	23	9	2004	700	366850
67	6	3	9	2004	2000	155200
68	3	15	9	2004	4500	413200
69	5	8	9	2004	1500	258100
70	6	10	9	2004	5000	410700
71	1	24	9	2004	600	475748
72	2	25	9	2004	200	413240
73	6	4	9	2004	200	157200
74	6	25	9	2004	3000	757900
75	6	9	9	2004	5000	325700
76	5	21	9	2004	2000	1047870
77	1	24	9	2004	800	488348
78	3	21	9	2004	420	695950
79	2	9	9	2004	300	156400
80	5	4	9	2004	2000	104700
81	6	17	8	2004	1000	42000
82	5	6	9	2004	1000	223100
83	1	25	9	2004	1500	543668
84	5	9	9	2004	2400	312100
85	1	10	9	2004	4500	297060
86	3	25	9	2004	400	837250
87	5	23	9	2004	220	1080070
88	5	17	9	2004	1000	676700
89	3	27	9	2004	400	987250
90	3	24	9	2004	300	779150
91	6	27	9	2004	3000	797900
92	5	18	8	2004	900	13500
93	3	24	9	2004	220	777650
94	5	10	9	2004	2000	421300
95	5	3	9	2004	3560	75900
96	2	10	9	2004	180	179800
97	2	24	9	2004	850	377600
98	2	6	9	2004	5000	91000
99	3	1	9	2004	5000	69000
100	6	25	9	2004	200	659500

Appendix Table A5 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
101	5	17	9	2004	25000	988270
102	1	3	9	2004	2500	69420
103	2	8	9	2004	7580	153900
104	4	25	9	2004	1500	157350
105	1	4	9	2004	1200	106020
106	6	23	9	2004	1000	575000
107	3	10	9	2004	2600	256550
108	6	29	9	2004	1000	814900
109	5	25	9	2004	1500	1242670
110	1	17	9	2004	550	343148
111	2	24	9	2004	1800	401600
112	5	10	9	2004	1000	381300
113	6	25	9	2004	1000	690500
114	4	8	9	2004	120	32340
115	6	10	9	2004	500	330700
116	4	6	9	2004	200	2000
117	2	21	9	2004	380	335600
118	1	30	9	2004	300	659228
119	1	24	9	2004	2700	525068
120	1	9	9	2004	1900	212880
121	1	8	9	2004	1220	163680
122	2	30	9	2004	670	487340
123	3	3	9	2004	300	70500
124	1	8	9	2004	1500	172680
125	2	24	9	2004	400	373350
126	5	18	9	2004	500	995270
127	3	8	10	2004	1200	1287250
128	2	24	8	2004	1000	6000
129	3	25	9	2004	400	839250
130	2	6	9	2004	500	58000
131	3	29	9	2004	4000	1043750
132	6	8	9	2004	3000	263700
133	2	10	9	2004	500	185700
134	3	9	9	2004	200	190150
135	6	17	9	2004	300	441200
136	1	6	9	2004	800	118560
137	6	25	9	2004	2000	727900
138	1	17	9	2004	1005	355178
139	5	10	9	2004	2000	441300
140	6	25	9	2004	200	661500
141	3	17	9	2004	4000	435200
142	6	25	9	2004	460	666100
143	3	21	9	2004	480	698350
144	3	4	9	2004	330	101650
145	1	24	9	2004	600	479348
146	3	15	9	2004	4000	370700
147	6	1	9	2004	1000	110200
148	2	24	9	2004	1000	387600
149	2	25	9	2004	3000	438490
150	2	17	9	2004	2700	320200

Appendix Table A5 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
151	2	15	9	2004	1100	266400
152	3	25	9	2004	400	841250
153	6	8	9	2004	900	233700
154	2	3	9	2004	300	15000
155	1	27	9	2004	1940	640268
156	1	17	9	2004	1400	363578
157	5	10	9	2004	3000	495300
158	5	10	9	2004	500	371300
159	5	23	9	2004	600	1086070
160	1	27	9	2004	600	598628
161	3	23	9	2004	480	735050
162	6	6	10	2004	1000	849900
163	3	3	9	2004	400	72500
164	1	9	9	2004	4000	236880
165	1	27	9	2004	1500	619628
166	3	24	9	2004	420	781250
167	4	30	9	2004	1500	173350
168	6	29	9	2004	200	799900
169	1	24	9	2004	1420	496868
170	1	24	9	2004	450	472148
171	3	15	9	2004	4000	390700
172	3	30	9	2004	10000	1148750
173	2	17	9	2004	1000	296400
174	1	6	9	2004	1500	133560
175	2	15	9	2004	1000	255900
176	1	30	9	2004	2510	691688
177	6	6	9	2004	2000	224700
178	5	25	9	2004	500	1198670
179	1	23	9	2004	2500	451418
180	5	17	9	2004	1000	686700
181	6	30	9	2004	500	834900
182	6	18	9	2004	2000	556200
183	5	10	9	2004	5000	545300
184	2	24	9	2004	1000	392600
185	3	18	9	2004	1200	593200
186	5	18	9	2004	1000	1005270
187	2	29	9	2004	400	477990
188	6	4	9	2004	2000	184700
189	5	18	9	2004	1000	1015270
190	5	24	9	2004	500	1146970
191	6	3	9	2004	1000	125200
192	3	10	9	2004	1000	221550
193	3	17	9	2004	400	415200
194	4	18	9	2004	200	139850
195	2	9	9	2004	500	158900
196	5	9	9	2004	5000	362100
197	6	9	9	2004	200	265700
198	5	25	9	2004	1000	1217670
199	6	25	10	2004	5800	907900
200	6	3	9	2004	500	115200

Appendix Table A5 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
201	1	4	10	2004	2000	709688
202	3	25	9	2004	500	843750
203	1	25	9	2004	2900	595028
204	5	27	9	2004	1680	1332470
205	1	29	9	2004	960	651428
206	2	8	9	2004	1000	96000
207	5	25	9	2004	2000	1282670
208	3	3	9	2004	2500	85000
209	1	17	9	2004	1400	371978
210	1	25	9	2004	1300	534668
211	2	15	9	2004	540	247400
212	5	8	10	2004	840	1413270
213	2	1	9	2004	700	8500
214	2	17	9	2004	500	283900
215	3	15	9	2004	2000	324700
216	5	4	9	2004	10000	204700
217	2	25	9	2004	800	423490
218	5	3	9	2004	1000	40300
219	2	30	9	2004	200	483990
220	2	10	9	2004	10500	241700
221	5	24	9	2004	1000	1166970
222	3	30	9	2004	7000	1098750
223	5	30	9	2004	5000	1404870
224	3	25	9	2004	1000	857250
225	2	18	9	2004	900	328700
226	2	15	9	2004	300	244700
227	3	4	9	2004	4000	124150
228	3	21	9	2004	130	693850
229	2	6	10	2004	400	489340
230	6	9	9	2004	1000	275700
231	1	25	9	2004	300	526868
232	6	23	9	2004	5000	655000
233	1	25	9	2004	1670	553688
234	5	17	9	2004	140	656700
235	3	15	9	2004	2000	334700
236	1	10	9	2004	2500	251880
237	6	17	9	2004	1100	456200
238	5	23	9	2004	5000	1136070
239	2	15	9	2004	1000	260900
240	1	25	9	2004	1890	565028
241	3	4	9	2004	500	104150
242	5	27	9	2004	200	1310670
243	1	24	9	2004	2000	508868
244	6	25	9	2004	840	680500
245	2	25	9	2004	400	416990
246	5	15	9	2004	1000	555300
247	2	15	9	2004	700	250900
248	1	1	9	2004	1710	43020
249	4	10	9	2004	8000	83850
250	3	10	9	2004	10000	306550

Appendix Table A5 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
251	5	8	9	2004	3000	288100
252	3	25	9	2004	800	847750
253	5	29	9	2004	500	1337470
254	6	30	9	2004	500	839900
255	1	29	9	2004	1000	657428
256	5	10	9	2004	2400	465300
257	3	25	9	2004	900	852250
258	3	3	9	2004	3000	100000
259	3	10	9	2004	300	216550
260	1	27	9	2004	1500	628628
261	5	15	10	2004	800	1421270
262	1	4	9	2004	400	89820
263	2	4	9	2004	5000	55500
264	1	27	9	2004	1000	604628
265	5	15	9	2004	6800	655300
266	6	1	8	2004	2000	32000
267	3	15	9	2004	100	307050
268	1	15	9	2004	2600	339848
269	2	25	9	2004	128	412240
270	3	17	9	2004	4400	457200
271	5	1	9	2004	900	30300
272	6	4	9	2004	750	164700
273	1	8	9	2004	400	156360
274	4	17	9	2004	500	126350
275	2	23	9	2004	900	371350
276	1	6	9	2004	3400	153960
277	6	27	9	2004	1000	767900
278	3	29	9	2004	4000	1063750
279	1	6	9	2004	1000	124560
280	1	4	9	2004	600	93420
281	6	23	9	2004	380	565000
282	1	3	9	2004	900	48420
283	2	10	9	2004	700	189200
284	2	17	9	2004	500	286400
285	3	25	9	2004	1000	862250
286	3	15	9	2004	200	308050
287	4	6	9	2004	4750	32100
288	3	27	9	2004	800	991250
289	6	15	9	2004	550	418200
290	3	27	9	2004	1000	996250
291	4	18	9	2004	1000	144850
292	1	27	9	2004	1000	610628
293	6	15	9	2004	1000	428200
294	5	24	9	2004	1000	1176970
295	1	15	9	2004	2000	310860
296	5	6	9	2004	1000	233100
297	3	24	9	2004	3000	813750
298	6	10	9	2004	2000	360700
299	3	10	9	2004	2000	231550
300	5	18	9	2004	200	990270

Appendix Table A5 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
301	1	10	9	2004	3030	270060
302	1	4	9	2004	1290	113760
303	6	15	9	2004	1000	438200
304	2	21	9	2004	750	339350
305	4	21	9	2004	1000	149850
306	2	18	9	2004	800	324200
307	6	29	9	2004	500	804900
308	3	6	9	2004	9000	169150
309	5	6	9	2004	840	213100
310	6	17	9	2004	3000	516200
311	1	17	9	2004	1000	349148
312	3	9	9	2004	400	192150
313	3	24	9	2004	4000	833750
314	6	1	9	2004	500	100200
315	3	23	9	2004	260	732650
316	1	29	9	2004	900	645668
317	3	23	9	2004	3900	754550
318	3	15	9	2004	1000	314700
319	3	29	9	2004	1000	1014250
320	5	15	9	2004	3200	587300
321	3	9	9	2004	480	194550
322	3	24	9	2004	1400	791250
323	3	18	9	2004	20000	693200
324	2	23	9	2004	500	363350
325	3	17	9	2004	26000	587200
326	1	3	9	2004	1000	54420
327	3	21	9	2004	600	701350
328	6	18	9	2004	1000	526200
329	5	1	9	2004	480	21300
330	2	4	9	2004	1500	30500
331	2	23	9	2004	400	360850
332	5	24	9	2004	1000	1186970
333	3	9	9	2004	2800	215050
334	2	10	9	2004	400	183200
335	2	18	9	2004	1000	333700
336	4	15	8	2004	200	1200
337	1	15	9	2004	2231	324248
338	3	30	9	2004	25600	1276750
339	6	3	9	2004	1000	135200
340	3	27	9	2004	1000	1001250
341	5	24	9	2004	90	1136970
342	4	29	9	2004	700	165850
343	5	25	9	2004	1000	1227670
344	2	21	9	2004	1300	345850
345	3	25	9	2004	300	835250
346	6	25	9	2004	1740	707900
347	5	17	9	2004	1200	718700
348	2	8	9	2004	1000	101000
349	5	8	9	2004	1000	243100
350	3	8	9	2004	3600	189150

Appendix Table A5 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
351	1	3	9	2004	3000	87420
352	6	27	8	2004	5200	95200
353	6	29	9	2004	1500	829900
354	2	17	9	2004	2060	306700
355	3	9	9	2004	1300	201050
356	6	6	9	2004	1000	194700
357	3	24	9	2004	600	784250
358	5	25	9	2004	900	1207670
359	1	17	9	2004	3500	392978
360	6	6	9	2004	1000	204700
361	6	18	9	2004	1000	536200
362	1	30	9	2004	400	661628
363	1	1	9	2004	1000	14160
364	5	17	9	2004	1000	696700
365	2	25	9	2004	500	419490
366	3	15	9	2004	330	309700
367	1	8	9	2004	3000	201480
368	1	21	9	2004	2500	436418
369	5	10	9	2004	1000	391300
370	5	10	9	2004	1000	401300
371	6	21	9	2004	500	561200
372	5	30	9	2004	600	1354870
373	3	23	9	2004	4400	776550
374	1	18	9	2004	1340	401018
375	3	25	9	2004	21000	985250
376	4	17	9	2004	500	128850
377	2	10	9	2004	280	181200
378	5	17	9	2004	1957	738270
379	6	25	9	2004	150	657500
380	3	15	9	2004	3200	350700
381	5	27	9	2004	500	1315670
382	5	4	9	2004	300	78900
383	5	20	8	2004	300	16500
384	5	10	9	2004	420	366300
385	3	1	9	2004	4500	44200
386	5	17	9	2004	1000	706700

Appendix Table A6 The number of order jobs and completion time for DATA 6.

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
1	3	13	8	2004	200	148630
2	2	28	8	2004	300	443085
3	5	7	8	2004	2000	201200
4	2	21	8	2004	5000	393560
5	3	27	8	2004	1500	652170
6	5	6	9	2004	200	1027860
7	4	23	8	2004	1600	133525
8	6	6	8	2004	1000	56250
9	5	23	8	2004	230	616550
10	5	21	8	2004	2200	510250
11	3	20	8	2004	13000	540820
12	3	7	8	2004	1000	80130
13	5	28	8	2004	100	821750
14	6	7	8	2004	300	79250
15	3	30	8	2004	1000	734770
16	3	6	8	2004	200	21130
17	6	5	8	2004	2000	36000
18	5	28	8	2004	1500	867860
19	2	28	8	2004	100	440585
20	3	13	8	2004	3000	173130
21	2	6	8	2004	800	47560
22	5	6	8	2004	2000	67400
23	4	20	8	2004	300	100525
24	5	16	8	2004	505	365050
25	4	22	7	2004	5000	30000
26	6	13	8	2004	1500	230630
27	5	26	8	2004	1500	634550
28	3	31	8	2004	1800	789445
29	4	27	8	2004	500	162875
30	2	26	7	2004	400	36872
31	6	21	8	2004	10000	826780
32	2	21	8	2004	1000	315610
33	3	21	8	2004	600	547070
34	6	9	8	2004	2300	208630
35	2	5	8	2004	500	39872
36	5	7	8	2004	2700	248200
37	6	26	8	2004	900	857820
38	5	27	8	2004	900	657750
39	2	28	8	2004	1000	452585
40	6	14	8	2004	3800	363630
41	6	27	8	2004	6000	997070
42	2	21	8	2004	100	306110
43	3	28	8	2004	500	679170
44	2	19	8	2004	1710	284610
45	4	28	8	2004	300	170875
46	2	30	8	2004	1000	477585
47	1	9	8	2004	1500	66048
48	3	28	8	2004	520	681770
49	2	28	7	2004	1000	38872
50	3	14	8	2004	220	233270

Appendix Table A6 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
51	6	31	8	2004	900	1114570
52	2	9	8	2004	100	154960
53	6	23	8	2004	1400	840780
54	6	14	8	2004	5000	413630
55	4	6	8	2004	2000	47025
56	5	6	8	2004	5000	157400
57	2	9	8	2004	200	155960
58	3	6	8	2004	3000	68130
59	3	14	8	2004	400	235270
60	3	16	8	2004	500	322270
61	3	6	8	2004	1000	38130
62	3	7	8	2004	500	72630
63	6	27	8	2004	600	872070
64	6	27	8	2004	2000	917070
65	3	14	8	2004	200	232170
66	2	27	8	2004	250	403060
67	5	16	8	2004	3500	444750
68	3	31	8	2004	300	773945
69	5	20	8	2004	200	446750
70	6	5	8	2004	1000	16000
71	3	26	8	2004	600	598670
72	2	16	8	2004	1000	224910
73	2	7	8	2004	2000	96960
74	3	20	8	2004	3500	420820
75	1	7	8	2004	900	57048
76	1	23	8	2004	1500	238316
77	4	31	8	2004	2000	208375
78	3	27	8	2004	700	635670
79	2	28	8	2004	600	447585
80	6	21	8	2004	2000	686780
81	5	28	8	2004	1111	852860
82	2	19	8	2004	1340	276060
83	5	27	9	2004	500	1032860
84	3	30	8	2004	2300	751445
85	2	6	8	2004	1000	52560
86	4	27	8	2004	600	165875
87	4	23	8	2004	300	122025
88	1	28	8	2004	600	260516
89	3	30	8	2004	4000	771445
90	5	5	8	2004	3000	47400
91	6	14	8	2004	600	286630
92	5	21	8	2004	3000	540250
93	2	27	8	2004	2200	427085
94	2	7	8	2004	200	72660
95	1	13	9	2004	3400	388676
96	2	16	8	2004	300	215410
97	1	6	8	2004	1000	36048
98	5	30	8	2004	3000	992860
99	2	16	8	2004	900	219910
100	2	14	8	2004	2500	212910

Appendix Table A6 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
101	6	6	8	2004	525	46250
102	6	20	8	2004	1200	465780
103	6	18	8	2004	700	423630
104	5	20	8	2004	300	449750
105	1	26	7	2004	1200	7200
106	5	27	8	2004	3000	707750
107	2	14	8	2004	2000	200410
108	5	7	8	2004	800	172200
109	6	27	8	2004	525	866070
110	3	21	8	2004	700	550570
111	3	20	8	2004	11000	475820
112	2	20	8	2004	800	301110
113	2	21	8	2004	1890	343560
114	1	14	8	2004	1800	103316
115	6	6	8	2004	2000	76250
116	6	21	8	2004	800	648780
117	3	26	8	2004	700	602170
118	3	26	8	2004	2100	612670
119	2	6	8	2004	500	43560
120	2	19	8	2004	550	266160
121	5	16	8	2004	700	372050
122	5	27	8	2004	7800	820750
123	2	31	8	2004	640	483585
124	5	28	8	2004	5000	935860
125	5	30	8	2004	300	938860
126	6	20	8	2004	1100	453780
127	6	13	8	2004	2000	250630
128	2	21	8	2004	1000	320610
129	2	19	8	2004	2100	295110
130	5	27	8	2004	620	648750
131	3	28	8	2004	8000	729770
132	6	28	8	2004	1500	1046570
133	5	5	8	2004	600	9600
134	3	6	8	2004	500	25630
135	6	7	8	2004	1000	95250
136	3	28	8	2004	200	675670
137	6	6	8	2004	500	41000
138	1	27	8	2004	400	245516
139	6	31	8	2004	300	1105570
140	6	27	8	2004	2000	937070
141	1	28	8	2004	700	268376
142	1	28	8	2004	3000	339176
143	1	30	8	2004	1500	365276
144	1	14	8	2004	800	72648
145	3	14	8	2004	6000	318770
146	5	27	8	2004	2000	677750
147	6	7	8	2004	1008	115330
148	5	22	7	2004	200	3000
149	5	6	8	2004	4000	107400
150	2	28	8	2004	1500	465085

Appendix Table A6 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
151	5	16	8	2004	2770	409750
152	3	16	8	2004	200	319770
153	2	7	8	2004	360	74460
154	2	7	8	2004	2500	109460
155	1	6	8	2004	300	23448
156	3	26	8	2004	220	595670
157	2	7	8	2004	9000	154460
158	2	17	9	2004	1200	499585
159	2	21	8	2004	1200	326610
160	3	13	8	2004	5000	198130
161	2	21	8	2004	2500	356060
162	6	16	8	2004	300	416630
163	2	26	8	2004	100	398310
164	6	7	8	2004	2500	185630
165	1	28	8	2004	800	277376
166	1	30	8	2004	1000	350276
167	2	21	8	2004	900	310610
168	5	28	8	2004	900	831750
169	5	21	8	2004	3600	576250
170	3	6	8	2004	500	28130
171	2	16	8	2004	1000	229910
172	5	28	8	2004	1000	841750
173	2	7	8	2004	1000	79460
174	3	7	8	2004	400	70130
175	3	18	8	2004	500	324770
176	2	6	8	2004	2500	71160
177	1	21	8	2004	1800	169916
178	3	21	8	2004	800	554570
179	5	7	8	2004	900	181200
180	1	18	8	2004	700	133316
181	6	28	8	2004	1000	1011070
182	3	14	8	2004	600	238270
183	3	6	8	2004	500	30630
184	4	14	8	2004	600	86525
185	3	5	8	2004	1022	20130
186	3	20	8	2004	2900	403320
187	1	28	8	2004	1500	297176
188	4	6	8	2004	300	30600
189	1	6	8	2004	1000	42048
190	3	28	8	2004	200	676670
191	3	6	8	2004	500	33130
192	2	27	8	2004	305	404585
193	5	7	8	2004	2000	221200
194	3	31	8	2004	7000	865445
195	3	3	9	2004	1500	872945
196	1	3	9	2004	500	368276
197	1	14	8	2004	300	67848
198	6	20	8	2004	15000	640780
199	4	19	8	2004	2500	99025
200	3	21	8	2004	250	542070

Appendix Table A6 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
201	6	7	8	2004	2000	160630
202	6	21	8	2004	1800	666780
203	3	19	8	2004	400	326770
204	2	31	8	2004	360	480385
205	1	14	8	2004	1500	92516
206	1	28	8	2004	2000	309176
207	1	21	8	2004	5000	229316
208	1	6	8	2004	1300	49848
209	3	19	8	2004	10600	379770
210	4	6	8	2004	2500	59525
211	1	7	8	2004	300	51648
212	6	21	8	2004	2000	706780
213	6	31	8	2004	1200	1126570
214	6	20	8	2004	900	432630
215	2	16	8	2004	200	213910
216	3	14	8	2004	4000	267770
217	3	22	7	2004	2004	12024
218	3	23	7	2004	1000	15020
219	6	26	8	2004	300	843780
220	1	21	8	2004	300	159116
221	3	20	8	2004	700	383820
222	2	28	8	2004	300	444585
223	6	27	8	2004	1500	897070
224	5	9	8	2004	3500	336000
225	1	18	8	2004	1000	139316
226	3	31	8	2004	6000	830445
227	1	14	8	2004	840	77696
228	1	21	8	2004	2800	199316
229	3	6	8	2004	1000	43130
230	6	14	8	2004	1900	305630
231	3	13	8	2004	1000	158130
232	2	13	8	2004	2900	170460
233	4	6	8	2004	300	31200
234	1	28	8	2004	700	272576
235	3	7	8	2004	1000	85130
236	5	20	8	2004	300	452750
237	6	28	8	2004	1050	1031570
238	3	7	8	2004	3000	100130
239	1	29	7	2004	298	8988
240	6	28	8	2004	1500	1061570
241	5	21	8	2004	250	485250
242	5	20	8	2004	1000	462750
243	6	20	8	2004	2500	490780
244	4	6	8	2004	1500	37025
245	3	31	8	2004	1000	780445
246	6	13	8	2004	3000	280630
247	6	7	8	2004	600	85250
248	1	30	8	2004	700	344276
249	1	28	8	2004	300	255116
250	3	21	8	2004	400	544070

Appendix Table A6 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
251	5	9	8	2004	480	290000
252	1	30	8	2004	1000	356276
253	4	27	8	2004	700	169375
254	3	14	8	2004	4200	288770
255	3	7	8	2004	3000	115130
256	6	31	8	2004	3000	1156570
257	4	6	8	2004	305	31810
258	2	14	8	2004	600	175460
259	6	28	8	2004	1700	1078570
260	3	13	8	2004	500	153130
261	1	28	8	2004	1000	288176
262	3	20	8	2004	110	380320
263	2	7	8	2004	1500	86960
264	6	28	8	2004	1000	1021070
265	5	13	8	2004	2200	358000
266	2	14	8	2004	700	178960
267	1	27	8	2004	1300	253316
268	3	7	8	2004	500	75130
269	3	6	9	2004	600	875945
270	4	6	8	2004	4800	83525
271	5	7	8	2004	250	159900
272	6	27	8	2004	1000	882070
273	6	7	8	2004	1030	125630
274	5	21	8	2004	300	488250
275	6	28	8	2004	2400	1102570
276	5	7	8	2004	430	164200
277	2	27	8	2004	1000	416085
278	3	21	8	2004	4000	574570
279	4	31	8	2004	1000	190875
280	2	22	7	2004	6012	36072
281	5	30	8	2004	2400	962860
282	5	28	8	2004	1800	885860
283	3	26	8	2004	3900	632170
284	4	26	8	2004	5000	158525
285	1	28	8	2004	610	264176
286	3	21	8	2004	4000	594570
287	5	31	8	2004	1000	1002860
288	6	14	8	2004	2000	325630
289	2	7	8	2004	100	71660
290	1	16	8	2004	2300	129116
291	2	27	8	2004	500	407085
292	6	21	8	2004	2000	726780
293	5	21	8	2004	3800	614250
294	2	20	8	2004	900	305610
295	1	29	7	2004	2000	20988
296	3	13	8	2004	400	150630
297	5	9	8	2004	1100	301000
298	1	21	8	2004	2100	182516
299	1	6	8	2004	600	30048
300	3	7	8	2004	3000	130130

Appendix Table A6 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
301	2	21	8	2004	1500	334110
302	1	28	8	2004	800	282176
303	1	6	8	2004	500	26448
304	2	23	8	2004	850	397810
305	6	13	8	2004	700	215630
306	3	6	8	2004	400	23130
307	5	26	8	2004	300	619550
308	6	26	8	2004	504	848820
309	3	6	8	2004	2000	53130
310	2	28	8	2004	1500	472585
311	2	27	8	2004	800	411085
312	1	26	8	2004	500	243116
313	2	14	8	2004	400	172460
314	2	26	8	2004	700	401810
315	6	17	9	2004	1500	1221570
316	5	27	8	2004	300	637550
317	5	16	8	2004	1000	382050
318	3	14	8	2004	1000	247770
319	3	28	8	2004	600	684770
320	5	31	8	2004	1000	1012860
321	3	28	8	2004	1000	689770
322	2	27	8	2004	2600	440085
323	5	28	8	2004	100	822750
324	1	28	8	2004	2000	321176
325	2	19	8	2004	640	269360
326	2	28	8	2004	200	441585
327	1	14	8	2004	2000	115316
328	5	27	8	2004	3500	742750
329	3	27	8	2004	800	639670
330	5	14	8	2004	200	360000
331	3	20	8	2004	1000	388820
332	2	14	8	2004	1290	190410
333	5	20	8	2004	2000	482750
334	6	7	8	2004	1500	140630
335	6	10	9	2004	5000	1206570
336	4	23	8	2004	700	125525
337	4	20	8	2004	3000	120525
338	1	20	8	2004	2000	157316
339	3	31	8	2004	2200	800445
340	2	18	8	2004	5200	263410
341	3	30	8	2004	1035	739945
342	3	13	8	2004	6608	231170
343	2	6	8	2004	300	41060
344	1	26	8	2004	300	240116
345	3	31	8	2004	300	775445
346	3	27	8	2004	4500	674670
347	3	27	8	2004	1000	644670
348	1	30	8	2004	150	340076
349	2	6	8	2004	1220	58660
350	3	31	8	2004	200	772445

Appendix Table A6 (Cont'd)

Job	Class	Due date			Pcs.	Cmax
		Date	Month	Year		
351	2	14	8	2004	1000	183960
352	2	28	8	2004	1000	457585
353	1	14	8	2004	970	83516
354	4	28	8	2004	3000	185875
355	4	27	8	2004	370	160375
356	1	28	8	2004	300	256916
357	1	5	8	2004	110	21648
358	2	31	8	2004	200	478585
359	6	28	8	2004	400	1001070
360	2	18	8	2004	1500	237410
361	3	9	8	2004	500	147630
362	4	20	8	2004	1000	105525
363	5	31	8	2004	1300	1025860
364	5	7	8	2004	3700	285200
365	4	31	8	2004	1500	198375
366	3	7	8	2004	3000	145130
367	3	14	8	2004	900	242770
368	2	20	8	2004	400	297110
369	6	27	8	2004	300	860820
370	5	27	8	2004	500	642550
371	6	7	8	2004	1000	105250
372	2	21	8	2004	2500	368560
373	2	31	8	2004	2000	493585
374	6	20	8	2004	1015	442780
375	1	20	8	2004	1000	145316

Appendix B

The completion time in the different dispatching rule and skill for two step scheduling.

Appendix Table B1 The result of C_{max} from two step scheduling in different dispatching rule and skill, penalty 25 % (class 1,data 1).

			FIFO	EDD	SPT	LPT
Cmax Company			**259501.4**			
Cmax Standard			**349970.3**	**302758.9**	**164730**	**469266.7**
100 : 0			349980.92	302761.14	164732.91	469273.22
80 : 20	Single skill	Processing	349977.38	302760.22	164732.16	469272.19
80 : 20	Single skill	Continuous	349981.51	302760.67	164733.01	469275.27
80 : 20	Single skill	Maximum M/C	350028.63	302813.64	164851.91	469592.46
80 : 20	Multi skill	Processing	350009.19	302791.17	164820.3	469519.9
80 : 20	Multi skill	Continuous	350031.87	302802.12	164855.78	469625
80 : 20	Multi skill	Maximum M/C	350057.79	302908.76	164902.66	469755.35
80 : 20	Random allocate	Processing	350028.63	302847.24	164857.9	469612.33
80 : 20	Random allocate	Continuous	350062.65	302877.21	164908.14	469774.18
80 : 20	Random allocate	Maximum M/C	352700.07	302981.52	165019.17	469913.22
50 : 50	Single skill	Processing	351790.15	302890.13	164944.2	469811.74
50 : 50	Single skill	Continuous	352851.72	302934.65	165028.35	470116.62
50 : 50	Single skill	Maximum M/C	363619.14	308190.79	176827.04	501592.61
50 : 50	Multi skill	Processing	359069.53	305960.86	173690.77	494391.56
50 : 50	Multi skill	Continuous	364377.41	307047.24	177211.07	504821.56
50 : 50	Multi skill	Maximum M/C	370443.56	317629.82	181863.46	517755.56
50 : 50	Random allocate	Processing	363619.14	311524.92	177421.45	503564.12
50 : 50	Random allocate	Continuous	371580.97	314499.1	182407.38	519624.29
50 : 50	Random allocate	Maximum M/C	354403.26	303023.51	165073.72	470035.17
20 : 80	Single skill	Processing	352925.6	302914.88	164984.61	469914.55
20 : 80	Single skill	Continuous	354649.53	302967.8	165084.63	470276.94
20 : 80	Single skill	Maximum M/C	372135.09	309215.42	179108.91	507690.26
20 : 80	Multi skill	Processing	364746.82	306564.85	175381.05	499130.87
20 : 80	Multi skill	Continuous	373366.46	307856.15	179565.39	511528.3
20 : 80	Multi skill	Maximum M/C	383217.48	320434.93	185095.35	526902.04
20 : 80	Random allocate	Processing	372135.09	313178.46	179815.45	510033.66
20 : 80	Random allocate	Continuous	385064.54	316713.66	185741.87	529123.26
20 : 80	Random allocate	Maximum M/C	362569.23	303334.14	165477.22	470937.29
0 : 100	Single skill	Processing	358369.59	303097.99	165283.49	470675.06
0 : 100	Single skill	Continuous	363269.17	303213.04	165500.94	471462.87
0 : 100	Single skill	Maximum M/C	444462.28	341185.06	209002.51	594560.91
0 : 100	Random allocate	Processing	412964.95	325410.11	197524.45	557890.53
0 : 100	Random allocate	Continuous	449711.84	333095.34	210407.98	599389.66
0 : 100	Random allocate	Maximum M/C	349980.92	302761.14	164732.91	469273.22

Appendix Table B1 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 1,data 2).

			FIFO	EDD	SPT	LPT
Cmax Company			**232856**			
Cmax Standard			**347425.81**	**325972.92**	**253244.29**	**434961.92**
100 : 0			347425.81	325972.92	253244.29	434961.92
80 : 20	Single skill	Processing	347436.34	325975.32	253248.78	434967.94
80 : 20	Single skill	Continuous	347432.83	325974.32	253247.62	434966.99
80 : 20	Single skill	Maximum M/C	347436.92	325974.81	253248.92	434969.84
80 : 20	Multi skill	Processing	347483.7	326031.84	253431.71	435263.85
80 : 20	Multi skill	Continuous	347464.4	326007.64	253383.12	435196.59
80 : 20	Multi skill	Maximum M/C	347486.92	326019.43	253437.66	435294.01
80 : 20	Random allocate	Processing	347512.66	326134.25	253509.74	435414.83
80 : 20	Random allocate	Continuous	347483.7	326068.01	253440.92	435282.27
80 : 20	Random allocate	Maximum M/C	347517.48	326100.28	253518.17	435432.28
50 : 50	Single skill	Processing	350135.72	326212.59	253688.85	435561.16
50 : 50	Single skill	Continuous	349232.41	326114.19	253573.6	435467.09
50 : 50	Single skill	Maximum M/C	350286.27	326162.13	253702.97	435749.69
50 : 50	Multi skill	Processing	360975.41	331821.28	271841.44	464924.69
50 : 50	Multi skill	Continuous	356458.87	329420.37	267019.96	458250.05
50 : 50	Multi skill	Maximum M/C	361728.16	330590.05	272431.83	467917.6
50 : 50	Random allocate	Processing	367750.21	341984.05	279584.07	479906.08
50 : 50	Random allocate	Continuous	360975.41	335411.05	272755.24	466752.08
50 : 50	Random allocate	Maximum M/C	368879.34	338613.28	280420.26	481638.2
20 : 80	Single skill	Processing	351826.53	326257.8	253772.71	435674.19
20 : 80	Single skill	Continuous	350359.62	326140.84	253635.71	435562.39
20 : 80	Single skill	Maximum M/C	352071.01	326197.82	253789.48	435898.29
20 : 80	Multi skill	Processing	369429.43	332924.47	275349.43	470576.58
20 : 80	Multi skill	Continuous	362094.89	330070.67	269618.47	462642.91
20 : 80	Multi skill	Maximum M/C	370651.86	331460.98	276051.18	474134.05
20 : 80	Random allocate	Processing	380431.25	345004.24	284552.56	488383.92
20 : 80	Random allocate	Continuous	369429.43	337191.37	276435.6	472748.68
20 : 80	Random allocate	Maximum M/C	382264.89	340997.64	285546.47	490442.77
0 : 100	Single skill	Processing	359933.13	326592.25	254393.02	436510.36
0 : 100	Single skill	Continuous	355764.02	326337.99	254095.2	436267.31
0 : 100	Single skill	Maximum M/C	360627.98	326461.86	254429.48	436997.52
0 : 100	Random allocate	Processing	441230.77	367345.38	321305.73	551096.73
0 : 100	Random allocate	Continuous	409962.44	350360.89	303660.18	517107.06
0 : 100	Random allocate	Maximum M/C	446442.15	358635.38	323466.41	555572.49

Appendix Table B1 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 1,data 3).

			FIFO	EDD	SPT	LPT
Cmax Company				**269105.6**		
Cmax Standard			**313978.9**	**299539.6**	**214197.6**	**416888.9**
100 : 0	Single skill	Processing	313978.89	299539.65	214197.62	416888.88
80 : 20	Single skill	Processing	313988.42	299541.82	214201.39	416894.69
80 : 20	Single skill	Continuous	313985.25	299540.91	214200.41	416893.78
80 : 20	Single skill	Maximum M/C	313988.95	299541.35	214201.51	416896.51
80 : 20	Multi skill	Processing	314031.23	299593.76	214356.12	417178.3
80 : 20	Multi skill	Continuous	314013.79	299571.52	214315.02	417113.84
80 : 20	Multi skill	Maximum M/C	314034.14	299582.36	214361.15	417207.21
80 : 20	Random allocate	Processing	314057.39	299687.87	214422.11	417323.01
80 : 20	Random allocate	Continuous	314031.23	299627	214363.91	417195.95
80 : 20	Random allocate	Maximum M/C	314061.76	299656.65	214429.24	417339.74
50 : 50	Single skill	Processing	316427.94	299759.85	214573.61	417463.26
50 : 50	Single skill	Continuous	315611.59	299669.43	214476.13	417373.1
50 : 50	Single skill	Maximum M/C	316563.99	299713.48	214585.55	417643.95
50 : 50	Multi skill	Processing	326224.08	304913.74	229927.32	445606.71
50 : 50	Multi skill	Continuous	322142.35	302707.51	225849.25	439209.41
50 : 50	Multi skill	Maximum M/C	326904.36	303782.34	230426.68	448475.26
50 : 50	Random allocate	Processing	332346.67	314252.4	236476.15	459965.61
50 : 50	Random allocate	Continuous	326224.08	308212.41	230700.23	447358.17
50 : 50	Random allocate	Maximum M/C	333367.1	311154.97	237183.41	461625.76
20 : 80	Single skill	Processing	317955.97	299801.4	214644.54	417571.6
20 : 80	Single skill	Continuous	316630.28	299693.92	214528.66	417464.44
20 : 80	Single skill	Maximum M/C	318176.91	299746.28	214658.72	417786.38
20 : 80	Multi skill	Processing	333864.23	305927.46	232894.43	451023.76
20 : 80	Multi skill	Continuous	327235.79	303305.08	228047.1	443419.74
20 : 80	Multi skill	Maximum M/C	334968.97	304582.65	233487.98	454433.41
20 : 80	Random allocate	Processing	343806.9	317027.68	240678.57	468091.19
20 : 80	Random allocate	Continuous	333864.23	309848.36	233813.13	453105.61
20 : 80	Random allocate	Maximum M/C	345464.01	313345.98	241519.23	470064.5
0 : 100	Single skill	Processing	325282.14	300108.73	215169.2	418373.02
0 : 100	Single skill	Continuous	321514.39	299875.08	214917.3	418140.07
0 : 100	Single skill	Maximum M/C	325910.1	299988.91	215200.04	418839.94
0 : 100	Random allocate	Processing	398753.2	337557.17	271764.92	528198.24
0 : 100	Random allocate	Continuous	370495.1	321949.95	256840.06	495620.87
0 : 100	Random allocate	Maximum M/C	403462.89	329553.47	273592.45	532488.02

Appendix Table B1 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 1,data 4).

			FIFO	EDD	SPT	LPT
Cmax Company			**243137**			
Cmax Standard			**357512.4**	**340386.9**	**216722**	**467440.1**
100 : 0			357512.4	340386.9	216722	467440.1
80 : 20	Single skill	Processing	357523.24	340389.42	216725.83	467446.59
80 : 20	Single skill	Continuous	357519.63	340388.39	216724.84	467445.57
80 : 20	Single skill	Maximum M/C	357523.85	340388.89	216725.96	467448.63
80 : 20	Multi skill	Processing	357571.99	340448.44	216882.38	467764.6
80 : 20	Multi skill	Continuous	357552.12	340423.18	216840.8	467692.31
80 : 20	Multi skill	Maximum M/C	357575.3	340435.49	216887.48	467797.01
80 : 20	Random allocate	Processing	357601.78	340555.39	216949.16	467926.85
80 : 20	Random allocate	Continuous	357571.99	340486.22	216890.27	467784.39
80 : 20	Random allocate	Maximum M/C	357606.74	340519.92	216956.37	467945.6
50 : 50	Single skill	Processing	360301	340637.19	217102.44	468084.1
50 : 50	Single skill	Continuous	359371.46	340534.44	217003.81	467983.02
50 : 50	Single skill	Maximum M/C	360455.92	340584.49	217114.52	468286.71
50 : 50	Multi skill	Processing	371455.38	346493.89	232637.1	499640.18
50 : 50	Multi skill	Continuous	366807.72	343986.81	228510.97	492467.16
50 : 50	Multi skill	Maximum M/C	372229.99	345208.21	233142.35	502856.57
50 : 50	Random allocate	Processing	378426.88	357106.04	239263.11	515740.22
50 : 50	Random allocate	Continuous	371455.38	350242.39	233419.12	501604.02
50 : 50	Random allocate	Maximum M/C	379588.79	353586.22	239978.7	517601.67
20 : 80	Single skill	Processing	362040.89	340684.4	217174.2	468205.58
20 : 80	Single skill	Continuous	360531.39	340562.27	217056.97	468085.43
20 : 80	Single skill	Maximum M/C	362292.47	340621.77	217188.56	468446.41
20 : 80	Multi skill	Processing	380154.85	347645.85	235639.18	505714.1
20 : 80	Multi skill	Continuous	372607.37	344665.86	230734.72	497188.03
20 : 80	Multi skill	Maximum M/C	381412.77	346117.65	236239.72	509537.19
20 : 80	Random allocate	Processing	391476.08	360259.78	243515.05	524851.09
20 : 80	Random allocate	Continuous	380154.85	352101.44	236568.71	508048.38
20 : 80	Random allocate	Maximum M/C	393362.95	356076.01	244365.63	527063.67
0 : 100	Single skill	Processing	370382.85	341033.64	217705.05	469104.19
0 : 100	Single skill	Continuous	366092.7	340768.13	217450.19	468842.98
0 : 100	Single skill	Maximum M/C	371097.87	340897.48	217736.26	469627.72
0 : 100	Random allocate	Processing	454040.75	383588.81	274967.77	592246.61
0 : 100	Random allocate	Continuous	421864.63	365853.29	259867.02	555718.97
0 : 100	Random allocate	Maximum M/C	459403.43	374493.67	276816.84	597056.57

Appendix Table B1 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 1,data 5).

			FIFO	EDD	SPT	LPT
Cmax Company				**361777.8**		
Cmax Standard			**409999.79**	**422079.01**	**281873.94**	**557349.35**
100 : 0	Single skill	Processing	409999.79	422079.01	281873.94	557349.35
80 : 20	Single skill	Processing	410012.24	422080.99	281876.89	557355.44
80 : 20	Single skill	Continuous	410008.09	422082.14	281877.9	557359.78
80 : 20	Single skill	Maximum M/C	410012.93	422080.66	281876.58	557354.57
80 : 20	Multi skill	Processing	410068.13	422155.32	282082.54	557736.26
80 : 20	Multi skill	Continuous	410045.36	422123.99	282028.46	557650.07
80 : 20	Multi skill	Maximum M/C	410071.93	422139.26	282089.16	557774.91
80 : 20	Random allocate	Processing	410102.3	422287.93	282169.39	557929.72
80 : 20	Random allocate	Continuous	410068.13	422202.17	282092.79	557759.86
80 : 20	Random allocate	Maximum M/C	410107.99	422243.95	282178.77	557952.08
50 : 50	Single skill	Processing	413197.8	422389.36	282368.75	558117.22
50 : 50	Single skill	Continuous	412131.8	422261.96	282240.47	557996.69
50 : 50	Single skill	Maximum M/C	413375.47	422324.03	282384.46	558358.8
50 : 50	Multi skill	Processing	425989.79	429651.66	302573.51	595742.92
50 : 50	Multi skill	Continuous	420659.79	426542.89	297206.96	587190.21
50 : 50	Multi skill	Maximum M/C	426878.13	428057.42	303230.64	599577.96
50 : 50	Random allocate	Processing	433984.79	442810.7	311191.46	614939.7
50 : 50	Random allocate	Continuous	425989.79	434299.8	303590.62	598084.49
50 : 50	Random allocate	Maximum M/C	435317.29	438446.14	312122.18	617159.19
20 : 80	Single skill	Processing	415193.13	422447.91	282462.09	558262.07
20 : 80	Single skill	Continuous	413462.02	422296.47	282309.6	558118.8
20 : 80	Single skill	Maximum M/C	415481.65	422370.24	282480.76	558549.21
20 : 80	Multi skill	Processing	435966.45	431080.1	306478.08	602985.11
20 : 80	Multi skill	Continuous	427310.9	427384.91	300099.23	592819.11
20 : 80	Multi skill	Maximum M/C	437409.05	429185.13	307259.17	607543.56
20 : 80	Random allocate	Processing	448949.78	446721.33	316721.64	625803
20 : 80	Random allocate	Continuous	435966.45	436605.01	307687.05	605768.38
20 : 80	Random allocate	Maximum M/C	451113.67	441533.48	317827.92	628441.15
0 : 100	Single skill	Processing	424759.79	422880.96	283152.52	559333.51
0 : 100	Single skill	Continuous	419839.8	422551.74	282821.04	559022.07
0 : 100	Single skill	Maximum M/C	425579.79	422712.13	283193.11	559957.74
0 : 100	Random allocate	Processing	520699.75	475649.28	357629.82	706161.63
0 : 100	Random allocate	Continuous	483799.76	453657.27	337989.4	662608.12
0 : 100	Random allocate	Maximum M/C	526849.74	464371.33	360034.76	711896.75

Appendix Table B1 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 1,data 6).

			FIFO	EDD	SPT	LPT
Cmax Company			**184081.9**			
Cmax Standard			**246993.67**	**214789.64**	**141573.46**	**320219.85**
100 : 0			246993.67	214789.64	141573.46	320219.85
80 : 20	Single skill	Processing	247001.19	214791.23	141575.96	320224.3
80 : 20	Single skill	Continuous	246998.69	214790.58	141575.32	320223.6
80 : 20	Single skill	Maximum M/C	247001.61	214790.9	141576.04	320225.69
80 : 20	Multi skill	Processing	247034.87	214828.47	141678.23	320442.15
80 : 20	Multi skill	Continuous	247021.14	214812.53	141651.07	320392.63
80 : 20	Multi skill	Maximum M/C	247037.15	214820.3	141681.56	320464.35
80 : 20	Random allocate	Processing	247055.45	214895.96	141721.85	320553.29
80 : 20	Random allocate	Continuous	247034.87	214852.31	141683.38	320455.7
80 : 20	Random allocate	Maximum M/C	247058.88	214873.58	141726.56	320566.15
50 : 50	Single skill	Processing	248920.25	214947.57	141821.98	320661.02
50 : 50	Single skill	Continuous	248278.07	214882.74	141757.55	320591.77
50 : 50	Single skill	Maximum M/C	249027.28	214914.33	141829.87	320799.82
50 : 50	Multi skill	Processing	256626.45	218643.25	151969.99	342278.51
50 : 50	Multi skill	Continuous	253415.54	217061.24	149274.59	337364.64
50 : 50	Multi skill	Maximum M/C	257161.61	217831.96	152300.04	344481.9
50 : 50	Random allocate	Processing	261442.83	225339.69	156298.42	353307.85
50 : 50	Random allocate	Continuous	256626.45	221008.61	152480.84	343623.85
50 : 50	Random allocate	Maximum M/C	262245.56	223118.62	156765.88	354583.04
20 : 80	Single skill	Processing	250122.29	214977.37	141868.86	320744.24
20 : 80	Single skill	Continuous	249079.42	214900.3	141792.28	320661.93
20 : 80	Single skill	Maximum M/C	250296.1	214937.84	141878.24	320909.22
20 : 80	Multi skill	Processing	262636.63	219370.16	153931.09	346439.45
20 : 80	Multi skill	Continuous	257422.32	217489.73	150727.26	340598.67
20 : 80	Multi skill	Maximum M/C	263505.69	218405.84	154323.4	349058.47
20 : 80	Random allocate	Processing	270458.1	227329.75	159076	359549.25
20 : 80	Random allocate	Continuous	262636.63	222181.7	154538.3	348038.55
20 : 80	Random allocate	Maximum M/C	271761.68	224689.72	159631.64	361064.98
0 : 100	Single skill	Processing	255885.47	215197.74	142215.64	321359.83
0 : 100	Single skill	Continuous	252921.55	215030.2	142049.15	321180.89
0 : 100	Single skill	Maximum M/C	256379.46	215111.82	142236.02	321718.48
0 : 100	Random allocate	Processing	313682	242050.74	179622.46	405718.55
0 : 100	Random allocate	Continuous	291452.57	230859.34	169757.9	380695.29
0 : 100	Random allocate	Maximum M/C	317386.9	236311.56	180830.36	409013.61

Appendix Table B2 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 2,data 1).

			FIFO	EDD	SPT	LPT
Cmax Company			**235247.5**			
Cmax Standard			**223278.18**	**197671.52**	**137720.26**	**317895.13**
100 : 0			223278.18	197671.52	137720.26	317895.13
80 : 20	Single skill	Processing	223284.97	197672.96	137722.74	317899.51
80 : 20	Single skill	Continuous	223282.72	197672.36	137722.1	317898.82
80 : 20	Single skill	Maximum M/C	223285.35	197672.66	137722.81	317900.9
80 : 20	Multi skill	Processing	223315.41	197707.24	137822.22	318115.78
80 : 20	Multi skill	Continuous	223303.01	197692.57	137795.8	318066.62
80 : 20	Multi skill	Maximum M/C	223317.48	197699.72	137825.46	318137.83
80 : 20	Random allocate	Processing	223334.02	197769.35	137864.65	318226.12
80 : 20	Random allocate	Continuous	223315.41	197729.18	137827.23	318129.24
80 : 20	Random allocate	Maximum M/C	223337.12	197748.75	137869.24	318238.88
50 : 50	Single skill	Processing	225019.77	197816.85	137962.06	318333.07
50 : 50	Single skill	Continuous	224439.25	197757.18	137899.38	318264.32
50 : 50	Single skill	Maximum M/C	225116.52	197786.25	137969.73	318470.86
50 : 50	Multi skill	Processing	231986.05	201217.99	147833.87	339793.62
50 : 50	Multi skill	Continuous	229083.43	199762.06	145211.83	334915.42
50 : 50	Multi skill	Maximum M/C	232469.82	200471.36	148154.93	341981.01
50 : 50	Random allocate	Processing	236339.97	207380.74	152044.5	350742.88
50 : 50	Random allocate	Continuous	231986.05	203394.84	148330.82	341129.19
50 : 50	Random allocate	Maximum M/C	237065.63	205336.69	152499.23	352008.81
20 : 80	Single skill	Processing	226106.39	197844.26	138007.66	318415.69
20 : 80	Single skill	Continuous	225163.66	197773.34	137933.16	318333.97
20 : 80	Single skill	Maximum M/C	226263.51	197807.89	138016.78	318579.46
20 : 80	Multi skill	Processing	237419.15	201886.96	149741.6	343924.35
20 : 80	Multi skill	Continuous	232705.5	200156.4	146624.96	338125.97
20 : 80	Multi skill	Maximum M/C	238204.76	200999.5	150123.22	346524.35
20 : 80	Random allocate	Processing	244489.63	209212.19	154746.48	356938.98
20 : 80	Random allocate	Continuous	237419.15	204474.44	150332.28	345511.84
20 : 80	Random allocate	Maximum M/C	245668.04	206782.57	155286.99	358443.7
0 : 100	Single skill	Processing	231316.22	198047.08	138345	319026.81
0 : 100	Single skill	Continuous	228636.88	197892.89	138183.04	318849.17
0 : 100	Single skill	Maximum M/C	231762.77	197968.01	138364.83	319382.85
0 : 100	Random allocate	Processing	283563.31	222759.97	174733.73	402773.09
0 : 100	Random allocate	Continuous	263468.28	212460.49	165137.66	377931.5
0 : 100	Random allocate	Maximum M/C	286912.49	217478.18	175908.76	406044.23

Appendix Table B2 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 2,data 2).

			FIFO	EDD	SPT	LPT
Cmax Company			**264183**			
Cmax Standard			**194063.27**	**226850.91**	**99596.97**	**325172.48**
100 : 0			194063.27	226850.91	99596.97	325172.48
80 : 20	Single skill	Processing	194069.19	226852.59	99598.732	325176.99
80 : 20	Single skill	Continuous	194067.22	226851.9	99598.275	325176.29
80 : 20	Single skill	Maximum M/C	194069.51	226852.24	99598.788	325178.42
80 : 20	Multi skill	Processing	194095.64	226891.93	99670.677	325398.21
80 : 20	Multi skill	Continuous	194084.86	226875.09	99651.567	325347.93
80 : 20	Multi skill	Maximum M/C	194097.44	226883.29	99673.016	325420.76
80 : 20	Random allocate	Processing	194111.82	226963.2	99701.363	325511.08
80 : 20	Random allocate	Continuous	194095.64	226917.1	99674.298	325411.98
80 : 20	Random allocate	Maximum M/C	194114.51	226939.56	99704.677	325524.13
50 : 50	Single skill	Processing	195576.99	227017.71	99771.806	325620.48
50 : 50	Single skill	Continuous	195072.43	226949.24	99726.478	325550.16
50 : 50	Single skill	Maximum M/C	195661.09	226982.6	99777.356	325761.42
50 : 50	Multi skill	Processing	201631.77	230920.91	106910.93	347572.31
50 : 50	Multi skill	Continuous	199108.95	229250.07	105014.72	342582.43
50 : 50	Multi skill	Maximum M/C	202052.24	230064.07	107143.12	349809.78
50 : 50	Random allocate	Processing	205416	237993.38	109955.99	358772.23
50 : 50	Random allocate	Continuous	201631.77	233419.1	107270.31	348938.45
50 : 50	Random allocate	Maximum M/C	206046.71	235647.6	110284.84	360067.14
20 : 80	Single skill	Processing	196521.44	227049.18	99804.785	325704.98
20 : 80	Single skill	Continuous	195702.06	226967.78	99750.907	325621.4
20 : 80	Single skill	Maximum M/C	196658	227007.44	99811.382	325872.51
20 : 80	Multi skill	Processing	206353.98	231688.64	108290.57	351797.6
20 : 80	Multi skill	Continuous	202257.08	229702.63	106036.67	345866.48
20 : 80	Multi skill	Maximum M/C	207036.79	230670.17	108566.55	354457.12
20 : 80	Random allocate	Processing	212499.31	240095.19	111910.01	365110.16
20 : 80	Random allocate	Continuous	206353.98	234658.07	108717.74	353421.44
20 : 80	Random allocate	Maximum M/C	213523.54	237306.92	112300.9	366649.34
0 : 100	Single skill	Processing	201049.58	227281.93	100048.74	326330.09
0 : 100	Single skill	Continuous	198720.82	227104.98	99931.616	326148.39
0 : 100	Single skill	Maximum M/C	201437.71	227191.19	100063.08	326694.29
0 : 100	Random allocate	Processing	246460.39	255642.83	126364.45	411993.53
0 : 100	Random allocate	Continuous	228994.69	243822.99	119424.73	386583.25
0 : 100	Random allocate	Maximum M/C	249371.34	249581.37	127214.21	415339.56

Appendix Table B2 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 2,data 3).

			FIFO	EDD	SPT	LPT
Cmax Company			**248668.7**			
Cmax Standard			**216073.77**	**210626.03**	**97965.915**	**325446.59**
100 : 0			216073.77	210626.03	97965.915	325446.59
80 : 20	Single skill	Processing	216080.35	210627.59	97967.648	325451.11
80 : 20	Single skill	Continuous	216078.17	210626.95	97967.199	325450.4
80 : 20	Single skill	Maximum M/C	216080.72	210627.26	97967.703	325452.53
80 : 20	Multi skill	Processing	216109.81	210664.11	98038.415	325672.52
80 : 20	Multi skill	Continuous	216097.81	210648.48	98019.618	325622.19
80 : 20	Multi skill	Maximum M/C	216111.81	210656.09	98040.716	325695.08
80 : 20	Random allocate	Processing	216127.82	210730.29	98068.599	325785.48
80 : 20	Random allocate	Continuous	216109.81	210687.49	98041.977	325686.29
80 : 20	Random allocate	Maximum M/C	216130.82	210708.34	98071.858	325798.54
50 : 50	Single skill	Processing	217759.18	210780.9	98137.888	325894.96
50 : 50	Single skill	Continuous	217197.38	210717.32	98093.302	325824.58
50 : 50	Single skill	Maximum M/C	217852.81	210748.3	98143.347	326036.03
50 : 50	Multi skill	Processing	224500.68	214404.94	105160.1	347865.3
50 : 50	Multi skill	Continuous	221691.72	212853.6	103294.94	342871.22
50 : 50	Multi skill	Maximum M/C	224968.84	213609.38	105388.48	350104.66
50 : 50	Random allocate	Processing	228714.12	220971.57	108155.29	359074.66
50 : 50	Random allocate	Continuous	224500.68	216724.45	105513.6	349232.59
50 : 50	Random allocate	Maximum M/C	229416.36	218793.56	108478.76	360370.66
20 : 80	Single skill	Processing	218810.73	210810.12	98170.327	325979.54
20 : 80	Single skill	Continuous	217898.42	210734.54	98117.331	325895.89
20 : 80	Single skill	Maximum M/C	218962.79	210771.36	98176.816	326147.21
20 : 80	Multi skill	Processing	229758.47	215117.76	106517.14	352094.16
20 : 80	Multi skill	Continuous	225196.92	213273.78	104300.16	346158.04
20 : 80	Multi skill	Maximum M/C	230518.73	214172.13	106788.61	354755.92
20 : 80	Random allocate	Processing	236600.81	222923.05	110077.31	365417.94
20 : 80	Random allocate	Continuous	229758.47	217874.8	106937.32	353719.36
20 : 80	Random allocate	Maximum M/C	237741.2	220334.2	110461.8	366958.41
0 : 100	Single skill	Processing	223852.46	211026.22	98410.288	326605.18
0 : 100	Single skill	Continuous	221259.57	210861.93	98295.08	326423.32
0 : 100	Single skill	Maximum M/C	224284.6	210941.97	98424.395	326969.68
0 : 100	Random allocate	Processing	274413.73	237358.69	124295.04	412340.83
0 : 100	Random allocate	Continuous	254967.08	226384.23	117468.97	386909.13
0 : 100	Random allocate	Maximum M/C	277654.83	231730.76	125130.88	415689.67

Appendix Table B2 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 2,data 4).

			FIFO	EDD	SPT	LPT
Cmax Company			**256303.5**			
Cmax Standard			**247238.24**	**219777.79**	**96506.176**	**339036.47**
100 : 0	Single skill	Processing	247238.24	219777.79	96506.176	339036.47
80 : 20	Single skill	Processing	247245.7	219779.42	96507.883	339041.18
80 : 20	Single skill	Continuous	247243.2	219778.75	96507.441	339040.44
80 : 20	Single skill	Maximum M/C	247246.12	219779.08	96507.937	339042.66
80 : 20	Multi skill	Processing	247279.41	219817.53	96577.595	339271.83
80 : 20	Multi skill	Continuous	247265.67	219801.21	96559.079	339219.4
80 : 20	Multi skill	Maximum M/C	247281.7	219809.16	96579.863	339295.34
80 : 20	Random allocate	Processing	247300.01	219886.58	96607.33	339389.51
80 : 20	Random allocate	Continuous	247279.41	219841.92	96581.105	339286.18
80 : 20	Random allocate	Maximum M/C	247303.44	219863.67	96610.541	339403.11
50 : 50	Single skill	Processing	249166.66	219939.39	96675.586	339503.57
50 : 50	Single skill	Continuous	248523.84	219873.05	96631.665	339430.25
50 : 50	Single skill	Maximum M/C	249273.79	219905.37	96680.964	339650.52
50 : 50	Multi skill	Processing	256880.49	223720.89	103593.16	362391.34
50 : 50	Multi skill	Continuous	253666.39	222102.15	101755.8	357188.71
50 : 50	Multi skill	Maximum M/C	257416.17	222890.77	103818.15	364724.2
50 : 50	Random allocate	Processing	261701.63	230572.84	106543.72	374068.77
50 : 50	Random allocate	Continuous	256880.49	226141.19	103941.39	363815.72
50 : 50	Random allocate	Maximum M/C	262505.16	228300.2	106862.37	375418.89
20 : 80	Single skill	Processing	250369.88	219969.88	96707.542	339591.68
20 : 80	Single skill	Continuous	249325.99	219891.02	96655.336	339504.53
20 : 80	Single skill	Maximum M/C	250543.87	219929.44	96713.934	339766.35
20 : 80	Multi skill	Processing	262896.62	224464.68	104929.98	366796.78
20 : 80	Multi skill	Continuous	257677.15	222540.59	102746.03	360612.78
20 : 80	Multi skill	Maximum M/C	263766.53	223477.97	105197.41	369569.69
20 : 80	Random allocate	Processing	270725.83	232609.12	108437.11	380676.93
20 : 80	Random allocate	Continuous	262896.62	227341.52	105343.9	368489.84
20 : 80	Random allocate	Maximum M/C	272030.7	229907.79	108815.87	382281.72
0 : 100	Single skill	Processing	256138.78	220195.37	96943.928	340243.44
0 : 100	Single skill	Continuous	253171.92	220023.94	96830.437	340053.99
0 : 100	Single skill	Maximum M/C	256633.25	220107.46	96957.825	340623.16
0 : 100	Random allocate	Processing	313992.51	247671.99	122442.98	429559.21
0 : 100	Random allocate	Continuous	291741.08	236220.69	115718.63	403065.54
0 : 100	Random allocate	Maximum M/C	317701.09	241799.52	123266.37	433047.89

Appendix Table B2 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 2,data 5).

			FIFO	EDD	SPT	LPT
Cmax Company			**268446.1**			
Cmax Standard			**236139.21**	**229048.85**	**99542.479**	**305808.79**
100 : 0			236139.21	229048.85	99542.479	305808.79
80 : 20	Single skill	Processing	236146.36	229050.55	99544.24	305813.04
80 : 20	Single skill	Continuous	236143.98	229049.85	99543.783	305812.37
80 : 20	Single skill	Maximum M/C	236146.76	229050.19	99544.296	305814.37
80 : 20	Multi skill	Processing	236178.56	229090.26	99616.145	306021.08
80 : 20	Multi skill	Continuous	236165.44	229073.26	99597.047	305973.79
80 : 20	Multi skill	Maximum M/C	236180.74	229081.54	99618.484	306042.29
80 : 20	Random allocate	Processing	236198.23	229162.23	99646.815	306127.23
80 : 20	Random allocate	Continuous	236178.56	229115.68	99619.765	306034.03
80 : 20	Random allocate	Maximum M/C	236201.51	229138.36	99650.127	306139.5
50 : 50	Single skill	Processing	237981.09	229217.27	99717.219	306230.11
50 : 50	Single skill	Continuous	237367.12	229148.13	99671.916	306163.98
50 : 50	Single skill	Maximum M/C	238083.41	229181.81	99722.766	306362.66
50 : 50	Multi skill	Processing	245348.63	233158.29	106852.44	326874.73
50 : 50	Multi skill	Continuous	242278.82	231471.26	104957.26	322182
50 : 50	Multi skill	Maximum M/C	245860.26	232293.14	107084.5	328978.96
50 : 50	Random allocate	Processing	249953.34	240299.28	109895.83	337407.71
50 : 50	Random allocate	Continuous	245348.63	235680.68	107211.63	328159.52
50 : 50	Random allocate	Maximum M/C	250720.8	237930.77	110224.5	338625.51
20 : 80	Single skill	Processing	239130.3	229249.04	99750.18	306309.58
20 : 80	Single skill	Continuous	238133.26	229166.86	99696.332	306230.97
20 : 80	Single skill	Maximum M/C	239296.47	229206.89	99756.774	306467.14
20 : 80	Multi skill	Processing	251094.68	233933.45	108231.32	330848.41
20 : 80	Multi skill	Continuous	246109.52	231928.2	105978.66	325270.49
20 : 80	Multi skill	Maximum M/C	251925.54	232905.12	108507.16	333349.56
20 : 80	Random allocate	Processing	258572.42	242421.45	111848.78	343368.23
20 : 80	Random allocate	Continuous	251094.68	236931.65	108658.26	332375.55
20 : 80	Random allocate	Maximum M/C	259818.71	239606.17	112239.46	344815.74
0 : 100	Single skill	Processing	244640.21	229484.04	99994.004	306897.47
0 : 100	Single skill	Continuous	241806.54	229305.38	99876.942	306726.58
0 : 100	Single skill	Maximum M/C	245112.49	229392.42	100008.34	307239.98
0 : 100	Random allocate	Processing	299896.78	258119.73	126295.32	387459.74
0 : 100	Random allocate	Continuous	278644.26	246185.37	119359.4	363562.61
0 : 100	Random allocate	Maximum M/C	303438.87	251999.54	127144.61	390606.51

Appendix Table B2 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 2,data 6).

			FIFO	EDD	SPT	LPT
Cmax Company			**273964.8**			
Cmax Standard			**204343.09**	**230530.24**	**108909.6**	**303677.78**
100 : 0			204343.09	230530.24	108909.58	303677.78
80 : 20	Single skill	Processing	204349.3	230531.95	108911.53	303682
80 : 20	Single skill	Continuous	204347.23	230531.25	108911.03	303681.33
80 : 20	Single skill	Maximum M/C	204349.64	230531.59	108911.59	303683.32
80 : 20	Multi skill	Processing	204377.16	230571.92	108990.2	303888.59
80 : 20	Multi skill	Continuous	204365.8	230554.81	108969.3	303841.63
80 : 20	Multi skill	Maximum M/C	204379.05	230563.15	108992.76	303909.65
80 : 20	Random allocate	Processing	204394.19	230644.35	109023.75	303994
80 : 20	Random allocate	Continuous	204377.16	230597.5	108994.16	303901.45
80 : 20	Random allocate	Maximum M/C	204397.02	230620.33	109027.38	304006.19
50 : 50	Single skill	Processing	205936.98	230699.75	109100.78	304096.16
50 : 50	Single skill	Continuous	205405.68	230630.16	109051.22	304030.49
50 : 50	Single skill	Maximum M/C	206025.52	230664.06	109106.85	304227.79
50 : 50	Multi skill	Processing	212312.48	234666.26	116907.44	324596.93
50 : 50	Multi skill	Continuous	209656.02	232968.31	114833.93	319936.89
50 : 50	Multi skill	Maximum M/C	212755.22	233795.52	117161.34	326686.49
50 : 50	Random allocate	Processing	216297.17	241853.43	120237.22	335056.5
50 : 50	Random allocate	Continuous	212312.48	237204.96	117300.43	325872.76
50 : 50	Random allocate	Maximum M/C	216961.29	239469.6	120596.82	336265.82
20 : 80	Single skill	Processing	206931.45	230731.72	109136.85	304175.08
20 : 80	Single skill	Continuous	206068.66	230649.01	109077.93	304097.02
20 : 80	Single skill	Maximum M/C	207075.24	230689.31	109144.06	304331.54
20 : 80	Multi skill	Processing	217284.83	235446.44	118416.08	328542.92
20 : 80	Multi skill	Continuous	212970.92	233428.21	115951.43	323003.86
20 : 80	Multi skill	Maximum M/C	218003.81	234411.45	118717.87	331026.64
20 : 80	Random allocate	Processing	223755.69	243989.33	122373.95	340975.48
20 : 80	Random allocate	Continuous	217284.83	238464.02	118883.19	330059.41
20 : 80	Random allocate	Maximum M/C	224834.17	241155.84	122801.39	342412.91
0 : 100	Single skill	Processing	211699.45	230968.25	109403.61	304758.87
0 : 100	Single skill	Continuous	209247.33	230788.43	109275.54	304589.18
0 : 100	Single skill	Maximum M/C	212108.14	230876.04	109419.3	305098.99
0 : 100	Random allocate	Processing	259515.74	259789.14	138179.93	384759.75
0 : 100	Random allocate	Continuous	241124.86	247777.59	130591.32	361029.15
0 : 100	Random allocate	Maximum M/C	262580.88	253629.37	139109.14	387884.59

Appendix Table B3 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 3,data 1).

			FIFO	EDD	SPT	LPT
Cmax Company			**480181.7**			
Cmax Standard			**344659.37**	**467808.17**	**208841.66**	**678416.83**
100 : 0	Single skill	Processing	344659.37	467808.17	208841.66	678416.83
80 : 20	Single skill	Processing	344669.85	467811.64	208845.35	678426.25
80 : 20	Single skill	Continuous	344666.37	467810.21	208844.4	678424.77
80 : 20	Single skill	Maximum M/C	344670.44	467810.91	208845.47	678429.21
80 : 20	Multi skill	Processing	344716.84	467892.75	208996.21	678887.79
80 : 20	Multi skill	Continuous	344697.7	467858.03	208956.14	678782.87
80 : 20	Multi skill	Maximum M/C	344720.03	467874.94	209001.12	678934.83
80 : 20	Random allocate	Processing	344745.56	468039.73	209060.56	679123.27
80 : 20	Random allocate	Continuous	344716.84	467944.67	209003.81	678916.51
80 : 20	Random allocate	Maximum M/C	344750.35	467990.98	209067.51	679150.49
50 : 50	Single skill	Processing	347347.74	468152.15	209208.27	679351.5
50 : 50	Single skill	Continuous	346451.63	468010.94	209113.22	679204.79
50 : 50	Single skill	Maximum M/C	347497.1	468079.73	209219.91	679645.55
50 : 50	Multi skill	Processing	358101.12	476201.27	224178.07	725150.25
50 : 50	Multi skill	Continuous	353620.54	472755.68	220201.96	714739.73
50 : 50	Multi skill	Maximum M/C	358847.88	474434.3	224664.94	729818.34
50 : 50	Random allocate	Processing	364821.97	490785.99	230563.14	748516.96
50 : 50	Random allocate	Continuous	358101.12	481352.99	224931.65	728000.47
50 : 50	Random allocate	Maximum M/C	365942.12	485948.55	231252.72	751218.57
20 : 80	Single skill	Processing	349025.09	468217.03	209277.42	679527.81
20 : 80	Single skill	Continuous	347569.86	468049.18	209164.45	679353.42
20 : 80	Single skill	Maximum M/C	349267.62	468130.96	209291.25	679877.33
20 : 80	Multi skill	Processing	366487.83	477784.46	227070.98	733965.6
20 : 80	Multi skill	Continuous	359211.69	473688.93	222344.86	721591.33
20 : 80	Multi skill	Maximum M/C	367700.52	475684.19	227649.69	739514.24
20 : 80	Random allocate	Processing	377402.04	495120.31	234660.48	761739.99
20 : 80	Random allocate	Continuous	366487.83	483907.96	227966.71	737353.45
20 : 80	Random allocate	Maximum M/C	379221.08	489370.38	235480.12	764951.2
0 : 100	Single skill	Processing	357067.14	468697.01	209788.97	680831.99
0 : 100	Single skill	Continuous	352931.23	468332.12	209543.37	680452.89
0 : 100	Single skill	Maximum M/C	357756.46	468509.88	209819.04	681591.82
0 : 100	Random allocate	Processing	437717.44	527182.38	264969.53	859554.12
0 : 100	Random allocate	Continuous	406698.09	502807.71	250417.86	806539.92
0 : 100	Random allocate	Maximum M/C	442887.33	514682.55	266751.36	866535.03

Appendix Table B3 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 3,data 2).

			FIFO	EDD	SPT	LPT
Cmax Company			**495819**			
Cmax Standard			**663186.18**	**495863.63**	**223477.25**	**920171.18**
100 : 0			663186.18	495863.63	223477.25	920171.18
80 : 20	Single skill	Processing	663206.32	495867.3	223481.2	920183.96
80 : 20	Single skill	Continuous	663199.61	495865.8	223480.18	920181.95
80 : 20	Single skill	Maximum M/C	663207.43	495866.53	223481.33	920187.97
80 : 20	Multi skill	Processing	663296.73	495953.28	223642.63	920809.96
80 : 20	Multi skill	Continuous	663259.89	495916.48	223599.76	920667.66
80 : 20	Multi skill	Maximum M/C	663302.87	495934.41	223647.88	920873.77
80 : 20	Random allocate	Processing	663352	496109.08	223711.49	921129.35
80 : 20	Random allocate	Continuous	663296.73	496008.31	223650.76	920848.92
80 : 20	Random allocate	Maximum M/C	663361.21	496057.4	223718.93	921166.28
50 : 50	Single skill	Processing	668359.05	496228.24	223869.55	921438.92
50 : 50	Single skill	Continuous	666634.77	496078.56	223767.84	921239.93
50 : 50	Single skill	Maximum M/C	668646.43	496151.48	223882	921837.76
50 : 50	Multi skill	Processing	689050.46	504760.08	239888.43	983558.09
50 : 50	Multi skill	Continuous	680429.04	501107.85	235633.68	969437.77
50 : 50	Multi skill	Maximum M/C	690487.37	502887.14	240409.42	989889.66
50 : 50	Random allocate	Processing	701982.59	520219.48	246720.97	1015251.5
50 : 50	Random allocate	Continuous	689050.46	510220.76	240694.82	987423.98
50 : 50	Random allocate	Maximum M/C	704137.95	515091.93	247458.87	1018915.9
20 : 80	Single skill	Processing	671586.56	496297.01	223943.55	921678.05
20 : 80	Single skill	Continuous	668786.44	496119.1	223822.66	921441.52
20 : 80	Single skill	Maximum M/C	672053.25	496205.78	223958.35	922152.12
20 : 80	Multi skill	Processing	705187.99	506438.22	242984.08	995514.8
20 : 80	Multi skill	Continuous	691187.4	502097.07	237926.75	978730.95
20 : 80	Multi skill	Maximum M/C	707521.43	504211.99	243603.34	1003040.7
20 : 80	Random allocate	Processing	726188.89	524813.74	251105.45	1033186.6
20 : 80	Random allocate	Continuous	705187.99	512928.96	243942.58	1000109.9
20 : 80	Random allocate	Maximum M/C	729689.04	518718.98	251982.53	1037542.1
0 : 100	Single skill	Processing	687060.9	496805.77	224490.94	923446.99
0 : 100	Single skill	Continuous	679102.67	496419	224228.13	922932.8
0 : 100	Single skill	Maximum M/C	688387.28	496607.43	224523.12	924477.58
0 : 100	Random allocate	Processing	842246.47	558798.64	283538.55	1165856.9
0 : 100	Random allocate	Continuous	782559.72	532962.16	267967.1	1093951
0 : 100	Random allocate	Maximum M/C	852194.27	545549.17	285445.26	1175325.4

Appendix Table B3 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 3,data 3).

			FIFO	EDD	SPT	LPT
Cmax Company			**498053.3**			
Cmax Standard			**690173.19**	**458765.22**	**185030.87**	**902123.19**
100 : 0			690173.19	458765.22	185030.87	902123.19
80 : 20	Single skill	Processing	690194.13	458768.62	185034.14	902135.72
80 : 20	Single skill	Continuous	690187.15	458767.22	185033.29	902133.75
80 : 20	Single skill	Maximum M/C	690195.29	458767.9	185034.25	902139.66
80 : 20	Multi skill	Processing	690288.22	458848.17	185167.8	902749.44
80 : 20	Multi skill	Continuous	690249.88	458814.11	185132.3	902609.94
80 : 20	Multi skill	Maximum M/C	690294.61	458830.7	185172.15	902812
80 : 20	Random allocate	Processing	690345.73	458992.3	185224.81	903062.57
80 : 20	Random allocate	Continuous	690288.22	458899.08	185174.53	902787.64
80 : 20	Random allocate	Maximum M/C	690355.32	458944.5	185230.97	903098.77
50 : 50	Single skill	Processing	695556.54	459102.55	185355.68	903366.06
50 : 50	Single skill	Continuous	693762.09	458964.07	185271.47	903170.97
50 : 50	Single skill	Maximum M/C	695855.62	459031.53	185365.99	903757.08
50 : 50	Multi skill	Processing	717089.94	466996.07	198618.72	964266.85
50 : 50	Multi skill	Continuous	708117.69	463617.09	195095.94	950423.48
50 : 50	Multi skill	Maximum M/C	718585.32	465263.26	199050.08	970474.23
50 : 50	Random allocate	Processing	730548.32	481298.87	204275.81	995338.68
50 : 50	Random allocate	Continuous	717089.94	472048.21	199286.38	968056.91
50 : 50	Random allocate	Maximum M/C	732791.38	476554.94	204886.76	998931.14
20 : 80	Single skill	Processing	698915.38	459166.18	185416.95	903600.51
20 : 80	Single skill	Continuous	696001.32	459001.58	185316.85	903368.62
20 : 80	Single skill	Maximum M/C	699401.06	459081.77	185429.2	904065.28
20 : 80	Multi skill	Processing	733884.16	468548.66	201181.8	975989.04
20 : 80	Multi skill	Continuous	719313.84	464532.3	196994.52	959534.38
20 : 80	Multi skill	Maximum M/C	736312.55	466488.99	201694.53	983367.32
20 : 80	Random allocate	Processing	755739.64	485549.4	207905.99	1012922
20 : 80	Random allocate	Continuous	733884.16	474553.79	201975.4	980494.02
20 : 80	Random allocate	Maximum M/C	759382.22	479910.63	208632.19	1017192.1
0 : 100	Single skill	Processing	715019.42	459636.87	185870.17	905334.75
0 : 100	Single skill	Continuous	706737.35	459279.04	185652.57	904830.64
0 : 100	Single skill	Maximum M/C	716399.77	459453.37	185896.81	906345.13
0 : 100	Random allocate	Processing	876519.95	516991.7	234759.4	1142990.1
0 : 100	Random allocate	Continuous	814404.36	493088.2	221866.82	1072494.6
0 : 100	Random allocate	Maximum M/C	886872.55	504733.5	236338.08	1152272.9

Appendix Table B3 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 3,data 4).

			FIFO	EDD	SPT	LPT
Cmax Company			**806619.2**			
Cmax Standard			**726537.5**	**806356.67**	**304470.28**	**1113793**
100 : 0			726537.5	806356.67	304470.28	1113793
80 : 20	Single skill	Processing	726559.54	806362.65	304475.67	111380.85
80 : 20	Single skill	Continuous	726552.19	806360.19	304474.27	111380.6
80 : 20	Single skill	Maximum M/C	726560.76	806361.39	304475.84	111381.33
80 : 20	Multi skill	Processing	726658.59	806502.46	304695.6	111456.62
80 : 20	Multi skill	Continuous	726618.23	806442.61	304637.19	111439.4
80 : 20	Multi skill	Maximum M/C	726665.32	806471.77	304702.76	111464.34
80 : 20	Random allocate	Processing	726719.13	806755.81	304789.41	111495.28
80 : 20	Random allocate	Continuous	726658.59	806591.95	304706.67	111461.34
80 : 20	Random allocate	Maximum M/C	726729.23	806671.78	304799.54	111499.75
50 : 50	Single skill	Processing	732204.49	806949.58	305004.76	111532.75
50 : 50	Single skill	Continuous	730315.5	806706.18	304866.19	111508.66
50 : 50	Single skill	Maximum M/C	732519.33	806824.76	305021.72	111581.03
50 : 50	Multi skill	Processing	754872.46	820823.77	326829.23	119051.77
50 : 50	Multi skill	Continuous	745427.48	814884.65	321032.46	117342.62
50 : 50	Multi skill	Maximum M/C	756446.63	817778.07	327539.04	119818.16
50 : 50	Random allocate	Processing	769039.94	845963.33	336138.03	122888.01
50 : 50	Random allocate	Continuous	754872.46	829703.75	327927.88	119519.71
50 : 50	Random allocate	Maximum M/C	771401.19	837625.09	337143.36	123331.55
20 : 80	Single skill	Processing	735740.31	807061.43	305105.58	111561.69
20 : 80	Single skill	Continuous	732672.71	806772.1	304940.87	111533.06
20 : 80	Single skill	Maximum M/C	736251.58	806913.06	305125.74	111619.08
20 : 80	Multi skill	Processing	772551.54	823552.71	331046.81	120499.04
20 : 80	Multi skill	Continuous	757213.53	816493.28	324156.6	118467.49
20 : 80	Multi skill	Maximum M/C	775107.88	819932.49	331890.51	121409.99
20 : 80	Random allocate	Processing	795558.56	853434.35	342111.54	125058.91
20 : 80	Random allocate	Continuous	772551.54	834107.73	332352.69	121055.24
20 : 80	Random allocate	Maximum M/C	799393.07	843523.26	343306.5	125586.11
0 : 100	Single skill	Processing	752692.85	807888.75	305851.36	111775.81
0 : 100	Single skill	Continuous	743974.4	807259.79	305493.3	111713.57
0 : 100	Single skill	Maximum M/C	754145.93	807566.21	305895.2	111900.56
0 : 100	Random allocate	Processing	922702.63	908699.46	386299.1	141117.57
0 : 100	Random allocate	Continuous	857314.25	866685.05	365084.22	132413.95
0 : 100	Random allocate	Maximum M/C	933600.69	887153.61	388896.84	142263.67

Appendix Table B3 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 3,data 5).

			FIFO	EDD	SPT	LPT
Cmax Company			**578156**			
Cmax Standard			**485308.43**	**578105.42**	**241375.3**	**1061383.7**
100 : 0			485332.53	578150	241376.51	1061697
80 : 20	Single skill	Processing	485323.12	578109.7	241379.57	1061398.4
80 : 20	Single skill	Continuous	485318.21	578107.95	241378.46	1061396.1
80 : 20	Single skill	Maximum M/C	485323.94	578108.8	241379.71	1061403.1
80 : 20	Multi skill	Processing	485389.28	578209.94	241553.93	1062120.5
80 : 20	Multi skill	Continuous	485362.32	578167.03	241507.62	1061956.4
80 : 20	Multi skill	Maximum M/C	485393.78	578187.94	241559.6	1062194.1
80 : 20	Random allocate	Processing	485429.73	578391.58	241628.3	1062488.9
80 : 20	Random allocate	Continuous	485389.28	578274.1	241562.71	1062165.4
80 : 20	Random allocate	Maximum M/C	485436.47	578331.33	241636.33	1062531.5
50 : 50	Single skill	Processing	489093.81	578530.5	241799.02	1062846
50 : 50	Single skill	Continuous	487832	578355.99	241689.17	1062616.5
50 : 50	Single skill	Maximum M/C	489304.11	578441.01	241812.47	1063306
50 : 50	Multi skill	Processing	504235.43	588477.39	259100.83	1134498.2
50 : 50	Multi skill	Continuous	497926.42	584219.43	254505.32	1118210.9
50 : 50	Multi skill	Maximum M/C	505286.93	586293.82	259663.55	1141801.4
50 : 50	Random allocate	Processing	513698.94	606500.83	266480.59	1171055.4
50 : 50	Random allocate	Continuous	504235.43	594843.76	259971.81	1138957.3
50 : 50	Random allocate	Maximum M/C	515276.19	600522.85	267277.58	1175282.1
20 : 80	Single skill	Processing	491455.64	578610.68	241878.94	1063121.8
20 : 80	Single skill	Continuous	489406.56	578403.26	241748.37	1062849
20 : 80	Single skill	Maximum M/C	491797.15	578504.31	241894.93	1063668.6
20 : 80	Multi skill	Processing	516044.6	590433.86	262444.41	1148289.8
20 : 80	Multi skill	Continuous	505799.2	585372.71	256982.05	1128930.2
20 : 80	Multi skill	Maximum M/C	517752.17	587838.4	263113.27	1156970.6
20 : 80	Random allocate	Processing	531412.7	611857.06	271216.21	1191742.8
20 : 80	Random allocate	Continuous	516044.6	598001.13	263479.68	1153590.1
20 : 80	Random allocate	Maximum M/C	533974.05	604751.46	272163.54	1196766.8
0 : 100	Single skill	Processing	502779.5	579203.82	242470.18	1065162.2
0 : 100	Single skill	Continuous	496955.8	578752.9	242186.32	1064569.1
0 : 100	Single skill	Maximum M/C	503750.12	578972.58	242504.94	1066351
0 : 100	Random allocate	Processing	616341.67	651478.56	306246.84	1344773.1
0 : 100	Random allocate	Continuous	572663.91	621356.96	289428.29	1261832.4
0 : 100	Random allocate	Maximum M/C	623621.29	636031.58	308306.26	1355694.8

Appendix Table B3 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 3,data 6).

			FIFO	EDD	SPT	LPT
Cmax Company			**578159.3**			
Cmax Standard			**451424.55**	**401859.36**	**190574.44**	**695359.94**
100 : 0			451424.55	401859.36	190574.44	695359.94
80 : 20	Single skill	Processing	451438.29	401862.38	190577.77	695369.55
80 : 20	Single skill	Continuous	451433.73	401861.16	190576.9	695368.04
80 : 20	Single skill	Maximum M/C	451439.05	401861.75	190577.88	695372.59
80 : 20	Multi skill	Processing	451499.84	401932.06	190715.43	695842.62
80 : 20	Multi skill	Continuous	451474.76	401902.23	190678.87	695735.09
80 : 20	Multi skill	Maximum M/C	451504.02	401916.76	190719.91	695890.84
80 : 20	Random allocate	Processing	451537.46	402058.32	190774.15	696083.98
80 : 20	Random allocate	Continuous	451499.84	401976.66	190722.36	695872.06
80 : 20	Random allocate	Maximum M/C	451543.73	402016.44	190780.49	696111.88
50 : 50	Single skill	Processing	454945.71	402154.89	190908.94	696317.91
50 : 50	Single skill	Continuous	453772.01	402033.58	190822.21	696167.54
50 : 50	Single skill	Maximum M/C	455141.33	402092.68	190919.56	696619.31
50 : 50	Multi skill	Processing	469030.16	409069.29	204569.34	743260.46
50 : 50	Multi skill	Continuous	463161.64	406109.44	200941.02	732589.94
50 : 50	Multi skill	Maximum M/C	470008.25	407551.42	205013.62	748045.14
50 : 50	Random allocate	Processing	477832.94	421597.95	210395.92	767210.74
50 : 50	Random allocate	Continuous	469030.16	413494.75	205257.01	746181.86
50 : 50	Random allocate	Maximum M/C	479300.07	417442.46	211025.17	769979.83
20 : 80	Single skill	Processing	457142.64	402210.63	190972.04	696498.62
20 : 80	Single skill	Continuous	455236.63	402066.44	190868.95	696319.88
20 : 80	Single skill	Maximum M/C	457460.31	402136.68	190984.67	696856.87
20 : 80	Multi skill	Processing	480014.82	410429.29	207209.21	752295.97
20 : 80	Multi skill	Continuous	470484.75	406911.13	202896.48	739612.66
20 : 80	Multi skill	Maximum M/C	481603.17	408625.1	207737.3	757983.18
20 : 80	Random allocate	Processing	494309.94	425321.24	214134.86	780764
20 : 80	Random allocate	Continuous	480014.82	415689.54	208026.59	755768.43
20 : 80	Random allocate	Maximum M/C	496692.46	420381.9	214882.81	784055.42
0 : 100	Single skill	Processing	467675.89	402622.93	191438.85	697835.38
0 : 100	Single skill	Continuous	462258.79	402309.48	191214.73	697446.81
0 : 100	Single skill	Maximum M/C	468578.73	402462.19	191466.29	698614.18
0 : 100	Random allocate	Processing	573309.24	452863.4	241792.79	881020.99
0 : 100	Random allocate	Continuous	532681.03	431924.91	228513.95	826682.79
0 : 100	Random allocate	Maximum M/C	580080.61	442125.71	243418.78	888176.25

Appendix Table B4 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 4,data 1).

			FIFO	EDD	SPT	LPT
Cmax Company			**135958.3**			
Cmax Standard			**198000**	**162250**	**81000**	**224500**
100 : 0			198000	162250	81000	224500
80 : 20	Single skill	Processing	198006.01	162251.2	81001.433	224503.12
80 : 20	Single skill	Continuous	198004	162250.71	81001.061	224502.63
80 : 20	Single skill	Maximum M/C	198006.34	162250.95	81001.478	224504.1
80 : 20	Multi skill	Processing	198033	162279.34	81059.944	224655.85
80 : 20	Multi skill	Continuous	198022	162267.29	81044.403	224621.13
80 : 20	Multi skill	Maximum M/C	198034.83	162273.16	81061.847	224671.42
80 : 20	Random allocate	Processing	198049.5	162330.31	81084.901	224733.77
80 : 20	Random allocate	Continuous	198033	162297.34	81062.889	224665.35
80 : 20	Random allocate	Maximum M/C	198052.25	162313.4	81087.596	224742.78
50 : 50	Single skill	Processing	199544.4	162369.3	81142.19	224809.3
50 : 50	Single skill	Continuous	199029.6	162320.33	81105.326	224760.75
50 : 50	Single skill	Maximum M/C	199630.2	162344.19	81146.704	224906.61
50 : 50	Multi skill	Processing	205722	165160.98	86948.281	239964.91
50 : 50	Multi skill	Continuous	203148	163965.95	85406.134	236519.88
50 : 50	Multi skill	Maximum M/C	206151	164548.14	87137.116	241509.66
50 : 50	Random allocate	Processing	209583	170219.4	89424.757	247697.36
50 : 50	Random allocate	Continuous	205722	166947.75	87240.561	240908.09
50 : 50	Random allocate	Maximum M/C	210226.5	168541.63	89692.21	248591.37
20 : 80	Single skill	Processing	200508	162391.81	81169.011	224867.64
20 : 80	Single skill	Continuous	199672	162333.59	81125.194	224809.93
20 : 80	Single skill	Maximum M/C	200647.33	162361.95	81174.377	224983.3
20 : 80	Multi skill	Processing	210540	165710.08	88070.309	242882.06
20 : 80	Multi skill	Continuous	206360	164289.63	86237.266	238787.2
20 : 80	Multi skill	Maximum M/C	211236.67	164981.64	88294.763	244718.2
20 : 80	Random allocate	Processing	216810	171722.67	91013.923	252073.09
20 : 80	Random allocate	Continuous	210540	167833.89	88417.721	244003.16
20 : 80	Random allocate	Maximum M/C	217855	169728.43	91331.825	253135.74
0 : 100	Single skill	Processing	205128	162558.28	81367.416	225299.22
0 : 100	Single skill	Continuous	202752	162431.72	81272.16	225173.77
0 : 100	Single skill	Maximum M/C	205524	162493.38	81379.08	225550.66
0 : 100	Random allocate	Processing	251460	182842.77	102769.4	284441.5
0 : 100	Random allocate	Continuous	233640	174388.9	97125.48	266898.17
0 : 100	Random allocate	Maximum M/C	254430	178507.45	103460.49	286751.61

Appendix Table B4 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 4,data 2).

			FIFO	EDD	SPT	LPT
Cmax Company			**57658**			
Cmax Standard			**117619.5**	**68937.75**	**52806**	**205177.5**
100 : 0			117619.5	68937.75	52806	205177.5
80 : 20	Single skill	Processing	117623.07	68938.311	52806.934	205180.35
80 : 20	Single skill	Continuous	117621.88	68938.101	52806.692	205179.9
80 : 20	Single skill	Maximum M/C	117623.27	68938.203	52806.964	205181.24
80 : 20	Multi skill	Processing	117639.1	68950.264	52845.079	205319.93
80 : 20	Multi skill	Continuous	117632.57	68945.147	52834.947	205288.2
80 : 20	Multi skill	Maximum M/C	117640.19	68947.64	52846.32	205334.16
80 : 20	Random allocate	Processing	117648.9	68971.923	52861.349	205391.15
80 : 20	Random allocate	Continuous	117639.1	68957.915	52846.999	205328.62
80 : 20	Random allocate	Maximum M/C	117650.54	68964.74	52863.106	205399.39
50 : 50	Single skill	Processing	118536.93	68988.49	52898.697	205460.18
50 : 50	Single skill	Continuous	118231.12	68967.68	52874.665	205415.81
50 : 50	Single skill	Maximum M/C	118587.9	68977.818	52901.64	205549.11
50 : 50	Multi skill	Processing	122206.66	70174.635	56683.839	219311.36
50 : 50	Multi skill	Continuous	120677.61	69666.882	55678.473	216162.84
50 : 50	Multi skill	Maximum M/C	122461.5	69914.249	56806.945	220723.15
50 : 50	Random allocate	Processing	124500.24	72323.89	58298.318	226378.29
50 : 50	Random allocate	Continuous	122206.66	70933.811	56874.383	220173.36
50 : 50	Random allocate	Maximum M/C	124882.5	71611.029	58472.677	227195.35
20 : 80	Single skill	Processing	119109.35	68998.052	52916.183	205513.5
20 : 80	Single skill	Continuous	118612.73	68973.317	52887.617	205460.76
20 : 80	Single skill	Maximum M/C	119192.12	68985.367	52919.681	205619.21
20 : 80	Multi skill	Processing	125068.74	70407.94	57415.317	221977.43
20 : 80	Multi skill	Continuous	122585.66	69804.409	56220.309	218235.01
20 : 80	Multi skill	Maximum M/C	125482.58	70098.437	57561.645	223655.54
20 : 80	Random allocate	Processing	128793.35	72962.609	59334.336	230377.4
20 : 80	Random allocate	Continuous	125068.74	71310.319	57641.805	223002.04
20 : 80	Random allocate	Maximum M/C	129414.12	72115.281	59541.585	231348.59
0 : 100	Single skill	Processing	121853.8	69068.782	53045.528	205907.93
0 : 100	Single skill	Continuous	120442.37	69015.01	52983.428	205793.28
0 : 100	Single skill	Maximum M/C	122089.04	69041.207	53053.132	206137.73
0 : 100	Random allocate	Processing	149376.77	77687.386	66998.035	259959.89
0 : 100	Random allocate	Continuous	138791.01	74095.45	63318.618	243926.5
0 : 100	Random allocate	Maximum M/C	151141.06	75845.368	67448.576	262071.17

Appendix Table B4 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 4,data 3).

			FIFO	EDD	SPT	LPT
Cmax Company			**97812.22**			
Cmax Standard			72296.471	120190.59	49934.118	190461.18
100 : 0			72296.471	120190.59	49934.118	190461.18
80 : 20	Single skill	Processing	72298.664	120191.48	49935.001	190463.82
80 : 20	Single skill	Continuous	72297.933	120191.11	49934.772	190463.41
80 : 20	Single skill	Maximum M/C	72298.786	120191.29	49935.029	190464.66
80 : 20	Multi skill	Processing	72308.52	120212.32	49971.072	190593.4
80 : 20	Multi skill	Continuous	72304.504	120203.4	49961.491	190563.94
80 : 20	Multi skill	Maximum M/C	72309.19	120207.75	49972.245	190606.61
80 : 20	Random allocate	Processing	72314.545	120250.08	49986.457	190659.51
80 : 20	Random allocate	Continuous	72308.52	120225.66	49972.887	190601.46
80 : 20	Random allocate	Maximum M/C	72315.549	120237.56	49988.118	190667.15
50 : 50	Single skill	Processing	72860.383	120278.97	50021.774	190723.58
50 : 50	Single skill	Continuous	72672.413	120242.69	49999.048	190682.39
50 : 50	Single skill	Maximum M/C	72891.712	120260.36	50024.557	190806.14
50 : 50	Multi skill	Processing	75116.033	122346.97	53601.059	203581.29
50 : 50	Multi skill	Continuous	74176.179	121461.72	52650.37	200658.6
50 : 50	Multi skill	Maximum M/C	75272.676	121892.99	53717.469	204891.83
50 : 50	Random allocate	Processing	76525.815	126094.12	55127.733	210141.34
50 : 50	Random allocate	Continuous	75116.033	123670.56	53781.24	204381.47
50 : 50	Random allocate	Maximum M/C	76760.778	124851.27	55292.61	210899.8
20 : 80	Single skill	Processing	73212.226	120295.64	50038.309	190773.08
20 : 80	Single skill	Continuous	72906.975	120252.51	50011.296	190724.12
20 : 80	Single skill	Maximum M/C	73263.102	120273.52	50041.616	190871.2
20 : 80	Multi skill	Processing	76875.247	122753.73	54292.755	206056.14
20 : 80	Multi skill	Continuous	75348.989	121701.49	53162.738	202582.14
20 : 80	Multi skill	Maximum M/C	77129.624	122214.12	54431.125	207613.89
20 : 80	Random allocate	Processing	79164.636	127207.7	56107.407	213853.62
20 : 80	Random allocate	Continuous	76875.247	124326.99	54506.925	207007.26
20 : 80	Random allocate	Maximum M/C	79546.2	125730.41	56303.385	214755.15
0 : 100	Single skill	Processing	74899.144	120418.95	50160.619	191139.22
0 : 100	Single skill	Continuous	74031.586	120325.2	50101.897	191032.79
0 : 100	Single skill	Maximum M/C	75043.737	120370.88	50167.81	191352.54
0 : 100	Random allocate	Processing	91816.518	135445.18	63354.312	241314.32
0 : 100	Random allocate	Continuous	85309.836	129182.77	59875.002	226430.92
0 : 100	Random allocate	Maximum M/C	92900.965	132233.69	63780.35	243274.16

Appendix Table B4 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 4,data 4).

			FIFO	EDD	SPT	LPT
Cmax Company			**74236.32**			
Cmax Standard			**96368**	**88432.67**	**63460.67**	**168238**
100 : 0			96368	88432.67	63460.67	168238
80 : 20	Single skill	Processing	96370.923	88433.325	63461.793	168240.34
80 : 20	Single skill	Continuous	96369.949	88433.056	63461.502	168239.97
80 : 20	Single skill	Maximum M/C	96371.086	88433.187	63461.828	168241.07
80 : 20	Multi skill	Processing	96384.061	88448.659	63507.634	168354.79
80 : 20	Multi skill	Continuous	96378.708	88442.095	63495.458	168328.77
80 : 20	Multi skill	Maximum M/C	96384.954	88445.293	63509.125	168366.46
80 : 20	Random allocate	Processing	96392.092	88476.443	63527.187	168413.19
80 : 20	Random allocate	Continuous	96384.061	88458.473	63509.942	168361.91
80 : 20	Random allocate	Maximum M/C	96393.43	88467.228	63529.298	168419.94
50 : 50	Single skill	Processing	97119.67	88497.695	63572.071	168469.78
50 : 50	Single skill	Continuous	96869.114	88471	63543.189	168433.4
50 : 50	Single skill	Maximum M/C	97161.43	88484.005	63575.607	168542.71
50 : 50	Multi skill	Processing	100126.35	90019.269	68120.941	179827.24
50 : 50	Multi skill	Continuous	98873.568	89367.928	66912.722	177245.58
50 : 50	Multi skill	Maximum M/C	100335.15	89685.248	68268.886	180984.86
50 : 50	Random allocate	Processing	102005.53	92776.309	70061.173	185621.86
50 : 50	Random allocate	Continuous	100126.35	90993.131	68349.931	180534.06
50 : 50	Random allocate	Maximum M/C	102318.72	91861.859	70270.713	186291.83
20 : 80	Single skill	Processing	97588.661	88509.96	63593.084	168513.51
20 : 80	Single skill	Continuous	97181.774	88478.231	63558.755	168470.26
20 : 80	Single skill	Maximum M/C	97656.476	88493.689	63597.288	168600.18
20 : 80	Multi skill	Processing	102471.31	90318.55	69000.01	182013.33
20 : 80	Multi skill	Continuous	100436.87	89544.346	67563.885	178944.68
20 : 80	Multi skill	Maximum M/C	102810.38	89921.522	69175.862	183389.31
20 : 80	Random allocate	Processing	105522.96	93595.652	71306.229	188900.99
20 : 80	Random allocate	Continuous	102471.31	91476.112	69272.195	182853.47
20 : 80	Random allocate	Maximum M/C	106031.57	92508.709	71555.294	189697.33
0 : 100	Single skill	Processing	99837.248	88600.692	63748.528	168836.93
0 : 100	Single skill	Continuous	98680.832	88531.715	63673.898	168742.92
0 : 100	Single skill	Maximum M/C	100029.98	88565.319	63757.666	169025.35
0 : 100	Random allocate	Processing	122387.36	99656.544	80516.233	213157.55
0 : 100	Random allocate	Continuous	113714.24	95048.849	76094.42	200010.76
0 : 100	Random allocate	Maximum M/C	123832.88	97293.624	81057.679	214888.72

Appendix Table B4 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 4,data 5).

			FIFO	EDD	SPT	LPT
Cmax Company			**97138.42**			
Cmax Standard			**118560**	**116052.63**	**49146.316**	**169822.11**
100 : 0			118560	116052.63	49146.316	169822.11
80 : 20	Single skill	Processing	118563.6	116053.49	49147.185	169824.47
80 : 20	Single skill	Continuous	118562.4	116053.14	49146.96	169824.1
80 : 20	Single skill	Maximum M/C	118563.8	116053.31	49147.213	169825.21
80 : 20	Multi skill	Processing	118579.76	116073.61	49182.687	169940
80 : 20	Multi skill	Continuous	118573.17	116065	49173.257	169913.74
80 : 20	Multi skill	Maximum M/C	118580.86	116069.2	49183.841	169951.78
80 : 20	Random allocate	Processing	118589.64	116110.07	49197.829	169998.95
80 : 20	Random allocate	Continuous	118579.76	116086.49	49184.474	169947.19
80 : 20	Random allocate	Maximum M/C	118591.29	116097.98	49199.464	170005.76
50 : 50	Single skill	Processing	119484.77	116137.96	49232.589	170056.08
50 : 50	Single skill	Continuous	119176.51	116102.93	49210.222	170019.35
50 : 50	Single skill	Maximum M/C	119536.14	116120	49235.328	170129.69
50 : 50	Multi skill	Processing	123183.84	118134.77	52755.404	181520.48
50 : 50	Multi skill	Continuous	121642.56	117280	51819.714	178914.5
50 : 50	Multi skill	Maximum M/C	123440.72	117696.42	52869.978	182689
50 : 50	Random allocate	Processing	125495.76	121752.91	54257.992	187369.66
50 : 50	Random allocate	Continuous	123183.84	119412.79	52932.743	182233.94
50 : 50	Random allocate	Maximum M/C	125881.08	120552.85	54420.268	188045.93
20 : 80	Single skill	Processing	120061.76	116154.06	49248.863	170100.21
20 : 80	Single skill	Continuous	119561.17	116112.42	49222.277	170056.56
20 : 80	Single skill	Maximum M/C	120145.19	116132.71	49252.118	170187.7
20 : 80	Multi skill	Processing	126068.8	118527.52	53436.188	183727.14
20 : 80	Multi skill	Continuous	123565.87	117511.51	52323.999	180629.6
20 : 80	Multi skill	Maximum M/C	126485.96	118006.49	53572.374	185116.09
20 : 80	Random allocate	Processing	129823.2	122828.15	55222.21	190679.66
20 : 80	Random allocate	Continuous	126068.8	120046.62	53646.978	184575.2
20 : 80	Random allocate	Maximum M/C	130448.93	121401.73	55415.096	191483.5
0 : 100	Single skill	Processing	122828.16	116273.13	49369.244	170426.68
0 : 100	Single skill	Continuous	121405.44	116182.61	49311.448	170331.78
0 : 100	Single skill	Maximum M/C	123065.28	116226.71	49376.321	170616.88
0 : 100	Random allocate	Processing	150571.2	130782.03	62354.782	215164.61
0 : 100	Random allocate	Continuous	139900.8	124735.22	58930.365	201894.03
0 : 100	Random allocate	Maximum M/C	152349.6	127681.1	62774.098	216912.08

Appendix Table B4 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 4,data 6).

			FIFO	EDD	SPT	LPT
Cmax Company			**115973.5**			
Cmax Standard			**121883.08**	**138495**	**69785.769**	**189881.54**
100 : 0			121883.08	138495	69785.769	189881.54
80 : 20	Single skill	Processing	121886.8	138496.03	69787.005	189884.18
80 : 20	Single skill	Continuous	121885.56	138495.6	69786.684	189883.76
80 : 20	Single skill	Maximum M/C	121887	138495.81	69787.044	189885.01
80 : 20	Multi skill	Processing	121903.41	138520.04	69837.415	190013.36
80 : 20	Multi skill	Continuous	121896.64	138509.76	69824.025	189983.99
80 : 20	Multi skill	Maximum M/C	121904.54	138514.77	69839.054	190026.52
80 : 20	Random allocate	Processing	121913.57	138563.55	69858.916	190079.26
80 : 20	Random allocate	Continuous	121903.41	138535.41	69839.953	190021.4
80 : 20	Random allocate	Maximum M/C	121915.26	138549.12	69861.238	190086.88
50 : 50	Single skill	Processing	122833.79	138596.84	69908.274	190143.14
50 : 50	Single skill	Continuous	122516.89	138555.03	69876.514	190102.08
50 : 50	Single skill	Maximum M/C	122886.6	138575.4	69912.163	190225.45
50 : 50	Multi skill	Processing	126636.54	140979.78	74910.528	202961.72
50 : 50	Multi skill	Continuous	125052.06	139959.71	73581.887	200047.93
50 : 50	Multi skill	Maximum M/C	126900.62	140456.67	75073.219	204268.27
50 : 50	Random allocate	Processing	129013.26	145297.6	77044.142	209501.81
50 : 50	Random allocate	Continuous	126636.54	142504.96	75162.342	203759.46
50 : 50	Random allocate	Maximum M/C	129409.38	143865.48	77274.567	210257.96
20 : 80	Single skill	Processing	123426.95	138616.04	69931.382	190192.49
20 : 80	Single skill	Continuous	122912.34	138566.35	69893.631	190143.68
20 : 80	Single skill	Maximum M/C	123512.72	138590.56	69936.005	190290.32
20 : 80	Multi skill	Processing	129602.36	141448.49	75877.214	205429.04
20 : 80	Multi skill	Continuous	127029.28	140236	74297.95	201965.62
20 : 80	Multi skill	Maximum M/C	130031.21	140826.7	76070.593	206982.04
20 : 80	Random allocate	Processing	133461.99	146580.78	78413.293	213202.79
20 : 80	Random allocate	Continuous	129602.36	143261.36	76176.528	206377.26
20 : 80	Random allocate	Maximum M/C	134105.27	144878.51	78687.182	214101.58
0 : 100	Single skill	Processing	126270.89	138758.14	70102.318	190557.52
0 : 100	Single skill	Continuous	124808.29	138650.11	70020.25	190451.41
0 : 100	Single skill	Maximum M/C	126514.66	138702.74	70112.367	190770.19
0 : 100	Random allocate	Processing	154791.54	156072.79	88541.254	240579.91
0 : 100	Random allocate	Continuous	143822.06	148856.64	83678.721	225741.81
0 : 100	Random allocate	Maximum M/C	156619.78	152372.2	89136.666	242533.79

Appendix Table B5 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 5,data 1).

			FIFO	EDD	SPT	LPT
Cmax Company			**686073**			
Cmax Standard			**435039.02**	**404693.52**	**252858.94**	**619476.73**
100 : 0			435039.02	404693.52	252858.94	619476.73
80 : 20	Single skill	Processing	435052.2	404696.52	252863.41	619485.33
80 : 20	Single skill	Continuous	435047.8	404695.29	252863.56	619488.32
80 : 20	Single skill	Maximum M/C	435052.93	404695.89	252862.25	619483.8
80 : 20	Multi skill	Processing	435111.51	404766.69	253046.07	619906.77
80 : 20	Multi skill	Continuous	435087.34	404736.65	252997.55	619810.97
80 : 20	Multi skill	Maximum M/C	435115.53	404751.29	253052.01	619949.73
80 : 20	Random allocate	Processing	435147.76	404893.84	253123.98	620121.79
80 : 20	Random allocate	Continuous	435111.51	404811.6	253055.26	619933
80 : 20	Random allocate	Maximum M/C	435153.8	404851.67	253132.39	620146.65
50 : 50	Single skill	Processing	438432.3	404991.09	253302.82	620330.2
50 : 50	Single skill	Continuous	437301.2	404868.93	253187.74	620196.23
50 : 50	Single skill	Maximum M/C	438620.82	404928.44	253316.91	620598.7
50 : 50	Multi skill	Processing	452005.52	411954.26	271427.78	662150
50 : 50	Multi skill	Continuous	446350.01	408973.53	266613.64	652643.93
50 : 50	Multi skill	Maximum M/C	452948.11	410425.68	272017.27	666412.54
50 : 50	Random allocate	Processing	460488.78	424571.27	279158.63	683486.64
50 : 50	Random allocate	Continuous	452005.52	416410.93	272340.19	664752.59
50 : 50	Random allocate	Maximum M/C	461902.66	420386.48	279993.54	685953.54
20 : 80	Single skill	Processing	440549.49	405047.22	253386.55	620491.19
20 : 80	Single skill	Continuous	438712.66	404902.02	253249.76	620331.95
20 : 80	Single skill	Maximum M/C	440855.63	404972.76	253403.29	620810.34
20 : 80	Multi skill	Processing	462591.47	413323.85	274930.43	670199.48
20 : 80	Multi skill	Continuous	453407.31	409780.87	269208.19	658900.28
20 : 80	Multi skill	Maximum M/C	464122.16	411506.94	275631.11	675266.06
20 : 80	Random allocate	Processing	476367.71	428320.82	284119.56	695560.86
20 : 80	Random allocate	Continuous	462591.47	418621.19	276014.95	673293
20 : 80	Random allocate	Maximum M/C	478663.74	423346.65	285111.96	698493.09
0 : 100	Single skill	Processing	450700.4	405462.44	254005.91	621682.07
0 : 100	Single skill	Continuous	445479.94	405146.78	253708.55	621335.9
0 : 100	Single skill	Maximum M/C	451570.48	405300.56	254042.32	622375.88
0 : 100	Random allocate	Processing	552499.53	456057.22	320816.8	784877.02
0 : 100	Random allocate	Continuous	513346.02	434971.07	303198.1	736468.63
0 : 100	Random allocate	Maximum M/C	559025.12	445243.81	322974.2	791251.43

Appendix Table B5 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 5,data 2).

			FIFO	EDD	SPT	LPT
Cmax Company			**526005**			
Cmax Standard			**396983.38**	**307317.03**	**179208.53**	**637949.45**
100 : 0			396983.38	307317.03	179208.53	637949.45
80 : 20	Single skill	Processing	396995.44	307319.31	179211.7	637958.31
80 : 20	Single skill	Continuous	396991.43	307318.37	179210.88	637956.92
80 : 20	Single skill	Maximum M/C	396996.11	307318.83	179211.8	637961.09
80 : 20	Multi skill	Processing	397049.56	307372.59	179341.15	638392.31
80 : 20	Multi skill	Continuous	397027.51	307349.78	179306.77	638293.66
80 : 20	Multi skill	Maximum M/C	397053.24	307360.9	179345.36	638436.55
80 : 20	Random allocate	Processing	397082.65	307469.15	179396.37	638613.75
80 : 20	Random allocate	Continuous	397049.56	307406.7	179347.67	638419.32
80 : 20	Random allocate	Maximum M/C	397088.16	307437.12	179402.33	638639.35
50 : 50	Single skill	Processing	400079.87	307543	179523.12	638828.37
50 : 50	Single skill	Continuous	399047.71	307450.23	179441.56	638690.41
50 : 50	Single skill	Maximum M/C	400251.9	307495.43	179533.11	639104.88
50 : 50	Multi skill	Processing	412465.75	312830.7	192368.81	681895.24
50 : 50	Multi skill	Continuous	407304.97	310567.2	188956.89	672105.69
50 : 50	Multi skill	Maximum M/C	413325.88	311669.93	192786.6	686284.88
50 : 50	Random allocate	Processing	420206.93	322411.84	197847.89	703868.13
50 : 50	Random allocate	Continuous	412465.75	316215.02	193015.46	684575.43
50 : 50	Random allocate	Maximum M/C	421497.12	319233.99	198439.62	706408.59
20 : 80	Single skill	Processing	402011.86	307585.63	179582.46	638994.16
20 : 80	Single skill	Continuous	400335.7	307475.36	179485.51	638830.17
20 : 80	Single skill	Maximum M/C	402291.22	307529.08	179594.33	639322.83
20 : 80	Multi skill	Processing	422125.68	313870.75	194851.24	690184.75
20 : 80	Multi skill	Continuous	413744.92	311180.28	190795.72	678548.6
20 : 80	Multi skill	Maximum M/C	423522.48	312491.02	195347.84	695402.41
20 : 80	Random allocate	Processing	434696.82	325259.18	201363.84	716302.4
20 : 80	Random allocate	Continuous	422125.68	317893.46	195619.87	693370.52
20 : 80	Random allocate	Maximum M/C	436792.01	321481.89	202067.19	719322.07
0 : 100	Single skill	Processing	411274.8	307900.93	180021.42	640220.55
0 : 100	Single skill	Continuous	406511	307661.23	179810.67	639864.06
0 : 100	Single skill	Maximum M/C	412068.77	307778.01	180047.23	640935.05
0 : 100	Random allocate	Processing	504168.92	346321.71	227372.26	808281.95
0 : 100	Random allocate	Continuous	468440.41	330309.26	214885.36	758430.03
0 : 100	Random allocate	Maximum M/C	510123.67	338110.2	228901.26	814846.45

Appendix Table B5 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 5,data 3).

			FIFO	EDD	SPT	LPT
Cmax Company			**716643.8**			
Cmax Standard			**398149.5**	**363040.46**	**173463.04**	**504931.31**
100 : 0			398149.5	363040.46	173463.04	504931.31
80 : 20	Single skill	Processing	398161.58	363043.15	173466.11	504938.32
80 : 20	Single skill	Continuous	398157.55	363042.05	173465.31	504937.22
80 : 20	Single skill	Maximum M/C	398162.25	363042.58	173466.21	504940.53
80 : 20	Multi skill	Processing	398215.86	363106.1	173591.41	505281.83
80 : 20	Multi skill	Continuous	398193.74	363079.15	173558.13	505203.75
80 : 20	Multi skill	Maximum M/C	398219.54	363092.28	173595.49	505316.85
80 : 20	Random allocate	Processing	398249.04	363220.16	173644.86	505457.09
80 : 20	Random allocate	Continuous	398215.86	363146.39	173597.72	505303.21
80 : 20	Random allocate	Maximum M/C	398254.57	363182.33	173650.63	505477.36
50 : 50	Single skill	Processing	401255.07	363307.4	173767.54	505626.96
50 : 50	Single skill	Continuous	400219.88	363197.82	173688.6	505517.77
50 : 50	Single skill	Maximum M/C	401427.6	363251.2	173777.21	505845.82
50 : 50	Multi skill	Processing	413677.33	369553.89	186201.4	539714.01
50 : 50	Multi skill	Continuous	408501.39	366879.95	182898.86	531965.67
50 : 50	Multi skill	Maximum M/C	414539.99	368182.64	186605.79	543188.37
50 : 50	Random allocate	Processing	421441.25	380872.3	191504.82	557105.36
50 : 50	Random allocate	Continuous	413677.33	373551.86	186827.32	541835.36
50 : 50	Random allocate	Maximum M/C	422735.23	377118.23	192077.57	559116.11
20 : 80	Single skill	Processing	403192.73	363357.76	173824.98	505758.19
20 : 80	Single skill	Continuous	401511.65	363227.5	173731.14	505628.39
20 : 80	Single skill	Maximum M/C	403472.91	363290.96	173836.47	506018.33
20 : 80	Multi skill	Processing	423365.64	370782.52	188604.24	546275.09
20 : 80	Multi skill	Continuous	414960.26	367604.2	184678.74	537065.18
20 : 80	Multi skill	Maximum M/C	424766.53	369152.61	189084.91	550404.82
20 : 80	Random allocate	Processing	435973.7	384235.92	194908.05	566946.97
20 : 80	Random allocate	Continuous	423365.64	375534.63	189348.23	548796.59
20 : 80	Random allocate	Maximum M/C	438075.05	379773.72	195588.84	569337.02
0 : 100	Single skill	Processing	412482.88	363730.24	174249.87	506728.87
0 : 100	Single skill	Continuous	407705.09	363447.07	174045.88	506446.71
0 : 100	Single skill	Maximum M/C	413279.18	363585.02	174274.85	507294.39
0 : 100	Random allocate	Processing	505649.87	409117.56	220082.62	639747.97
0 : 100	Random allocate	Continuous	469816.41	390201.7	207996.06	600290.62
0 : 100	Random allocate	Maximum M/C	511622.11	399417.11	221562.61	644943.71

Appendix Table B5 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 5,data 4).

			FIFO	EDD	SPT	LPT
Cmax Company			**598720.3**			
Cmax Standard			**351547.12**	**353494.92**	**165555.25**	**483302.37**
100 : 0			351547.1	353494.9	165555.3	483302.4
80 : 20	Single skill	Processing	351557.76	353497.54	165558.18	483309.08
80 : 20	Single skill	Continuous	351554.21	353496.46	165557.42	483308.03
80 : 20	Single skill	Maximum M/C	351558.36	353496.99	165558.27	483311.19
80 : 20	Multi skill	Processing	351605.69	353558.83	165677.77	483637.88
80 : 20	Multi skill	Continuous	351586.16	353532.6	165646	483563.14
80 : 20	Multi skill	Maximum M/C	351608.95	353545.38	165681.66	483671.39
80 : 20	Random allocate	Processing	351634.99	353669.9	165728.78	483805.63
80 : 20	Random allocate	Continuous	351605.69	353598.06	165683.79	483658.34
80 : 20	Random allocate	Maximum M/C	351639.87	353633.06	165734.29	483825.03
50 : 50	Single skill	Processing	354289.17	353754.84	165845.87	483968.23
50 : 50	Single skill	Continuous	353375.14	353648.14	165770.52	483863.71
50 : 50	Single skill	Maximum M/C	354441.5	353700.12	165855.1	484177.71
50 : 50	Multi skill	Processing	365257.44	359837.09	177712.89	516595.14
50 : 50	Multi skill	Continuous	360687.32	357233.46	174560.91	509178.71
50 : 50	Multi skill	Maximum M/C	366019.12	358501.89	178098.85	519920.67
50 : 50	Random allocate	Processing	372112.61	370857.9	182774.54	533241.52
50 : 50	Random allocate	Continuous	365257.44	363729.94	178310.28	518625.62
50 : 50	Random allocate	Maximum M/C	373255.13	367202.53	183321.19	535166.14
20 : 80	Single skill	Processing	356000.03	353803.87	165900.69	484093.83
20 : 80	Single skill	Continuous	354515.72	353677.04	165811.13	483969.59
20 : 80	Single skill	Maximum M/C	356247.41	353738.83	165911.66	484342.82
20 : 80	Multi skill	Processing	373811.75	361033.41	180006.2	522875.17
20 : 80	Multi skill	Continuous	366390.2	357938.66	176259.66	514059.77
20 : 80	Multi skill	Maximum M/C	375048.67	359446.36	180464.96	526828
20 : 80	Random allocate	Processing	384944.07	374133.08	186022.63	542661.57
20 : 80	Random allocate	Continuous	373811.75	365660.57	180716.27	525288.66
20 : 80	Random allocate	Maximum M/C	386799.46	369788.21	186672.39	544949.23
0 : 100	Single skill	Processing	364202.8	354166.56	166306.21	485022.93
0 : 100	Single skill	Continuous	359984.23	353890.83	166111.52	484752.86
0 : 100	Single skill	Maximum M/C	364905.89	354025.16	166330.05	485564.23
0 : 100	Random allocate	Processing	446464.82	398360.5	210049.55	612344.1
0 : 100	Random allocate	Continuous	414825.58	379942	198513.99	574576.92
0 : 100	Random allocate	Maximum M/C	451738.02	388915.11	211462.07	617317.28

Appendix Table B5 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 5,data 5).

			FIFO	EDD	SPT	LPT
Cmax Company			**778044.5**			
Cmax Standard			**473862.88**	**464967.77**	**197871.61**	**671356.04**
100 : 0			473862.88	464967.77	197871.61	671356.04
80 : 20	Single skill	Processing	473877.27	464971.22	197875.11	671365.36
80 : 20	Single skill	Continuous	473872.48	464969.8	197874.2	671363.9
80 : 20	Single skill	Maximum M/C	473878.07	464970.49	197875.22	671368.29
80 : 20	Multi skill	Processing	473941.88	465051.84	198018.04	671822.1
80 : 20	Multi skill	Continuous	473915.55	465017.33	197980.08	671718.27
80 : 20	Multi skill	Maximum M/C	473946.26	465034.14	198022.69	671868.65
80 : 20	Random allocate	Processing	473981.37	465197.92	198079.01	672055.12
80 : 20	Random allocate	Continuous	473941.88	465103.44	198025.24	671850.52
80 : 20	Random allocate	Maximum M/C	473987.95	465149.47	198085.59	672082.07
50 : 50	Single skill	Processing	477559.03	465309.66	198218.96	672280.98
50 : 50	Single skill	Continuous	476326.99	465169.31	198128.91	672135.8
50 : 50	Single skill	Maximum M/C	477764.37	465237.68	198229.99	672571.97
50 : 50	Multi skill	Processing	492343.55	473309.91	212402.42	717603.07
50 : 50	Multi skill	Continuous	486183.34	469885.24	208635.18	707300.9
50 : 50	Multi skill	Maximum M/C	493370.26	471553.67	212863.72	722222.58
50 : 50	Random allocate	Processing	501583.88	487806.08	218452.11	740726.59
50 : 50	Random allocate	Continuous	492343.55	478430.35	213116.42	720423.62
50 : 50	Random allocate	Maximum M/C	503123.93	482998.01	219105.46	743400.08
20 : 80	Single skill	Processing	479865.16	465374.15	198284.48	672455.45
20 : 80	Single skill	Continuous	477864.41	465207.32	198177.44	672282.88
20 : 80	Single skill	Maximum M/C	480198.62	465288.6	198297.59	672801.34
20 : 80	Multi skill	Processing	503874.22	474883.49	215143.38	726326.67
20 : 80	Multi skill	Continuous	493870.44	470812.82	210665.51	714081.19
20 : 80	Multi skill	Maximum M/C	505541.51	472795.97	215691.69	731817.56
20 : 80	Random allocate	Processing	518879.88	492114.08	222334.22	753811.99
20 : 80	Random allocate	Continuous	503874.22	480969.8	215992.06	729679.26
20 : 80	Random allocate	Maximum M/C	521380.82	486399.06	223110.81	756989.79
0 : 100	Single skill	Processing	490921.96	465851.21	198769.16	673746.07
0 : 100	Single skill	Continuous	485235.61	465488.53	198536.46	673370.91
0 : 100	Single skill	Maximum M/C	491869.69	465665.22	198797.65	674497.99
0 : 100	Random allocate	Processing	601805.88	523981.48	251051.19	850608.1
0 : 100	Random allocate	Continuous	559158.22	499754.8	237263.89	798145.66
0 : 100	Random allocate	Maximum M/C	608913.83	511557.54	252739.43	857516.36

Appendix Table B5 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 5,data 6).

			FIFO	EDD	SPT	LPT
Cmax Company				**538983.4**		
Cmax Standard			**327288.35**	**318168.1**	**163184.58**	**461970.06**
100 : 0			327288.35	318168.1	163184.58	461970.06
80 : 20	Single skill	Processing	327298.33	318170.36	163187.89	461976.51
80 : 20	Single skill	Continuous	327295.02	318169.39	163187.14	461975.51
80 : 20	Single skill	Maximum M/C	327298.88	318169.86	163187.98	461978.53
80 : 20	Multi skill	Processing	327342.95	318225.53	163305.76	462290.8
80 : 20	Multi skill	Continuous	327324.77	318201.91	163274.46	462219.36
80 : 20	Multi skill	Maximum M/C	327345.98	318213.42	163309.6	462322.83
80 : 20	Random allocate	Processing	327370.22	318325.49	163356.04	462451.15
80 : 20	Random allocate	Continuous	327342.95	318260.84	163311.7	462310.36
80 : 20	Random allocate	Maximum M/C	327374.77	318292.33	163361.47	462469.69
50 : 50	Single skill	Processing	329841.25	318401.95	163471.46	462606.57
50 : 50	Single skill	Continuous	328990.3	318305.91	163397.19	462506.66
50 : 50	Single skill	Maximum M/C	329983.07	318352.7	163480.55	462806.8
50 : 50	Multi skill	Processing	340052.65	323876.35	175168.58	493793.37
50 : 50	Multi skill	Continuous	335797.9	321532.92	172061.73	486704.29
50 : 50	Multi skill	Maximum M/C	340761.77	322674.6	175549.02	496972.12
50 : 50	Random allocate	Processing	346434.77	333795.79	180157.77	509705.01
50 : 50	Random allocate	Continuous	340052.65	327380.17	175757.42	495734.23
50 : 50	Random allocate	Maximum M/C	347498.46	330505.73	180696.58	511544.68
20 : 80	Single skill	Processing	331434.05	318446.08	163525.5	462726.62
20 : 80	Single skill	Continuous	330052.17	318331.92	163437.22	462607.87
20 : 80	Single skill	Maximum M/C	331664.37	318387.54	163536.3	462964.63
20 : 80	Multi skill	Processing	348016.67	324953.12	177429.05	499796.21
20 : 80	Multi skill	Continuous	341107.24	322167.65	173736.15	491369.91
20 : 80	Multi skill	Maximum M/C	349168.24	323524.68	177881.25	503574.57
20 : 80	Random allocate	Processing	358380.8	336743.67	183359.35	518709.27
20 : 80	Random allocate	Continuous	348016.67	329117.87	178128.96	502103.18
20 : 80	Random allocate	Maximum M/C	360108.15	332833	183999.8	520895.96
0 : 100	Single skill	Processing	339070.78	318772.52	163925.21	463614.71
0 : 100	Single skill	Continuous	335143.32	318524.35	163733.3	463356.56
0 : 100	Single skill	Maximum M/C	339725.36	318645.25	163948.71	464132.12
0 : 100	Random allocate	Processing	415656.27	358549.88	207042.27	585316.12
0 : 100	Random allocate	Continuous	386200.31	341972.06	195671.87	549215.93
0 : 100	Random allocate	Maximum M/C	420565.59	350048.43	208434.57	590069.79

Appendix Table B6 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 6,data 1).

			FIFO	EDD	SPT	LPT
Cmax Company			**1111697**			
Cmax Standard			**657535.71**	**767715.51**	**272848.37**	**1087491.4**
100 : 0			657535.71	767715.51	272848.37	1087491.4
80 : 20	Single skill	Processing	657555.65	767721.2	272853.2	1087506.5
80 : 20	Single skill	Continuous	657549	767718.86	272851.95	1087504.1
80 : 20	Single skill	Maximum M/C	657556.75	767720	272853.35	1087511.2
80 : 20	Multi skill	Processing	657645.29	767854.32	273050.29	1088246.3
80 : 20	Multi skill	Continuous	657608.76	767797.33	272997.94	1088078.2
80 : 20	Multi skill	Maximum M/C	657651.38	767825.09	273056.7	1088321.7
80 : 20	Random allocate	Processing	657700.08	768095.52	273134.36	1088623.8
80 : 20	Random allocate	Continuous	657645.29	767939.52	273060.21	1088292.4
80 : 20	Random allocate	Maximum M/C	657709.22	768015.52	273143.44	1088667.4
50 : 50	Single skill	Processing	662664.48	768280.01	273327.34	1088989.7
50 : 50	Single skill	Continuous	660954.89	768048.27	273203.16	1088754.5
50 : 50	Single skill	Maximum M/C	662949.41	768161.17	273342.54	1089461
50 : 50	Multi skill	Processing	683179.59	781489.34	292885.15	1162404.3
50 : 50	Multi skill	Continuous	674631.63	775834.82	287690.43	1145716.4
50 : 50	Multi skill	Maximum M/C	684604.25	778589.59	293521.23	1169887.2
50 : 50	Random allocate	Processing	696001.54	805424.19	301227.15	1199860.8
50 : 50	Random allocate	Continuous	683179.59	789943.79	293869.69	1166973.2
50 : 50	Random allocate	Maximum M/C	698138.53	797485.52	302128.06	1204191.4
20 : 80	Single skill	Processing	665864.49	768386.49	273417.68	1089272.3
20 : 80	Single skill	Continuous	663088.22	768111.04	273270.08	1088992.7
20 : 80	Single skill	Maximum M/C	666327.2	768245.23	273435.76	1089832.6
20 : 80	Multi skill	Processing	699179.63	784087.5	296664.69	1176535.2
20 : 80	Multi skill	Continuous	685298.32	777366.37	290490.09	1156699.4
20 : 80	Multi skill	Maximum M/C	701493.18	780640.77	297420.77	1185429.6
20 : 80	Random allocate	Processing	720001.59	812537.2	306580.25	1221057.1
20 : 80	Random allocate	Continuous	699179.63	794136.72	297834.95	1181965.9
20 : 80	Random allocate	Maximum M/C	723471.92	803101.05	307651.11	1226204.6
0 : 100	Single skill	Processing	681206.99	769174.17	274086.01	1091362.9
0 : 100	Single skill	Continuous	673316.56	768575.35	273765.14	1090755.2
0 : 100	Single skill	Maximum M/C	682522.06	768867.08	274125.3	1092580.9
0 : 100	Random allocate	Processing	835070.34	865153.96	346178.55	1377851.6
0 : 100	Random allocate	Continuous	775892.13	825152.91	327167.02	1292870.7
0 : 100	Random allocate	Maximum M/C	844933.37	844640.6	348506.49	1389041.9

Appendix Table B6 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 6,data 2).

			FIFO	EDD	SPT	LPT
Cmax Company				**466874**		
Cmax Standard			**448537.75**	**326614.0179**	**197882.09**	**682938.75**
100 : 0			448537.75	326614.0179	197882.09	682938.75
80 : 20	Single skill	Processing	448551.41	326616.44	197885.59	682948.23
80 : 20	Single skill	Continuous	448546.87	326615.44	197884.68	682946.74
80 : 20	Single skill	Maximum M/C	448552.16	326615.93	197885.7	682951.21
80 : 20	Multi skill	Processing	448612.56	326673.07	198028.53	683412.85
80 : 20	Multi skill	Continuous	448587.64	326648.83	197990.57	683307.23
80 : 20	Multi skill	Maximum M/C	448616.71	326660.64	198033.18	683460.2
80 : 20	Random allocate	Processing	448649.93	326775.69	198089.5	683649.89
80 : 20	Random allocate	Continuous	448612.56	326709.32	198035.73	683441.76
80 : 20	Random allocate	Maximum M/C	448656.16	326741.65	198096.09	683677.3
50 : 50	Single skill	Processing	452036.39	326854.18	198229.46	683879.65
50 : 50	Single skill	Continuous	450870.2	326755.59	198139.4	683731.96
50 : 50	Single skill	Maximum M/C	452230.76	326803.62	198240.49	684175.66
50 : 50	Multi skill	Processing	466030.77	332473.9	212413.67	729983.67
50 : 50	Multi skill	Continuous	460199.78	330068.27	208646.23	719503.75
50 : 50	Multi skill	Maximum M/C	467002.61	331240.24	212874.99	734682.87
50 : 50	Random allocate	Processing	474777.26	342656.66	218463.68	753506.13
50 : 50	Random allocate	Continuous	466030.77	336070.73	213127.71	732852.88
50 : 50	Random allocate	Maximum M/C	476235.01	339279.26	219117.06	756225.75
20 : 80	Single skill	Processing	454219.28	326899.48	198294.98	684057.13
20 : 80	Single skill	Continuous	452325.45	326782.29	198187.94	683881.58
20 : 80	Single skill	Maximum M/C	454534.92	326839.38	198308.09	684408.98
20 : 80	Multi skill	Processing	476945.19	333579.26	215154.77	738857.77
20 : 80	Multi skill	Continuous	467476.06	330719.84	210676.67	726401.03
20 : 80	Multi skill	Maximum M/C	478523.38	332112.89	215703.11	744443.39
20 : 80	Random allocate	Processing	491148.89	345682.79	222345.99	766817.29
20 : 80	Random allocate	Continuous	476945.19	337854.56	216003.5	742268.21
20 : 80	Random allocate	Maximum M/C	493516.17	341668.31	223122.62	770049.91
0 : 100	Single skill	Processing	464685.16	327234.58	198779.68	685370.01
0 : 100	Single skill	Continuous	459302.71	326979.83	198546.97	684988.39
0 : 100	Single skill	Maximum M/C	465582.24	327103.94	198808.18	686134.9
0 : 100	Random allocate	Processing	569643.01	368067.87	251064.48	865283.4
0 : 100	Random allocate	Continuous	529274.6	351049.97	237276.46	811915.83
0 : 100	Random allocate	Maximum M/C	576371.07	359340.74	252752.81	872310.84

Appendix Table B6 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 6,data 3).

			FIFO	EDD	SPT	LPT
Cmax Company				**475930.5**		
Cmax Standard			**413675.17**	**326808.28**	**211368.45**	**623991.21**
100 : 0			413675.17	326808.28	211368.45	623991.21
80 : 20	Single skill	Processing	413687.75	326810.72	211372.24	623999.86
80 : 20	Single skill	Continuous	413683.57	326809.73	211371.27	623998.5
80 : 20	Single skill	Maximum M/C	413688.45	326810.21	211372.36	624002.59
80 : 20	Multi skill	Processing	413744.15	326867.39	211524.92	624424.37
80 : 20	Multi skill	Continuous	413721.16	326843.13	211484.37	624327.88
80 : 20	Multi skill	Maximum M/C	413747.98	326854.95	211529.89	624467.64
80 : 20	Random allocate	Processing	413778.62	326970.07	211590.05	624640.96
80 : 20	Random allocate	Continuous	413744.15	326903.66	211532.61	624450.79
80 : 20	Random allocate	Maximum M/C	413784.36	326936.01	211597.08	624666
50 : 50	Single skill	Processing	416901.87	327048.6	211739.54	624850.89
50 : 50	Single skill	Continuous	415826.31	326949.95	211643.35	624715.94
50 : 50	Single skill	Maximum M/C	417081.13	326998.01	211751.32	625121.35
50 : 50	Multi skill	Processing	429808.53	332671.67	226890.47	666975.46
50 : 50	Multi skill	Continuous	424430.76	330264.6	222866.25	657400.11
50 : 50	Multi skill	Maximum M/C	430704.83	331437.28	227383.23	671269.05
50 : 50	Random allocate	Processing	437875.2	342860.48	233352.8	688467.59
50 : 50	Random allocate	Continuous	429808.53	336270.64	227653.17	669597.01
50 : 50	Random allocate	Maximum M/C	439219.64	339481.08	234050.71	690952.46
20 : 80	Single skill	Processing	418915.09	327093.93	211809.53	625013.05
20 : 80	Single skill	Continuous	417168.46	326976.67	211695.19	624852.65
20 : 80	Single skill	Maximum M/C	419206.19	327033.8	211823.53	625334.53
20 : 80	Multi skill	Processing	439874.63	333777.68	229818.38	675083.6
20 : 80	Multi skill	Continuous	431141.49	330916.57	225035.08	663702.05
20 : 80	Multi skill	Maximum M/C	441330.15	332310.44	230404.09	680187.1
20 : 80	Random allocate	Processing	452974.34	345888.41	237499.71	700629.8
20 : 80	Random allocate	Continuous	439874.63	338055.53	230724.95	678199.66
20 : 80	Random allocate	Maximum M/C	455157.63	341871.55	238329.27	703583.4
0 : 100	Single skill	Processing	428567.51	327429.24	212327.27	626212.61
0 : 100	Single skill	Continuous	423603.4	327174.33	212078.7	625863.92
0 : 100	Single skill	Maximum M/C	429394.86	327298.51	212357.7	626911.48
0 : 100	Random allocate	Processing	525367.5	368286.81	268175.48	790596.85
0 : 100	Random allocate	Continuous	488136.74	351258.79	253447.74	741835.68
0 : 100	Random allocate	Maximum M/C	531572.63	359554.49	269978.87	797017.72

Appendix Table B6 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 6,data 4).

			FIFO	EDD	SPT	LPT
Cmax Company			**476980**			
Cmax Standard			**388944.17**	**335010.33**	**215840**	**678824.5**
100 : 0			388944.17	335010.33	215840	678824.5
80 : 20	Single skill	Processing	388956	335012.78	215843.82	678833.92
80 : 20	Single skill	Continuous	388952.07	335011.76	215842.83	678832.45
80 : 20	Single skill	Maximum M/C	388956.65	335012.26	215843.94	678836.89
80 : 20	Multi skill	Processing	389009.02	335070.87	215999.73	679295.74
80 : 20	Multi skill	Continuous	388987.42	335046.01	215958.32	679190.76
80 : 20	Multi skill	Maximum M/C	389012.63	335058.12	216004.8	679342.81
80 : 20	Random allocate	Processing	389041.44	335176.13	216066.23	679531.36
80 : 20	Random allocate	Continuous	389009.02	335108.05	216007.58	679324.48
80 : 20	Random allocate	Maximum M/C	389046.84	335141.22	216073.42	679558.6
50 : 50	Single skill	Processing	391977.96	335256.63	216218.89	679759.73
50 : 50	Single skill	Continuous	390966.71	335155.51	216120.66	679612.93
50 : 50	Single skill	Maximum M/C	392146.51	335204.77	216230.92	680053.96
50 : 50	Multi skill	Processing	404113.02	341020.83	231690.33	725586
50 : 50	Multi skill	Continuous	399056.75	338553.35	227580.99	715169.22
50 : 50	Multi skill	Maximum M/C	404955.74	339755.45	232193.52	730256.9
50 : 50	Random allocate	Processing	411697.44	351465.35	238289.38	748966.76
50 : 50	Random allocate	Continuous	404113.02	344710.12	232469.17	728437.93
50 : 50	Random allocate	Maximum M/C	412961.5	348001.13	239002.06	751669.99
20 : 80	Single skill	Processing	393870.83	335303.1	216290.36	679936.14
20 : 80	Single skill	Continuous	392228.62	335182.9	216173.6	679761.65
20 : 80	Single skill	Maximum M/C	394144.53	335241.46	216304.66	680285.87
20 : 80	Multi skill	Processing	413577.33	342154.6	234680.19	734406.65
20 : 80	Multi skill	Continuous	405366.29	339221.67	229795.7	722024.95
20 : 80	Multi skill	Maximum M/C	414945.84	340650.53	235278.29	739958.62
20 : 80	Random allocate	Processing	425893.9	354569.27	242524.01	762197.73
20 : 80	Random allocate	Continuous	413577.33	346539.8	235605.94	737796.54
20 : 80	Random allocate	Maximum M/C	427946.66	350451.59	243371.13	765410.87
0 : 100	Single skill	Processing	402946.19	335646.82	216819.05	681241.12
0 : 100	Single skill	Continuous	398278.86	335385.51	216565.22	680861.79
0 : 100	Single skill	Maximum M/C	403724.08	335512.82	216850.13	682001.4
0 : 100	Random allocate	Processing	493959.13	377529.81	273848.73	860070.64
0 : 100	Random allocate	Continuous	458954.16	360074.43	258809.43	807024.58
0 : 100	Random allocate	Maximum M/C	499793.3	368578.33	275690.27	867055.75

Appendix Table B6 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 6,data 5).

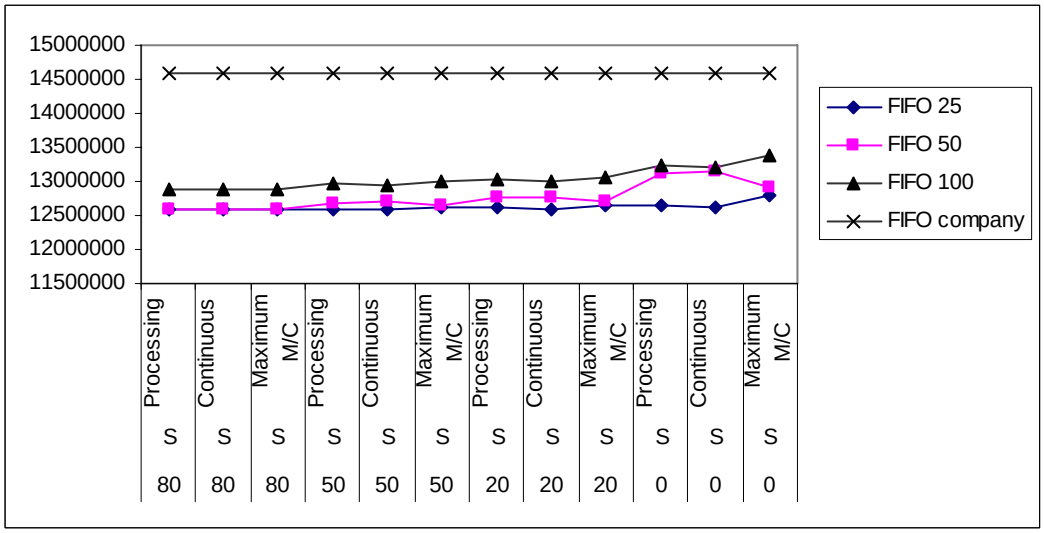
			FIFO	EDD	SPT	LPT
Cmax Company				**471869.4**		
Cmax Standard			**341894.19**	**332773.06**	**171235**	**488756.45**
100 : 0			341894.19	332773.06	171235	488756.45
80 : 20	Single skill	Processing	341904.57	332775.57	171238.03	488763.29
80 : 20	Single skill	Continuous	341901.11	332774.55	171237.24	488762.22
80 : 20	Single skill	Maximum M/C	341905.15	332775.05	171238.13	488765.42
80 : 20	Multi skill	Processing	341951.18	332833.27	171361.72	489095.79
80 : 20	Multi skill	Continuous	341932.19	332808.57	171328.87	489020.21
80 : 20	Multi skill	Maximum M/C	341954.35	332820.6	171365.75	489129.69
80 : 20	Random allocate	Processing	341979.67	332937.82	171414.48	489265.44
80 : 20	Random allocate	Continuous	341951.18	332870.2	171367.95	489116.49
80 : 20	Random allocate	Maximum M/C	341984.42	332903.14	171420.18	489285.06
50 : 50	Single skill	Processing	344560.97	333017.79	171535.59	489429.87
50 : 50	Single skill	Continuous	343672.05	332917.34	171457.66	489324.17
50 : 50	Single skill	Maximum M/C	344709.13	332966.27	171545.13	489641.72
50 : 50	Multi skill	Processing	355228.07	338743.49	183809.74	522424.98
50 : 50	Multi skill	Continuous	350783.45	336292.49	180549.62	514924.85
50 : 50	Multi skill	Maximum M/C	355968.84	337486.56	184208.94	525788.05
50 : 50	Random allocate	Processing	361895.01	349118.26	189045.04	539259.22
50 : 50	Random allocate	Continuous	355228.07	342408.14	184427.62	524478.38
50 : 50	Random allocate	Maximum M/C	363006.17	345677.18	189610.44	541205.56
20 : 80	Single skill	Processing	346224.86	333063.94	171592.29	489556.89
20 : 80	Single skill	Continuous	344781.31	332944.54	171499.66	489431.25
20 : 80	Single skill	Maximum M/C	346465.45	333002.71	171603.63	489808.69
20 : 80	Multi skill	Processing	363547.5	339869.69	186181.72	528775.88
20 : 80	Multi skill	Continuous	356329.73	336956.35	182306.64	519861
20 : 80	Multi skill	Maximum M/C	364750.46	338375.67	186656.22	532773.32
20 : 80	Random allocate	Processing	374374.15	352201.46	192404.56	548785.57
20 : 80	Random allocate	Continuous	363547.5	344225.61	186916.15	531216.61
20 : 80	Random allocate	Maximum M/C	376178.59	348111.28	193076.61	551099.05
0 : 100	Single skill	Processing	354202.39	333405.37	172011.72	490496.47
0 : 100	Single skill	Continuous	350099.66	333145.81	171810.35	490223.36
0 : 100	Single skill	Maximum M/C	354886.18	333272.26	172036.38	491043.88
0 : 100	Random allocate	Processing	434205.63	375008.66	217255.78	619254.49
0 : 100	Random allocate	Continuous	403435.16	357669.85	205324.46	581061.1
0 : 100	Random allocate	Maximum M/C	439334.05	366116.96	218716.75	624283.79

Appendix Table B6 The result of C_{max} from two step scheduling in different dispatching rule and skill (class 6,data 6).

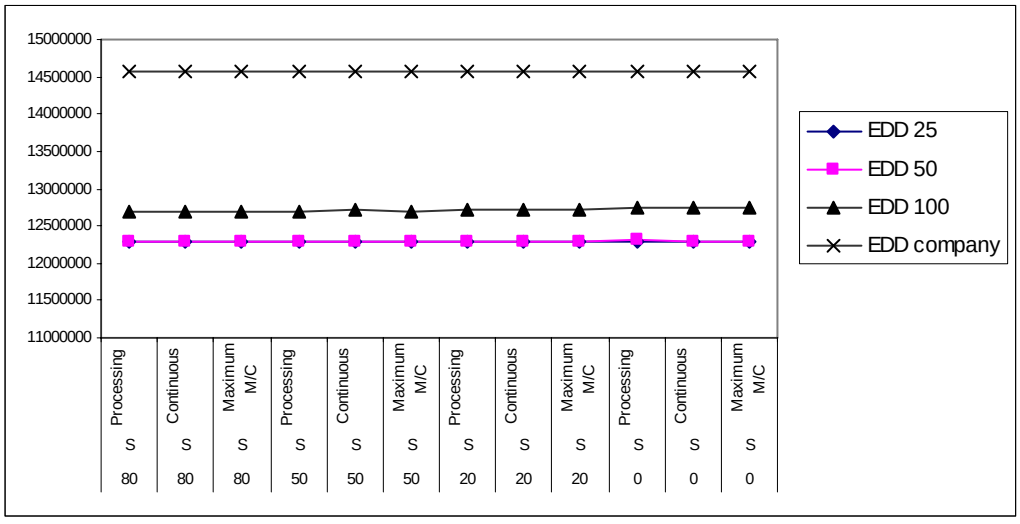
			FIFO	EDD	SPT	LPT
Cmax Company				**587405.5**		
Cmax Standard			**490553.75**	**411968.49**	**237816.0**	**687373.71**
100 : 0			490553.75	411968.49	237816.05	687373.71
80 : 20	Single skill	Processing	490568.68	411971.55	237820.21	687383.24
80 : 20	Single skill	Continuous	490563.72	411970.3	237819.12	687381.75
80 : 20	Single skill	Maximum M/C	490569.51	411970.91	237820.34	687386.25
80 : 20	Multi skill	Processing	490635.56	412042.99	237992	687850.87
80 : 20	Multi skill	Continuous	490608.31	412012.41	237946.37	687744.58
80 : 20	Multi skill	Maximum M/C	490640.1	412027.3	237997.58	687898.54
80 : 20	Random allocate	Processing	490676.44	412172.42	238065.27	688089.46
80 : 20	Random allocate	Continuous	490635.56	412088.71	238000.64	687879.98
80 : 20	Random allocate	Maximum M/C	490683.25	412129.49	238073.18	688117.05
50 : 50	Single skill	Processing	494380.12	412271.42	238233.47	688320.71
50 : 50	Single skill	Continuous	493104.68	412147.06	238125.24	688172.06
50 : 50	Single skill	Maximum M/C	494592.69	412207.65	238246.72	688618.64
50 : 50	Multi skill	Processing	509685.4	419359.76	255280.15	734724.12
50 : 50	Multi skill	Continuous	503308.2	416325.45	250752.41	724176.15
50 : 50	Multi skill	Maximum M/C	510748.26	417803.7	255834.57	739453.85
50 : 50	Random allocate	Processing	519251.2	432203.59	262551.09	758399.34
50 : 50	Random allocate	Continuous	509685.4	423896.55	256138.29	737611.97
50 : 50	Random allocate	Maximum M/C	520845.5	427943.57	263336.33	761136.62
20 : 80	Single skill	Processing	496767.48	412328.56	238312.22	688499.34
20 : 80	Single skill	Continuous	494696.25	412180.75	238183.57	688322.66
20 : 80	Single skill	Maximum M/C	497112.69	412252.76	238327.97	688853.48
20 : 80	Multi skill	Processing	521622.21	420753.98	258574.43	743655.86
20 : 80	Multi skill	Continuous	511266.07	417147.31	253192.61	731118.22
20 : 80	Multi skill	Maximum M/C	523348.23	418904.4	259233.42	749277.75
20 : 80	Random allocate	Processing	537156.41	436020.54	267216.88	771796.94
20 : 80	Random allocate	Continuous	521622.21	426146.54	259594.43	747088.44
20 : 80	Random allocate	Maximum M/C	539745.44	430956.95	268150.24	775050.55
0 : 100	Single skill	Processing	508213.74	412751.24	238894.73	689820.75
0 : 100	Single skill	Continuous	502327.09	412429.9	238615.06	689436.65
0 : 100	Single skill	Maximum M/C	509194.84	412586.45	238928.98	690590.61
0 : 100	Random allocate	Processing	623003.33	464255.54	301730.95	870902.48
0 : 100	Random allocate	Continuous	578853.48	442790.34	285160.41	817188.35
0 : 100	Random allocate	Maximum M/C	630361.63	453247.74	303760	877975.55

Appendix C

The company completion time compare with
the completion time of heuristics rule.

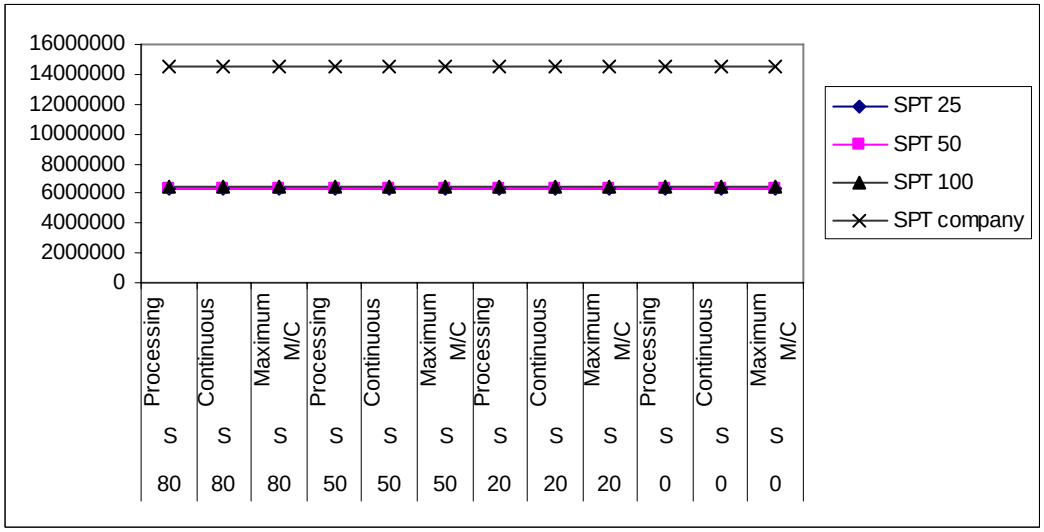


FIFO

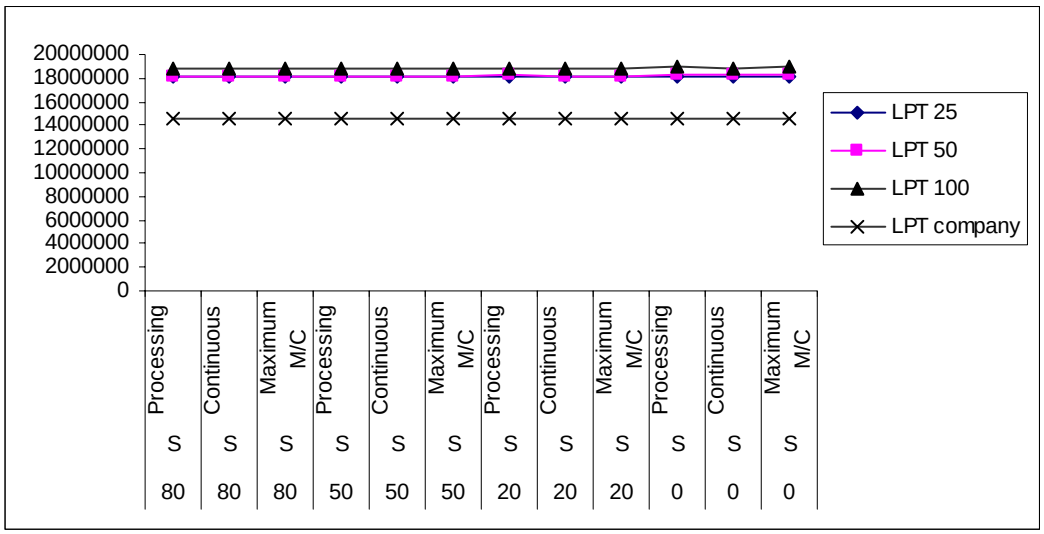


EDD

Appendix Figure C1 Single skill first at different dispatching rule and penalty rate.

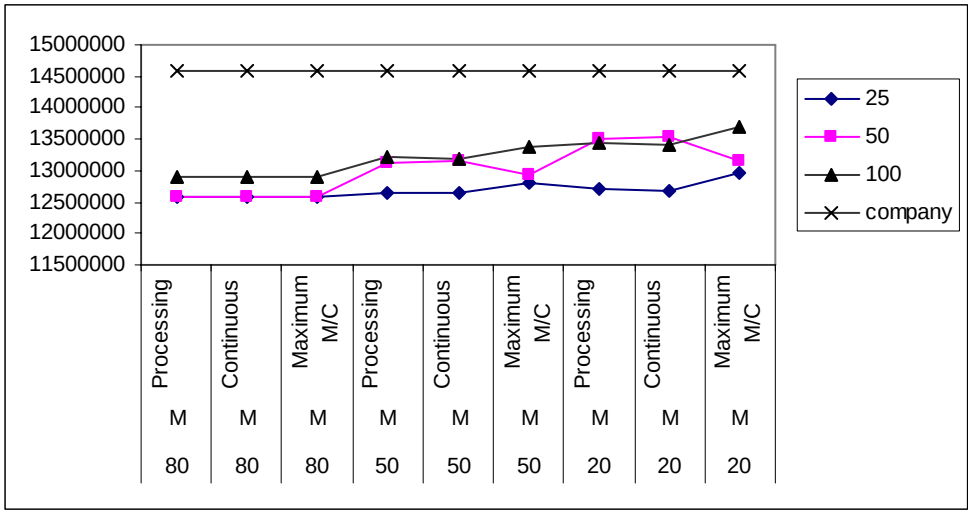


SPT

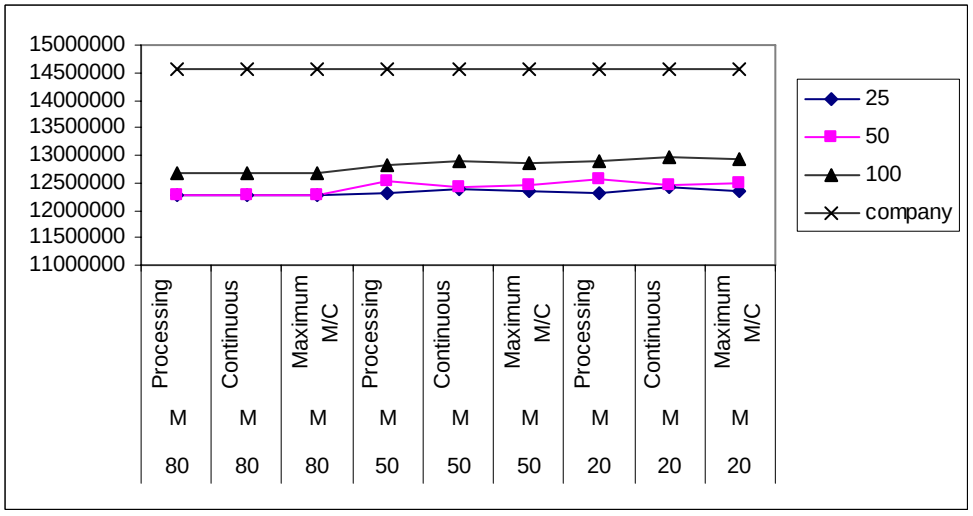


LPT

Appendix Figure C1 (Cont'd)

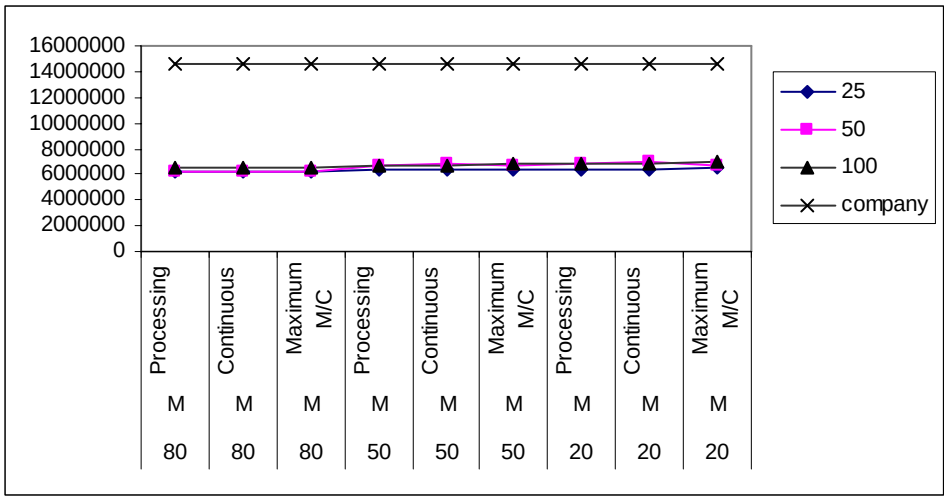


FIFO

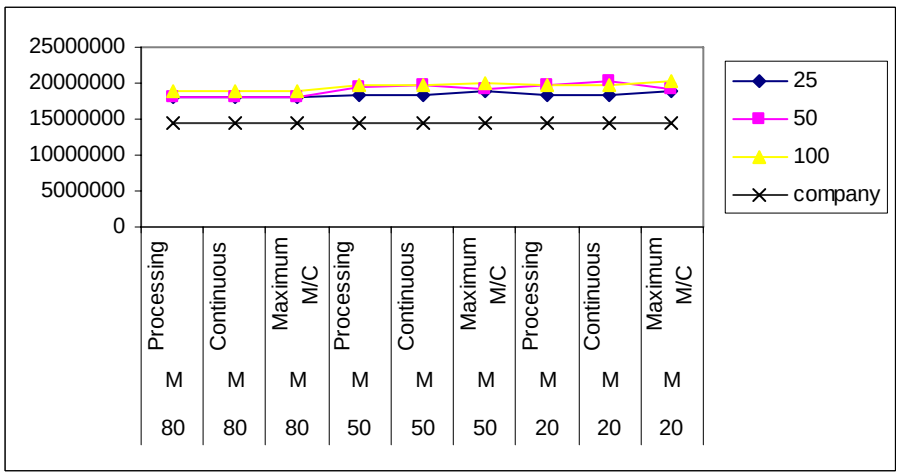


EDD

Appendix Figure C2 Multi skill first at different dispatching rule and penalty rate.

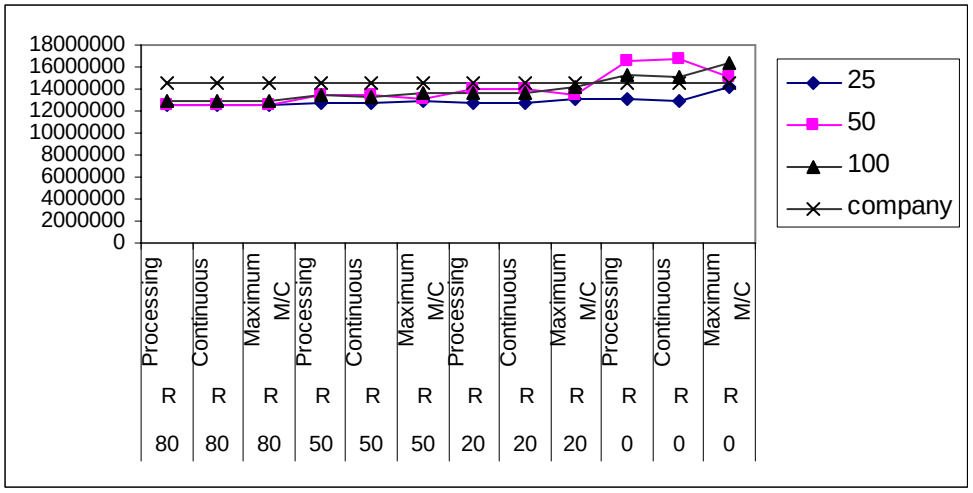


SPT

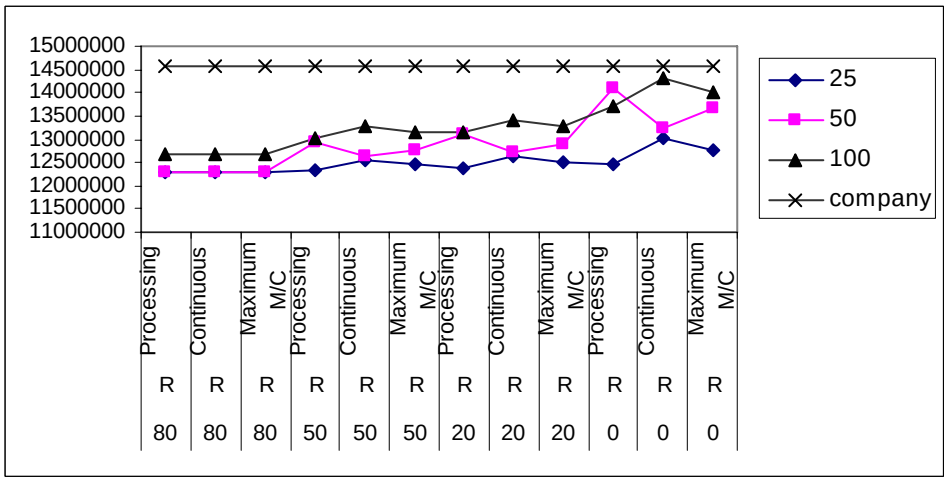


LPT

Appendix Figure C2 (Cont'd)

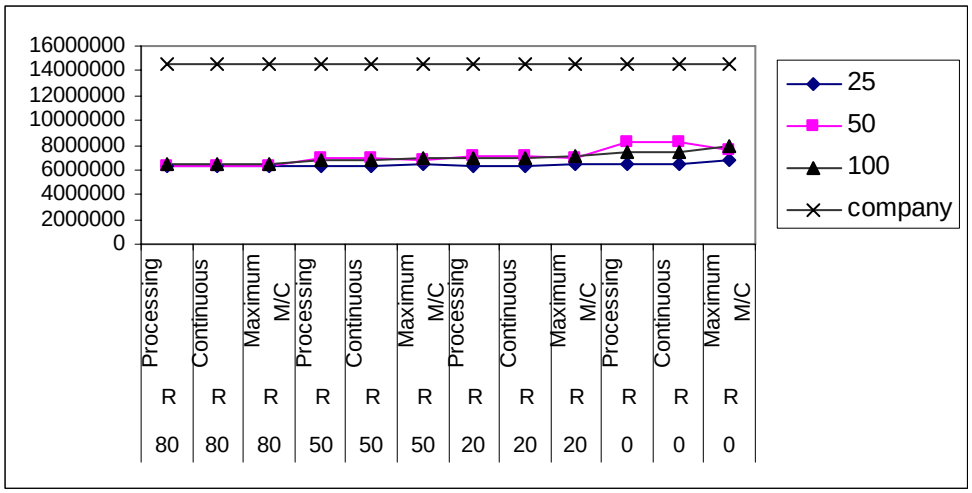


FIFO

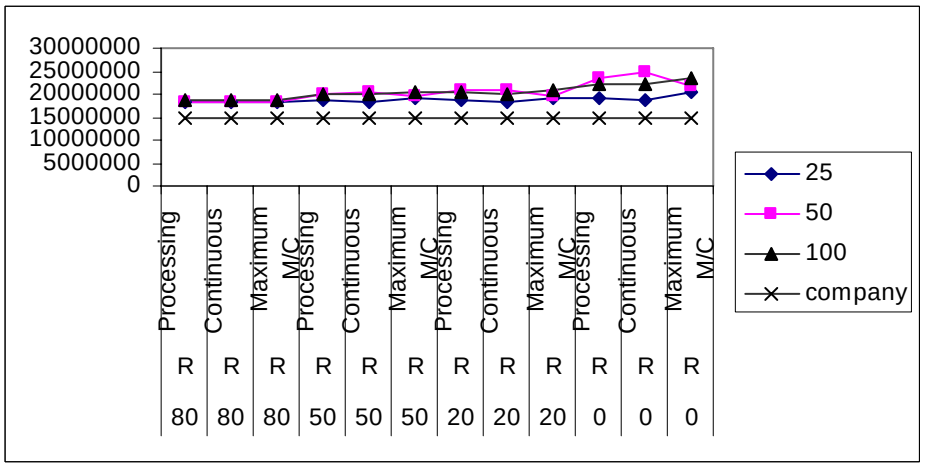


EDD

Appendix Figure C3 Random worker at different dispatching rule and penalty rate.



SPT



LPT

Appendix Figure C3 (Cont'd)