

TABLE OF CONTENTS

	Page
TABLE OF CONTENTS	i
LIST OF TABLES	ii
LIST OF FIGURES	v
LIST OF ABBRIVIATIONS	vii
INTRODUCTION	1
LITERATURE REVIEW	9
MATERIALS AND METHODS	45
Materials	45
Methods	46
RESULTS AND DISCUSSION	89
Results	89
Discussion	134
CONCLUSION AND RECOMMENDATION	139
Conclusion	139
Recommendation	142
LITERATURE CITED	144
APPENDIX	148
CURRICULUM VITAE	169

LIST OF TABLES

Table		Page
1	The example of AGVsp-P/D jobs	5
2	The ANOVA table for a single-factor experiment, fixed effects model	42
3	The distance table of the example layout from figure 1	49
4	The example of a part of job list for a regular AGV problem	50
5	The example of a part of job list for the single AGVsp-P/D	50
6	The example of cost matrix $[c_{ij}]$ of the AGVsp-P/D in a form of TSP	51
7	The assignment solution of variable x_{ij} of AGVsp-P/D from table 6	57
8	The example of master matrix	64
9	The example of step 1 and step 2 of Heuristic-1	66
10	The assignment solution of the example of Heuristic-1	67
11	The assignment solution of step 1 of Heuristic-2	67
12	The assignment solution of step 2 of Heuristic-2	68
13	The distance matrix, $[d_{ij}]$ of step 1 of Heuristic-3	68
14	The assignment of minimum distance matrix of Heuristic-3	78
15	The assignment solution of step 4 of Heuristic-3	79
16	The example of the alternative selection improvement heuristic	71
17	The assignment solution of table 16 by using Heuristic-3	72
18	The result of implementation of step 1 and 2 of the improvement heuristic	72
19	The result of step 4 of the alternative improvement heuristic	73
20	De-link 1-2, by assigning the cost of the link 1-2 to ∞	77
21	The solution of table 20	77
22	De-link 2-1, by assigning the cost of the link 2-1 to ∞	78
23	The solution of table 22	78
24	The example of the regular AGV distance matrix for multi AGVsp-P/D	79
25	The cost matrix of Aux-problem of 2 times faster AGVs	80
26	The MTSP distances matrix $[d_{ij}]$	86

LIST OF TABLES (Continued)

Table		Page
27	The AGVsp-P/D solution of table 26	87
28	The corresponding cost from solution of table 27	87
29	The running time in second of simulated problems of 2Al-5	91
30	The running time in second of simulated problems of 2Al-Max	92
31	The running time in second of regular assignment problems	93
32	The summarized running time in second of lower bound of AGVsp-P/D	94
33	The %Dev of alternative selection Heuristic-1 solutions	99
34	The %Dev of alternative selection Heuristic-2 solutions	100
35	The %Dev of alternative selection Heuristic-3 solutions	101
36	The comparison of the %Dev for all 3 heuristics	102
37	The summary of the %Dev for all 3 heuristics	103
38	The result of alternative selection improvement for Heuristic-1	108
39	The result of alternative selection improvement for Heuristic-2	109
40	The result of alternative selection improvement for Heuristic-3	110
41	The running time in second of solving the TSP tour of AGVsp-P/D	113
42	The comparison of the running time in second of solving the single TSP tour and the regular assignment problem	114
43	The running time in second of 10 nodes MTSP for the multi AGVsp-P/D	16
44	The summary of 10 nodes MTSP for the multi AGVsp-P/D	117
45	The running time in second of 20 nodes MTSP for the multi AGVsp-P/D	118
46	The summary of 20 nodes MTSP for the multi AGVsp-P/D	119
47	The running time in second of 30 nodes MTSP for the multi AGVsp-P/D	120
48	The summary of 30 nodes MTSP for the multi AGVsp-P/D	121
49	The data set from Box-Cox transformation of table 47	124
50	The ANOVA table of the data set on table 49	127
51	The solutions of multi tours from the heuristic of splitting a TSP tour (Spliting TSP Heu) and the solutions of multi TSP tours from the heuristic of solving MTSP as a standard TSP(MTSP Heu)	129

LIST OF TABLES (Continued)

Table	Page
52 The summary of table 51	137

LIST OF FIGURES

Figure		Page
1	The example of the layout of AGV systems	6
2	Subtours from the assignment solution	28
3	The example of the normal probability plot of the assignment data with 50 nodes from table 31 by using MINITAB	40
4	Subtours T_i and tour T^*	83
5	The TSP tour T''	84
6	The graph of running time in second of the lower bound of AGVsp-P/D	94
7	The normal probability plot of 2Al-5 data with 50 nodes from table 29	95
8	The normal probability plot of 2Al-Max data with 50 nodes from table 30	95
9	The normal probability plot of the regular assignment data with 50 nodes from table 31	96
10	The normal probability plot of Box-Cox transformation data of 2Al-5 with 50 nodes of table 29	97
11	The Kruskal-Wallis test of the data on Ass, 2Al-5, and 2Al-Max of 50 nodes	98
12	The normal probability plot of the %Dev of Heuristic-1 from table 36	103
13	The normal probability plot of the %Dev of Heuristic-2 from table 36	104
14	The normal probability plot of the %Dev of Heuristic-3 from table 36	104
15	The normal probability plot of Box-Cox transformation data of the %Dev of Heuristic-1 from table 36	105
16	The normal probability plot of Box-Cox transformation data of the %Dev of Heuristic-2 from table 36	105
17	The normal probability plot of Box-Cox transformation data of the %Dev of Heuristic-3 from table 36	106
18	The Kruskal-Wallis test of the %Dev for all 3 heuristics	106

LIST OF FIGURES (Continued)

Figure		Page
19	The Kruskal-Wallis test of the %Dev for all 3 heuristics with the alternative improvement algorithm	111
20	The graph of running time in second of the TSP tour of AGVsp-P/D	114
21	The graph of average running time in second of 10 nodes MTSP	117
22	The graph of average running time in second of 20 nodes MTSP	119
23	The graph of average running time in second of 30 nodes MTSP	121
24	The normal probability plot of the average running time of $M = 1$ from table 47	122
25	The normal probability plot of the average running time of $M = 2$ from table 47	123
26	The normal probability plot of the average running time of $M = 3$ from table 47	123
27	The normal probability plot of Box-Cox transformation data of $M = 1$ from table 49	125
28	The normal probability plot of Box-Cox transformation data of $M = 2$ from table 49	126
29	The normal probability plot of Box-Cox transformation data of $M = 3$ from table 49	126

LIST OF ABBREVIATIONS

Alt.	=	Alternative
AGV	=	Automated guided vehicle
AGVsp-P/D	=	AGV scheduling problem with alternative pick up and delivery nodes
Aux	=	Auxiliary
Avg.	=	Average
CPP	=	Chinese postman problem
Dev	=	Deviation
DL	=	Dual programming
GB	=	Giga bit
GHz	=	Giga hertz
Heu	=	Heuristic
Imp.	=	Improvement
IP	=	Integer programming
LP	=	Linear programming
MIP	=	Mixed integer programming
MTSP	=	Multi traveling salesman problem
No.	=	Number
OR	=	Operations research
P/D	=	Pick up and delivery node
S.D.	=	Standard deviation
Sec.	=	Second
Sel.	=	Selection
Sol.	=	Solution
Trans	=	Transformation
TSP	=	Traveling salesman problem
VRP	=	Vehicle routing problem
%Dev	=	Percentage deviation