ภาคผนวก

ภาคผนวก ก

ตัวอย่างการคำนวณ

การคำนวณหาปริมาณยิปซั่มและปริมาณค่าความร้อนที่ยิปซั่มต้องการและปริมาณความร้อนที่ต้องการเพิ่ม

จากขอบเขตของโครงการวิจัย ได้ทำการตั้งเป้าหมายไว้ว่าจะสามารถนำยิปซั่มมาทำการอบได้ 500 กิโลกรัมต่อวัน (1 วัน ทำงาน 8 ชั่วโมง) หลังจากที่ยิปซั่มถูกไล่ไอน้ำอิสระออกแล้วนำยิปซั่มมาทำให้ร้อนที่อุณหภูมิ 150°C โดยให้สัมผัสกับความร้อนทุกส่วนเป็นเวลาประมาณ 4 ชั่วโมง จะได้ปูนปลาสเตอร์

การคำนวณหาค่าปริมาณความร้อนที่ยิปซั่มต้องการ ,$\dot{Q}_{gypsum}$ ที่อุณหภูมิ 150°C ปริมาณยิปซั่ม 500 กิโลกรัมต่อวัน หรือ 250 กิโลกรัมต่อ 4 ชั่วโมง

จากสูตร $$\% MC_{db} = \frac{\dot{M}_{gypsum} - \dot{M}_{dry}}{\dot{M}_{dry}} \tag{1}$$

จากเส้นลักษณะเฉพาะของการอบแห้งที่อุณหภูมิ 150°C ณ เวลาเริ่มต้น จะได้ $\%MC_{db}$ = 17.53 แทนค่าต่างๆในสูตร (1)

$$0.1753 = \frac{250 - \dot{M}_{dry}}{\dot{M}_{dry}}$$

จะได้ $\dot{M}_{dry}$ = 212.71 Kg.

และ $\dot{M}_{water} = \dot{M}_{gypsum} - \dot{M}_{dry}$

= 250 - 212.71

= 37.29 Kg.

จากสูตร $$\dot{Q} = \dot{M}_{water} L \tag{2}$$

ที่อุณหภูมิ 150°C จะได้ L = 2112.92×10^3 J / Kg.

แทนค่าต่างๆในสูตร (2)

$\dot{Q}$ = $37.29 \times 2112.92 \times 10^3$

= 78,790.79 KJ / hr.

หรือ $\dot{Q}$ = 21886.33 W

แต่เมื่อทำการทดสอบเครื่องอุ่นอากาศแบบท่อความร้อนจำลองพบว่า ที่อุณหภูมิของก๊าซร้อนขาเข้า $170^{\circ}C$ ได้ปริมาณการถ่ายเทความร้อนจากท่อความร้อน ($\dot{Q}_{hp}$) เท่ากับ 73428.39 W ซึ่งสูงกว่าปริมาณความร้อนที่ยิปซั่มต้องการมาก (21886.33 W) ดังนั้นเป้าหมายที่จะนำปริมาณยิปซั่มมาอบ 500 กิโลกรัมต่อวันจึงน้อยไป นอกจากนี้อุณหภูมิของอากาศร้อนขาออกจากเครื่อง ซึ่งเท่ากับ $134^{\circ}C$ ก็ยังไม่สูงพอที่จะนำไปอบแห้งยิปซั่มได้ จึงต้องการอุณหภูมิของอากาศร้อนขาเข้าเพิ่มขึ้นอีกให้สูงถึง $150^{\circ}C$ ($\dot{Q}_{air}$) โดยจะต้องเป็นแหล่งพลังงานความร้อนจากภายนอก หลังจากนั้นก็จะทำการหาปริมาณยิปซั่มใหม่ที่สอดคล้องกับเครื่องต่อไป

การคำนวณหาปริมาณความร้อนที่ต้องการเพิ่ม , $\dot{Q}_{add}$

จากสูตร $$\dot{Q}_{add} = \dot{m}_a c_{pa} \Delta T \qquad (3)$$

ที่ $T_1 = 134^{\circ}C$ จะได้ c_{pa} = 1015 J/Kg .K และ $\dot{m}_a$ = 0.8215 Kg/s แทนค่าต่างๆในสูตร (3)

$$\dot{Q}_{add} = 0.8215 \times 1015 \times (150 - 134)$$
$$= 13341.16 \text{ W}$$

หา $\dot{Q}_{air}$ เนื่องจาก $$\dot{Q}_{air} = \dot{Q}_{hp} + \dot{Q}_{add}$$
$$= 73428.39 + 13341.16$$

ปริมาณความร้อนที่ให้แก่ยิปซั่ม $= 86769.55$ W

แต่ $$\dot{Q}_{air} = \dot{M}_{water} L$$

แทนค่า จะได้ $$\dot{M}_{water} = \frac{86769.55}{2112.92 \times 10^3}$$
$$= 0.04107 \text{ Kg / sec}$$
$$= 147.85 \text{ Kg / hr.}$$

หา $\dot{M}_{gypsum}$ จากสูตร $$\% MC_{db} = \frac{\dot{M}_{water}}{\dot{M}_{gypsum} - \dot{M}_{water}}$$

ณ ชั่วโมงแรกจะได้ $$0.1753 = \frac{147.852}{\dot{M}_{gypsum} - 147.852}$$

$$\dot{M}_{gypsum} = 991.27 \text{ Kg / hr.}$$

จะได้ปริมาณยิปซั่มที่นำมาอบแห้งได้ = 7930.16 Kg / day

การคำนวณหาปริมาณความร้อนที่ยิปซั่มต้องการ ($\dot{Q}_{gypsum}$) ในแต่ละชั่วโมง ที่อุณหภูมิ 150 $^{\circ}C$

จากสูตร $$\% MC_{db} = \frac{\dot{M}_{water}}{\dot{M}_{gypsum} - \dot{M}_{water}} \qquad (4)$$

จากเส้นลักษณะเฉพาะของการอบแห้ง ที่ชั่วโมงเริ่มต้น จะได้ $\% MC_{db}$ =17.53

และ $\dot{M}_{gypsum}$ = 991.27 Kg/Hr แทนค่าต่างๆในสูตร (4)

$$0.1753 = \frac{991.27 - \dot{M}_{dry}}{\dot{M}_{dry}}$$

จะได้ $\dot{M}_{dry}$ = 843.42 Kg/Hr.

และ $\dot{M}_{water} = \dot{M}_{gypsum} - \dot{M}_{dry}$

= 991.27 - 843.42

= 147.85 Kg/Hr.

จากสูตร $\dot{Q} = \dot{M}_{water} L$ (5)

ที่อุณหภูมิ 150 $^{\circ}C$ จะได้ L = 2112.92 x 10^3 J/Kg.

แทนค่าต่างๆในสูตร (5)

$\dot{Q}$ = 147.85 x 2112.92 x 10^3

$\dot{Q}_{gypsum,0}$ = 86776.45 W

ที่ชั่วโมงที่ 1 ได้ $\% MC_{db}$ = 9.23

แทนค่าต่างๆในสูตร (1)

$$0.0923 = \frac{\dot{M}_{gypsum} - 843.42}{843.42}$$

จะได้ $\dot{M}_{gypsum}$ = 921.27 Kg./ hr.

และ $\dot{M}_{water} = \dot{M}_{gypsum} - \dot{M}_{dry}$

= 921.27-843.42

= 77.85 Kg./ hr.

จากสูตร $\dot{Q} = \dot{M}_{water} L$

แทนค่าต่างๆในสูตร (5)

$$\dot{Q} = 77.85 \times 2112.92 \times 10^3$$

$$\dot{Q}_{gypsum,1} = 45691.89 \quad W$$

ที่ชั่วโมงที่ 2 ได้ $\%MC_{db} = 2.31$

แทนค่าต่างๆในสูตร (1)

$$0.0231 = \frac{\dot{M}_{gypsum} - 843.42}{843.42}$$

จะได้ $\dot{M}_{gypsum} = 862.90$ Kg./ hr.

และ

$$\dot{M}_{water} = \dot{M}_{gypsum} - \dot{M}_{dry}$$

$$= 862.90\text{-}843.42$$

$$= 19.48 \quad \text{Kg./ hr.}$$

จากสูตร $\dot{Q} = \dot{M}_{water} L$

แทนค่าต่างๆในสูตร (5)

$$\dot{Q} = 19.48 \times 2112.92 \times 10^3$$

$$\dot{Q}_{gypsum,2} = 11433.24 \quad W$$

ที่ชั่วโมงที่ 3 ได้ $\%MC_{db} = 0$, $\dot{M}_{water} = 0$ Kg/ hr.

จะได้ $\dot{M}_{gypsum} = 921.27$ Kg./ hr.

และ $\dot{Q}_{gypsum,3} = 0$ W

การคำนวณหาระยะเวลาคืนทุน

จากการทดสอบเครื่องอุ่นอากาศแบบท่อความร้อนได้ค่าความร้อนที่สามารถดึงกลับต่อชั่วโมงการทำงาน 1 วัน 587,427.1 วัตต์

จาก ค่าความร้อนของน้ำมันดีเซล (HHV)		45.39	MJ/Kg.fuel
ค่าความถ่วงจำเพาะของน้ำมันดีเซล		0.88	Kg/m
คิดเป็นค่าความร้อนของน้ำมันดีเซลได้	=	0.85 x 45.39 / 1000	
	=	38,581.5	J/Litre
คิดที่ราคาน้ำมันดีเซลลิตรละ		8.70	บาท
สามารถประหยัดค่าใช้จ่ายได้		132.41	บาท/วัน
รวมราคาชุดท่อความร้อนที่สร้าง		150,000	บาท
ดังนั้น จะมีระยะเวลาคืนทุน		150,000 / 132.41	
	=	1132	วัน
หรือ	=	3 ปี 36	วัน

การคำนวณหาค่า Internal Rate of Return (IRR)

กำหนดให้

P = 150,000 บาท

P_1 = 2,000 บาท

F = 132.41 x 365

= 48,329.65 บาท

n = 10 ปี

แทนค่าต่างๆในสมการ 5.9 จะได้

$$150{,}000 + 2000\left[\frac{(1+i)^{10}}{i(1+i)^{10}}\right] = 48{,}329.65\left[\frac{(1+i)^{10}-1}{i(1+i)^{100}}\right]$$

ทำการแก้สมการหาค่า i จะได้ ค่า IRR = 28.33 เปอร์เซ็นต์

ภาคผนวก ข

โปรแกรมคอมพิวเตอร์ช่วยออกแบบเครื่องอุ่นอากาศแบบท่อความร้อน

ความหมายของสัญลักษณ์ในโปรแกรม

สัญลักษณ์	ความหมาย
TA	Air temperature, $^{\circ}C$
LOA	Density of air, kg/m^3
MUA	Viscosity of air, Ns/m^3
KA	Thermal conductivity of air, W/m.K
PRA	Prandtl number of air
SHP	Specific heat capacity, J/Kg.K
TW	Water temperature, $^{\circ}C$
LOW	Density of water, kg/m^3
MUW	Viscosity of water, Ns/m^3
KW	Thermal conductivity of water, W/m.K
PRW	Prandtl number of water
PFI2W	Figure of merit for condensation, Kg ($K^{0.75}S^{2.5}$)
LHW	Specific latent heat of vaporization, J/Kg
LOV	Density of vapor, kg/m3
SIG	Surface tension, N/m
REN	Reynold number
CP	Specific heat capacity, J/Kg.K
KIND	Kind of thermosyphon
TYP	Type of tube
FLOW	Forms of fluid flow in heat exchanger
FLUID	Kind of fluid at condenser
TUBEARR	Tube arrangement
TUBEMAT	Tube material
FINMAT	Fin material
DIA	Tube diameter, m
THICK	Tube thickness, m

สัญลักษณ์	ความหมาย
TFI	Fresh air inlet temperature, $^{\circ}C$
FLOWAIR	Air flowrate, m^3/hr
TGI	Flue gas inlet temperature, $^{\circ}C$
FLOWGAS	Flue gas flowrate, m^3/hr
FINTHICK	Fin thickness, m
FINPITCH	Fin pitch, m
FINOD	Fin diameter, m
ST	Transverse pitch, m
SL	Longitudinal pitch, m
PIPE	Number of pipe per row
TGO	Flue gas outlet temperature, $^{\circ}C$
Le	Evaporation section, m
Lc	Condenser section, m
QN	Heat transfer of N heat pipes
Q1HP	Heat transfer of 1 heat pipes
NO	Total number of heat pipe
EFTN	Effectiveness, %
OPT	Optimization (energy/cost), w/Baht
KTUBE	Thermal conductivity of tube, W/m.K
c	Constant
m	Constant
MA	Mass flow rate of air, Kg/s
MF	Mass flow rate of flue gas, Kg/s
VEL	Velocity of air, m/s
FLUEVEL	Velocity of flue gas, m/s
DAIR	Density of air, Kg/m^3
CPA	Specific heat capacity of air, J/Kg.K
AC	Cross section area at cold side, m^2

สัญลักษณ์	ความหมาย
DFLUE	Density of flue gas, Kg/m^3
CPF	Specific heat capacity of flue gas, J/Kg.K
AF	Cross section area at hot side, m^2
Qhot	Heat transfer at hot side, W
TFO	Fresh air outlet temperature, $^{\circ}C$
Qcold	Heat transfer at cold side, W
Qmax	Maximum heat transfer capacity of N heat pipe, W
Qactual	Actual heat transfer capacity of N heat pipe, W
QSL	Heat transfer rate due to sonic limitation, W
QBL	Heat transfer rate due to boiling limitation, W
QCL	Heat transfer rate due to counter-current flow limitation, W
PDE	Pressure drop in evaporator, N/m^2
PDC	Pressure drop in condensor, N/m^2
CPMS	Cost per metre, Baht/m
ROW	Number of row
CASING	Cost of heat pipe unit
TCOST	Total cost/Baht
Vmax	Maximum velocity, m/s
NU	Nusselt number
RE	Reynolds number
H	Convection heat transfer coefficient, $W/m^2.K$
EFF	Fin efficiency
TUBEAREA	Total tube area, m^2
FINAREA	Total fin area, m^2
AREA	Total area, m^2
ID	Internal diameter, m
PHI3	Figure of merit for nucleate boiling
PV	Vapor pressure, N/m^2

สัญลักษณ์	ความหมาย
LMTD	Log Mean Temperature Differance
LF	Liquid filling
MCP	$(mCp)_{min}$
BO	Bond number
F1,F2	Kutare ladze number
REE	Reynolds number at evaporator side
REC	Reynolds number at condenser side
FFE	Friction factor
CFE	Correction factor
KFIN	Thermal conductivity of fin, W/m.K

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100 REM PROGRAM FOR CALCULATION HEAT TRANSFER CAPACITY OF THERMOSYPHON HEAT EXCHANGER
102 CLS : DIM TA(40), LOA(40), MUA(40), KA(40), PRA(40), SHP(40), TW(40), LOW(40), MUW(40), KW(40), PRW(40),
PHI2W(40), LHW(40), LOV(40), SIG(40), REN(40), FL(40), FH(40), CP(40)
104 CLS : PRINT
106 PRINT "*****************************************************************************************"
108 PRINT "*PROGRAM TO DETERMINE HEAT TRANSFER CAPACITY OF THERMOSYPHON HEAT EXCHANGER*"
110 PRINT "*                                                                              *"
112 PRINT "*                                  BY                                          *"
114 PRINT "*                       MR.PATTNAPONG    KHANTHA                               *"
116 PRINT "*                          HEAT PIPE PROJECT                                   *"
118 PRINT "*              DEPARTMENT OF MECHANICAL ENGINEERING                            *"
120 PRINT "*                      FACULTY OF ENGINEERING                                  *"
122 PRINT "*                       CHIANG MAI UNIVERSITY                                  *"
124 PRINT "*                        CHIANG MAI,THAILAND                                   *"
126 PRINT "*****************************************************************************************"
128 PRINT
130 INPUT "WHAT KIND OF YOUR THERMOSYPHON(1=SINGLE TUBE,2=TUBE BANK)"; KIND
135 PRINT "WHAT TYPE OF TUBE (1 = BOTH BARE , 2 = FINNED AT EVAPORATOR "
140 INPUT "              3 = FINNED AT CONDENSER ,4 = BOTH FINNED)"; TYP
145 INPUT "WHAT FORMS OF FLUIDS FLOW IN HEAT EXCHANGER (1=COCURRENT,2=COUNTERCURRENT) "; FLOW
150 INPUT "WHAT KIND OF FLUID AT CONDENSER (1=AIR,2=WATER) "; FLUID
155 INPUT "TUBE ARRANGEMENT (1=INLINE,2=STAGGERED)"; TUBEARR
160 INPUT "TUBE MATERIAL (1=COPPER,2=STAINLESS STEEL,3=CARBON STEEL) "; TUBEMAT
162 INPUT "FIN MATERIAL  (1=COPPER,2=ALUMINIUM ) "; FINMAT
164 INPUT "TUBE DIAMETER                 (M)=      "; DIA
166 INPUT "TUBE WALL THICKNESS           (M)=      "; THICK
170 INPUT "INLET FRESH AIR TEMPERATURE       (C)=      "; TFI
175 INPUT "VOLUMETRIC FLOW RATE CAPACITY OF AIR       (CU.M/HR)=  "; FLOWAIR
180 INPUT "INLET FLUE GAS TEMPERATURE        (C)=      "; TGI
185 INPUT "VOLUMETRIC FLOW RATE CAPACITY OF FLUE GAS  (CU.M/HR)=  "; FLOWGAS
190 FOR i = 1 TO 35: READ TA(i):  NEXT i
194 FOR i = 1 TO 35: READ LOA(i): NEXT i
196 FOR i = 1 TO 35: READ MUA(i): NEXT i
198 FOR i = 1 TO 35: READ KA(i):  NEXT i
200 FOR i = 1 TO 35: READ PRA(i): NEXT i
202 FOR i = 1 TO 35: READ SHP(i): NEXT i
204 FOR i = 1 TO 28: READ TW(i):  NEXT i
206 FOR i = 1 TO 28: READ LOW(i): NEXT i
208 FOR i = 1 TO 28: READ MUW(i): NEXT i
210 FOR i = 1 TO 28: READ KW(i):  NEXT i
212 FOR i = 1 TO 28: READ PRW(i): NEXT i
214 FOR i = 1 TO 28: READ PHI2W(i): NEXT i
216 FOR i = 1 TO 28: READ LHW(i): NEXT i
218 FOR i = 1 TO 28: READ LOV(i): NEXT i
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220 FOR i = 1 TO 28: READ SIG(i): NEXT i
222 FOR i = 1 TO 15: READ REN(i): NEXT i
224 FOR i = 1 TO 15: READ FL(i):  NEXT i
226 FOR i = 1 TO 15: READ FH(i):  NEXT i
228 FOR i = 1 TO 35: READ CP(i):  NEXT i
230 REM FIND OPTIMIZATION FROM VARIANT INPUT DATA & NON - STOP OUTPUT DATA
235 NUMBER = 0
245 FOR FINTHICK = .00018 TO .0002 STEP .00002
250 FOR FINPITCH = .0022 TO .0026 STEP .0004
255 FOR FINOD = .0318 TO .0398 STEP .008
260 FOR ST = .0318 TO .0398 STEP .008
265 FOR SL = .0318 TO .0398 STEP .008
270 FOR PIPE = 10 TO 18 STEP 2
275 FOR TGO = 110 TO 125 STEP 5
280 FOR Le = .4 TO .9 STEP .1
285 FOR Lc = .4 TO .9 STEP .1
287 NUMBER = NUMBER + 1
290 GOTO 300
295 NEXT Lc, Le, TGO, PIPE, SL, ST, FINOD, FINPITCH, FINTHICK
300 GOSUB 400: REM FOR FIND QN,Q1HP,E & NO
303 EFTN1 = 42: OPT1 = 5
305 IF FINTHICK = .0002 THEN PRINT : INPUT "PRESS 'ENTER' KEY TO CONTINUE...", F$
307 PRINT TAB(25); "RUNNING No. = "; NUMBER
310 PRINT TAB(25); "TO BE WORKING,DON'T TOUCHING"
312 IF OPT > OPT1 THEN OTP1 = OPT
315 IF EFTN > EFTN1 AND OPT > OPT1 THEN GOTO 325
320 GOTO 380
325 PRINT "FINOD", "FINPITCH", "FINTHICK", "DIA", "THICK"
330 PRINT USING "#.####        #.####        #.#####        #.####        #.######  "; FINOD; FINPITCH; FINTHICK; DIA; THICK
335 PRINT
340 PRINT "Le", "Lc", "ST", "SL", "PIPE/ROW"
345 PRINT USING "#.#        #.#        #.####        #.####        ##  "; Le; Lc; ST; SL; PIPE
350 PRINT
355 PRINT "FLUEVEL", "VEL", "TGO", "TFO", "NO"
360 PRINT USING "##.##        ##.##        ###        ###.#        ###.#"; FLUEVEL; VEL; TGO; TFO; NO
365 PRINT
370 PRINT "Qmax", "Q1", "QCL", "EFTN", "ENERGY/COST"
375 PRINT USING "###,###.#    ####.#     ####.#      ##.##       ###.####"; Qmax; Q; QCL; EFTN; OPT
380 GOTO 295
385 PRINT : INPUT " PRESS 'ENTER' KEY TO CONTINUE...", F$
390 END
400 REM SUBROUTINE FOR FIND HEAT TRANSFER CAPACITY etc.
435 IF TUBEMAT = 1 THEN KTUBE = 401
440 IF TUBEMAT = 2 THEN KTUBE = 14.9
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445 IF TUBEMAT = 3 THEN KTUBE = 51.9
470 IF KIND = 1 THEN GOTO 910: REM FIND Z
530 IF TUBEARR = 2 THEN GOTO 590
535 c(1, 1) = 0: c(1, 2) = 1.25: c(1, 3) = 1.5: c(1, 4) = 2!: c(1, 5) = 3!
540 c(2, 1) = 1.25: c(2, 2) = .348: c(2, 3) = .275: c(2, 4) = .1: c(2, 5) = .0633
545 c(3, 1) = 1.5: c(3, 2) = .367: c(3, 3) = .25: c(3, 4) = .101: c(3, 5) = .0678
550 c(4, 1) = 2: c(4, 2) = .418: c(4, 3) = .299: c(4, 4) = .299: c(4, 5) = .198
555 c(5, 1) = 3!: c(5, 2) = .29: c(5, 3) = .357: c(5, 4) = .374: c(5, 5) = .286
560 m(1, 1) = 0: m(1, 2) = 1.25: m(1, 3) = 1.5: m(1, 4) = 2!: m(1, 5) = 3!
565 m(2, 1) = 1.25: m(2, 2) = .592: m(2, 3) = .608: m(2, 4) = .704: m(2, 5) = .752
570 m(3, 1) = 1.5: m(3, 2) = .586: m(3, 3) = .62: m(3, 4) = .702: m(3, 5) = .744
575 m(4, 1) = 2!: m(4, 2) = .57: m(4, 3) = .602: m(4, 4) = .632: m(4, 5) = .648
580 m(5, 1) = 3!: m(5, 2) = .601: m(5, 3) = .584: m(5, 4) = .581: m(5, 5) = .608
585 GOTO 910
590 c(1, 1) = 0: c(1, 2) = 1.25: c(1, 3) = 1.5: c(1, 4) = 2!: c(1, 5) = 3!
595 c(2, 1) = 1.25: c(2, 2) = .518: c(2, 3) = .505: c(2, 4) = .519: c(2, 5) = .522
600 c(3, 1) = 1.5: c(3, 2) = .451: c(3, 3) = .46: c(3, 4) = .452: c(3, 5) = .488
605 c(4, 1) = 2!: c(4, 2) = .404: c(4, 3) = .416: c(4, 4) = .482: c(4, 5) = .449
610 c(5, 1) = 3!: c(5, 2) = .31: c(5, 3) = .356: c(5, 4) = .44: c(5, 5) = .428
615 m(1, 1) = 0: m(1, 2) = 1.25: m(1, 3) = 1.5: m(1, 4) = 2!: m(1, 5) = 3!
620 m(2, 1) = 1.25: m(2, 2) = .556: m(2, 3) = .554: m(2, 4) = .556: m(2, 5) = .562
625 m(3, 1) = 1.5: m(3, 2) = .568: m(3, 3) = .562: m(3, 4) = .568: m(3, 5) = .568
630 m(4, 1) = 2!: m(4, 2) = .572: m(4, 3) = .568: m(4, 4) = .556: m(4, 5) = .57
635 m(5, 1) = 3!: m(5, 2) = .592: m(5, 3) = .58: m(5, 4) = .562: m(5, 5) = .574
700 REM FIND MA,MF,VEL AND FLUEVEL
702 GOSUB 14100: REM FIND DAIR & CPA
704 MA = (DAIR * FLOWAIR) / 3600
706 AC = PIPE * ST * Lc
715 VEL = (FLOWAIR / 3600) / AC
718 PRINT : PRINT
720 REM PRINT "MASS FLOW RATE OF AIR  ="; MA; "KG/S"
722 REM PRINT "FACE VELOCITY OF AIR   ="; VEL; "M/S"
724 REM PRINT "DENSITY air ="; DAIR; "KG/CU.M"; "   SPECIFIC HEAT CAPACITY air ="; CPA; "J/KG.K"
728 GOSUB 14200: REM FIND DFLUE & CPF
730 MF = (DFLUE * FLOWGAS) / 3600
735 AF = PIPE * ST * Le
740 FLUEVEL = (FLOWGAS / 3600) / AF
742 PRINT : PRINT
745 REM PRINT "MASS FLOW RATE OF FLUE GAS ="; MF; "KG/S"
750 REM PRINT "FACE VELOCITY OF FLUE GAS ="; FLUEVEL; "M/S"
755 REM PRINT "DENSITY flue ="; DFLUE; "KG/CU.M"; "   SPECIFIC HEAT CAPACITY Flue ="; CPF; "J/KG.K"
800 REM FIND Qhot & Qcold OF HEAT PIPES N PIPES AND TFO
805 Qhot = MF * CPF * (TGI - TGO)
810 TFO = (Qhot / (MA * CPA)) + TFI
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813 PRINT : PRINT
815 REM PRINT "Qhot = Qcold ="; Qhot; "WATTS"
817 REM PRINT "THE HEAT TRANSFER RATE AT HOT SIDE ="; Qhot; "WATTS"
820 REM PRINT "THE OUTLET AIR TEMPERATURE ="; TFO; "C": INPUT w$
825 PRINT : PRINT
900 REM FIND THE THERMAL RESISTANCE Z1 TO Z10
905 REM Z4,Z5 & Z6 ARE NEGLIGIBLE
910 GOSUB 2000: REM FIND Z1
913 REM PRINT "Z1 = "; Z1; "K/W"
915 GOSUB 3000: REM FIND Z9
917 REM PRINT "Z9 = "; Z9; "K/W"
920 L = Le: GOSUB 4000: Z2 = Z: REM FIND Z2
925 REM PRINT "Z2 = "; Z2; "K/W"
930 L = Lc: GOSUB 4000: Z8 = Z: REM FIND Z8
935 REM PRINT "Z8 = "; Z8; "K/W"
1000 L = Le: GOSUB 5000: Z3F = Z: REM FIND Z3F
1005 L = Le: GOSUB 6000: Z3P = Z: REM FIND Z3P
1015 L = Lc: GOSUB 6032: Z7 = Z: REM FIND Z7
1020 GOSUB 6060: REM FIND Z10
1025 REM PRINT "Z10 ="; Z10; "K/W"
1030 REM FIND Ztotal
1045 GOSUB 7000: REM FIND Q
1200 REM PRINT "ABS(Y3) ="; ABS(Y3)
1205 REM PRINT "Z3P ="; ZP; "K/W"
1210 REM PRINT "Z3F ="; ZF; "K/W"
1215 REM PRINT "Z3 ="; Z3; "K/W"
1220 REM PRINT "Z7 ="; Z7; "K/W"
1222 REM PRINT "Ztotal="; Ztotal; "K/W": INPUT w$
1224 PRINT : PRINT
1225 GOSUB 9000: REM FIND EFTN
1230 REM PRINT "THE HEAT TRANSFER CAPACITY OF ONE HEAT PIPE ="; Q; "WATTS"
1235 REM PRINT "THE MAXIMUM HEAT TRANSFER CAPACITY OF N HEAT PIPES ="; Qmax; "WATTS"
1240 REM PRINT "THE EFFECTIVENESS OF HEAT EXCHANGER ="; EFTN; "%"
1245 REM PRINT "THE ACTUAL HEAT TRANSFER CAPACITY OF N HEAT PIPES ="; Qactual; "WATTS"
1250 REM FIND TOTAL NUMBER OF HEAT PIPES IN THIS HEAT EXCHANGER
1255 NO = Qhot / Q
1260 REM PRINT "THE TOTAL NUMBER OF HEAT PIPES ="; NO; "TUBES"
1265 PRINT : PRINT
1320 REM FOR CHECKING QF WITH THE LIMITATION OF HEAT PIPE
1325 GOSUB 11000: REM FOR FIND SONIC LIMIT (QSL)
1330 REM PRINT "THE HEAT TRANSFER RATE due to SONIC LIMITATION ="; QSL; "WATTS"
1335 IF QSL < Q THEN PRINT "There is danger of Sonic Limitation under design conditions"
1340 GOSUB 11050: REM FOR FIND BOILING LIMIT (QBL)
1345 REM PRINT "THE HEAT TRANSFER RATE due to BOILING LIMITATION ="; QBL; "WATTS"
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1350 IF QBL < Q THEN PRINT "There is danger of Boiling Limitation under design conditions"
1355 GOSUB 11100: REM FOR FIND COUNTER - CURRENT FLOW LIMIT (QCL)
1360 REM PRINT "THE HEAT TRANSFER RATE due to COUNTER-CURRENT FLOW LIMITATION ="; QCL; "WATTS"
1365 IF QCL < Q THEN PRINT "There is danger of Counter - Current Flow Limitation under design condition"
1400 REM FOR FINDING PRESSURE DROP IN HEAT EXCHANGER
1405 GOSUB 11200: REM FIND PDE
1407 PRINT : PRINT
1410 REM PRINT "THE PRESSURE DROP IN EVAPORATOR ="; PDE; "N/M^2"
1420 GOSUB 11245: REM FIND PDC
1425 REM PRINT "THE PRESSURE DROP IN CONDENSER  ="; PDC; "N/M^2": INPUT w$
1430 IF DIA = .0159 THEN CPMS = 150
1435 IF DIA = .0222 THEN CPMS = 240
1440 IF DIA = .0286 THEN CPMS = 350
1445 ROW = NO / PIPE
1450 CASING = 3 * ((1 + PIPE) * ST) * ((1 + ROW) * SL) + 2 * ((1 + ROW) * SL) * (Le + Lc)
1455 TCOST = NO * (Le + Lc) * CPMS * 1.5 + (117 * 30 * CASING) / (1.219 * 2.438)
1460 OPT = Qmax / TCOST
1463 PRINT "OPT="; OPT
1465 PRINT : PRINT
1500 RETURN
2000 REM SUBROUTINE FOR Z1
2010 REM FIND REYNOLDS NUMBER
2020 Vmax = (ST / (ST - DIA)) * FLUEVEL
2030 T = ((TGI + TGO) / 2) + 273.15: GOSUB 13000
2035 REM PRINT "Lo = "; LOA; " Mu = "; MUA; " KA = "; KA; "PRA ="; PRA: INPUT w$
2040 RE = (LOA * Vmax * DIA) / MUA
2050 GOSUB 15000: REM FIND C AND M
2055 REM PRINT "For Z1 ;Re = "; RE; "  Pr = "; PRA: INPUT w$
2060 NU = 1.13 * c * (RE ^ m) * (PRA ^ .333)
2061 REM PRINT "Nu ="; NU; "c ="; c; "m ="; m: INPUT w$
2070 H = NU * KA / DIA
2075 REM PRINT "For Z1, H = "; H: INPUT w$
2080 IF TYP = 1 THEN GOTO 2170
2085 IF TYP = 3 THEN GOTO 2170
2090 GOSUB 16000: REM FIND FIN EFF
2095 REM PRINT "For Z1, FIN EFFICIENCY = "; EFF: INPUT w$
2110 REM DETERMINE TUBE AREA
2120 TUBEAREA = (22 / 7) * DIA * (FINPITCH - FINTHICK) * (Le / FINPITCH)
2125 FINAREA = ((2 * Le * (22 / 7)) / (FINPITCH)) * (((FINOD / 2) ^ 2) - ((DIA / 2) ^ 2))
2140 AREA = TUBEAREA + (FINAREA * (EFF / 100))
2145 REM CLS:PRINT "TOTAL AREA = "; AREA: INPUT w$
2150 GOTO 2180
2170 AREA = (22 / 7) * Le * DIA
2180 Z1 = 1 / (H * AREA)
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2185 REM PRINT "Z1 = "; Z1; " K/W"
2190 RETURN
3000 REM SUBROUTINE FOR Z9
3020 Vmax = (ST / (ST - DIA) * VEL)
3025 REM CLS : PRINT "For Z9, velocity = "; VEL; " Vmax = "; vmax: INPUT w$
3030 IF FLUID = 2 THEN GOTO 3060
3040 T = ((TFI + TFO) / 2) + 273.15: GOSUB 13000
3050 LO = LOA: MU = MUA: k = KA: PR = PRA: GOTO 3080
3060 T = ((TFI + TFO) / 2) + 273.15: GOSUB 14000
3070 LO = LOW: MU = MUW: k = KW: PR = PRW
3075 REM CLS : PRINT "Density = "; LO; " Max. vel. = "; vmax; " Viscosity = "; MU; " Prandtle = "; PR: INPUT w$
3080 RE = LO * Vmax * DIA / MU
3090 GOSUB 15000: REM FIND C AND M
3095 REM CLS : PRINT "For Z9 ;  Re = "; RE; "  Pr = "; PR: INPUT w$
3100 NU = 1.13 * c * (RE ^ m) * (PR ^ .333)
3110 H = NU * k / DIA
3120 IF TYP = 1 THEN GOTO 3210
3125 IF TYP = 2 THEN GOTO 3210
3130 GOSUB 16000: REM FIND FIN EFFICIENCY
3135 REM PRINT "EFF ="; EFF
3150 REM DETERMINE TUBE AREA
3160 TUBEAREA = (22 / 7) * DIA * (FINPITCH - FINTHICK) * (Lc / FINPITCH)
3170 FINAREA = ((2 * Lc * (22 / 7)) / (FINPITCH)) * (((FINOD / 2) ^ 2) - ((DIA / 2) ^ 2))
3190 AREA = TUBEAREA + (FINAREA * (EFF / 100))
3200 GOTO 3220
3210 AREA = (22 / 7) * DIA * Lc
3220 Z9 = 1 / (H * AREA)
3225 REM PRINT "Z9 = "; Z9; " K/W"
3230 RETURN
4000 REM SUBROUTINE FOR Z2,Z8 OF TUBEWALL
4010 Z = (LOG(DIA / (DIA - (THICK * 2)))) / (2 * 22 / 7 * KTUBE * L)
4015 REM CLS:PRINT "For Z2,Z8 Tube thickness = "; THICK; " Ktube = "; KTUBE; " L = "; L: INPUT w$
4020 RETURN
5000 REM SUBROUTINE FOR Z3F OF LIQUID FILM
5005 T = ((TGI + TGO) / 2 + (TFI + TFO) / 2) / 2 + 273.15
5010 GOSUB 14000: REM FIND PHI2W
5015 PHI2 = PHI2W
5020 ID = DIA - (2 * THICK)
5021 REM CLS:PRINT "PHI2="; PHI2; "ID="; ID: INPUT w$
5030 Z = .235 / ((ID ^ (4 / 3)) * (9.81 ^ (1 / 3)) * L * (PHI2 ^ (4 / 3)))
5035 REM CLS:PRINT "For Z3F  ID = "; ID; "t = "; T; " Start = "; PHI2W(1); " PHI2 = "; PHI2: INPUT w$
5040 RETURN
6000 REM SUBROUTINE FOR Z3P OF LIQUID POOL
6005 T = ((TGI + TGO) / 2 + (TFI + TFO) / 2) / 2 + 273.15
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6015 PV = .401 - (.0276 * T) + (.000598 * T ^ 2) - (.0006 * T ^ 3) + (.00000602# * T ^ 4)
6020 PHI3 = 63 * ((PV / 100000!) ^ .23)
6025 Z = 1 / (PHI3 * (9.81 ^ .2) * ((22 / 7 * (DIA - (2 * THICK)) * L) ^ .6))
6030 RETURN
6032 REM SUBROUTINE FOR Z7
6034 T = ((TGI + TGO) / 2 + (TFI + TFO) / 2) / 2 + 273.15
6035 REM PRINT "T="; T
6036 GOSUB 14000: REM FIND MUW,LHW &PHI2W
6038 ID = DIA - (2 * THICK)
6039 REM PRINT "ID="; ID; "MUW"; MUW; "L="; L; "PHI2W="; PHI2W; "LHW="; LHW: INPUT w$
6040 Z = .235 / ((ID ^ (4 / 3)) * (9.81 ^ (1 / 3)) * L * (PHI2W ^ (4 / 3)))
6042 RETURN
6060 REM SUBROUTINE FOR Z10
6070 RAREA = ((22 / 7) / 4) * ((DIA ^ 2) - ((DIA - (2 * THICK)) ^ 2))
6080 Z10 = ((.5 * Le) + La + (.5 * Lc)) / (RAREA * KTUBE)
6090 RETURN
7000 REM SUBROUTINE FOR FINDING Q
7010 REM FIND LMTD FOR Q
7020 REM PRINT "FLOW="; FLOW: INPUT w$
7030 IF FLOW = 2 THEN GOTO 7050
7040 LMTD = ((TGI - TFI) - (TGO - TFO)) / (LOG((TGI - TFI) / (TGO - TFO))): GOTO 7060
7050 LMTD = ((TGI - TFO) - (TGO - TFI)) / (LOG((TGI - TFO) / (TGO - TFI)))
7060 REM PRINT "LMTD="; LMTD
7070 REM FIND Q BY ITERATION
7080 Q1 = .01: Q = Q1: GOSUB 7200: Y1 = Y
7090 Q2 = 1E+07: Q = Q2: GOSUB 7200: Y2 = Y
7100 IF Y1 * Y2 > 0 THEN PRINT "TOO NARROW RANGE OF Y;YOU MUST BE CHANGED DATA AGAIN": INPUT w$
7110 Q3 = (Q1 + Q2) / 2: Q = Q3: GOSUB 7200: Y3 = Y
7120 IF ABS(Y3) < .1 THEN GOTO 7180
7130 IF Y1 * Y3 < 0 THEN GOTO 7160
7140 IF Y2 * Y3 < 0 THEN GOTO 7170
7160 Q2 = Q3: Y2 = Y3: GOTO 7110
7170 Q1 = Q3: Y1 = Y3: GOTO 7110
7180 Q = Q3
7185 GOSUB 8000: REM FOR FIND Z3 AND Z7 FROM Q
7190 RETURN
7200 REM SUBROUTINE FOR Y
7203 LF = .5
7205 Ztotal = Z1 + (((Z2 + ((Z3P * LF) / (Q ^ (.4))) + (Z3F * (1 - LF) * (Q ^ (1 / 3))) + (Z7 * (Q ^ (1 / 3))) + Z8) * Z10) / ((Z2 + ((Z3P
* LF) / (Q ^ (.4))) + (Z3F * (1 - LF) * (Q ^ (1 / 3))) + (Z7 * (Q ^ (1 / 3))) + Z8) + Z10)) + Z9
7210 Y = Q - LMTD / (Ztotal)
7215 RETURN
8000 REM SUBROUTINE FOR FIND Z3 AND Z7 FROM Q
8005 T = ((TGI + TGO) / 2 + (TFI + TFO) / 2) / 2 + 273.15
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8010 GOSUB 14000: REM FIND PHI2W
8015 PHI2 = PHI2W
8020 ID = DIA - (2 * THICK)
8025 ZF = .235 * (Q ^ (1 / 3)) / ((ID ^ (4 / 3)) * (9.81 ^ (1 / 3)) * Le * (PHI2 ^ (4 / 3)))
8030 PV = .401 - (.0276 * T) + (.000598 * T ^ 2) - (.0006 * T ^ 3) + (.00000602# * T ^ 4)
8035 PHI3 = 63 * ((PV / 100000) ^ .23)
8040 ZP = 1 / (PHI3 * (9.81 ^ (.2)) * (Q ^ (.4)) * (22 / 7 * ID * Le) ^ (.6))
8045 Z3 = ZP * LF + ZF * (1 - LF)
8050 Z7 = .235 * (Q ^ (1 / 3)) / ((ID ^ (4 / 3)) * (9.81 ^ (1 / 3)) * Lc * (PHI2 ^ (4 / 3)))
8055 RETURN
9000 REM FIND THE EFFECTIVENESS OF HEAT EXCHANGER
9005 IF MF * CPF > MA * CPA THEN MCP = MA * CPA
9010 IF MA * CPA > MF * CPF THEN MCP = MF * CPF
9015 EFTN = (((MF * CPF) / MCP) * ((TGI - TGO) / (TGI - TFI))) * 100
9017 PRINT "EFTN="; EFTN
9020 Qmax = Qhot
9025 Qactual = (EFTN / 100) * Qmax
9030 RETURN
11000 REM SUBROUTINE FOR FIND SONIC LIMIT (QSL)
11005 AREA = ((22 / 7) * (DIA - 2 * THICK) ^ 2) / 4
11010 T = ((TGI + TGO) / 2 + (TFI + TFO) / 2) / 2 + 273.15
11015 GOSUB 14000: REM FIND LHW & LOV
11020 PV = .401 - (.0276 * T) + (.000598 * T ^ 2) - (.0006 * T ^ 3) + (.00000602# * T ^ 4)
11025 QSL = .5 * AREA * LHW * ((PV * LOV) ^ .5)
11030 RETURN
11050 REM SUBROUTINE FOR FIND BOILING LIMIT (QBL)
11055 SE = (22 / 7) * (DIA - 2 * THICK) * Le
11060 T = ((TGI + TGO) / 2 + (TFI + TFO) / 2) / 2 + 273.15
11065 GOSUB 14000: REM FIND LHW,LOV,LOW & SIG
11070 QBL = .12 * SE * LHW * ((LOV) ^ .5) * ((9.81 * SIG * (LOW - LOV)) ^ .25)
11075 RETURN
11100 REM SUBROUTINE FOR FIND COUNTER - CURRENT FLOW LIMIT (QCL)
11105 ID = DIA - 2 * THICK
11110 AREA = ((22 / 7) * (ID) ^ 2) / 4
11115 T = ((TGI + TGO) / 2 + (TFI + TFO) / 2) / 2 + 273.15
11120 REM FIND A FUNCTION OF THE BOND NUMBER (F1)
11125 GOSUB 14000: REM FIND LOW,LOV & SIG
11130 BO = ID * (((9.81 * (LOW - LOV)) / SIG) ^ .5)
11133 REM PRINT "BO="; BO
11135 IF BO > 11 THEN F1 = 8.2: GOTO 11145
11140 F1 = 3.1127 + (.9939 * BO) - (.1155 * BO ^ 2) + (.0121 * BO ^ 3) - (.0006 * BO ^ 4)
11145 REM FIND A FUNCTION OF THE DIMENSIONLESS PRESSURE PARAMETER (F2)
11150 PV = .401 - (.0276 * T) + (.000598 * T ^ 2) - (.0006 * T ^ 3) + (.00000602# * T ^ 4)
11155 KP = PV / ((9.81 * SIG * (LOW - LOV)) ^ .5)
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11157 REM PRINT "KP="; KP
11160 IF KP > 40000 THEN F2 = .165: GOTO 11170
11165 F2 = ((KP) ^ (-.17))
11170 QCL = F1 * F2 * AREA * LHW * ((LOV) ^ .5) * ((9.81 * SIG * (LOW - LOV)) ^ .25)
11175 RETURN
11200 REM SUBROUTINE FOR FIND PRESSURE DROP ACROSS TUBE BUNDLE IN EVAPORATOR (PDE)
11205 T = ((TGI + TGO) / 2) + 273.15
11210 VEmax = (ST / (ST - DIA)) * FLUEVEL
11215 PT = (ST / DIA): PL = (SL / DIA): RA = PT / PL
11220 GOSUB 13000: REM FIND LOA,MUA
11225 REE = (LOA * VEmax * DIA) / MUA
11227 REM PRINT "REE="; REE
11230 GOSUB 11400: REM FIND CFE&FFE
11233 CFE = CFE3
11235 PDE = ((NO / PIPE) * CFE * FFE) * ((LOA * (VEmax ^ 2)) / 2)
11240 RETURN
11245 REM SUBROUTINE FOR FIND PRESSURE DROP ACROSS TUBE BUNDLE IN CONDENSER (PDC)
11250 T = ((TFI + TFO) / 2) + 273.15
11255 VCmax = (ST / (ST - DIA)) * VEL
11260 PT = (ST / DIA): PL = (SL / DIA): RA = PT / PL
11265 IF FLUID = 2 THEN GOTO 11280
11270 GOSUB 13000: REM FIND LOA & MUA
11275 LO = LOA: MU = MUA
11279 GOTO 11290
11280 GOSUB 14000: REM FIND LOW &MUW
11285 LO = LOW: MU = MUW
11290 REC = (LO * VCmax * DIA) / MU
11293 REM PRINT "REC="; REC: INPUT w$
11295 GOSUB 14500: REM FIND CFC&FFC
11297 CFC = CFC3
11300 PDC = ((NO / PIPE) * CFC * FFC) * ((LO * (VCmax ^ 2)) / 2)
11305 RETURN
11400 REM SUBROUTINE FOR FIND FRICTION FACTOR (FFE) AND CORRECTION FACTOR (CFE)
11402 REM FIND FRICTION FACTOR (FFE)
11404 IF PT = 2 THEN GOTO 11408
11406 IF PT = 2.5 THEN GOTO 11412
11408 GOSUB 14300: REM FOR FIND FFE
11409 FFE = FL
11410 GOTO 11417
11412 GOSUB 14400: REM FOR FIND FFE
11414 FFE = FH
11417 REM PRINT "FFE="; FFE
11420 REM FIND CORRECTION FACTOR (CFE)
11425 IF REE <= 100 THEN GOTO 11450
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11430 IF REE >= 100000 THEN GOTO 11460
11435 IF 100 < REE AND REE < 1000 THEN GOTO 11475
11440 IF 1000 < REE AND REE < 10000 THEN GOTO 11490
11445 IF 10000 < REE AND REE < 100000 THEN GOTO 11505
11450 CFE3 = .9928 - (.0702 * RA) + (.0857 * RA ^ 2) - (.0083 * RA ^ 3)
11455 GOTO 11510
11460 CFE3 = 1.4615 - (.0688 * RA) - (.0204 * RA ^ 2) + (.004 * RA ^ 3) - (.0002 * RA ^ 4)
11465 GOTO 11510
11475 GOSUB 11800: REM FIND CFE
11480 GOTO 11510
11490 GOSUB 11900: REM FIND CFE
11495 GOTO 11510
11505 GOSUB 11950: REM FIND CFE
11510 RETURN
11800 REM SUBROUTINE FOR INTERPOLATION CFE
11803 REE1 = 100: REE2 = 1000: REE3 = REE
11805 CFE1 = .9928 - (.0702 * RA) + (.0857 * RA ^ 2) - (.0083 * RA ^ 3)
11807 REM PRINT "CFE1="; CFE1
11810 CFE2 = 1.0121 + (.0186 * RA) - (.022 * RA ^ 2) + (.0056 * RA ^ 3) - (.0003 * RA ^ 4)
11813 REM PRINT "CFE2="; CFE2
11815 CFE3 = CFE1 + (CFE2 - CFE1) * ((REE3 - REE1) / (REE2 - REE1))
11817 REM PRINT "CFE3="; CFE3
11825 RETURN
11900 REM SUBROUTINE FOR INTERPOLATION CFE
11903 REE1 = 1000: REE2 = 10000: REE3 = REE
11905 CFE1 = 1.0121 + (.0186 * RA) - (.022 * RA ^ 2) + (.0056 * RA ^ 3) - (.0003 * RA ^ 4)
11907 REM PRINT "CFE1="; CFE1
11910 CFE2 = 1.1784 - (.0898 * RA) + (.0114 * RA ^ 2) - (.0002 * RA ^ 3) + (.00002 * RA ^ 4)
11913 REM PRINT "CFE2="; CFE2
11915 CFE3 = CFE1 + (CFE2 - CFE1) * ((REE3 - REE1) / (REE2 - REE1))
11927 REM PRINT "CFE3="; CFE3
11925 RETURN
11950 REM SUBROUTINE FOR INTERPOLATION CFE
11953 REE1 = 10000: REE2 = 100000: REE3 = REE
11955 CFE1 = 1.1784 - (.0898 * RA) + (.0114 * RA ^ 2) - (.0002 * RA ^ 3) + (.00002 * RA ^ 4)
11957 REM PRINT "CFE1="; CFE1
11960 CFE2 = 1.4615 - (.0688 * RA) - (.0204 * RA ^ 2) + (.004 * RA ^ 3) - (.0002 * RA ^ 4)
11963 REM PRINT "CFE2="; CFE2
11965 CFE3 = CFE1 + (CFE2 - CFE1) * ((REE3 - REE1) / (REE2 - REE1))
11967 REM PRINT "CFE3="; CFE3
11975 RETURN
13000 REM SUBROUTINE FOR AIR PROPERTIES
13010 FOR i = 1 TO 35
13020 IF T > TA(i) THEN GOTO 13080
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13030 LOA = LOA(i - 1) + (LOA(i) - LOA(i - 1)) * (T - TA(i - 1)) / (TA(i) - TA(i - 1))
13040 MUA = MUA(i - 1) + (MUA(i) - MUA(i - 1)) * (T - TA(i - 1)) / (TA(i) - TA(i - 1))
13050  KA = KA(i - 1) + (KA(i) - KA(i - 1)) * (T - TA(i - 1)) / (TA(i) - TA(i - 1))
13060 PRA = PRA(i - 1) + (PRA(i) - PRA(i - 1)) * (T - TA(i - 1)) / (TA(i) - TA(i - 1))
13065 SHP = SHP(i - 1) + (SHP(i) - SHP(i - 1)) * (T - TA(i - 1)) / (TA(i) - TA(i - 1))
13070 GOTO 13090
13080 NEXT i
13090 RETURN
14000 REM SUBROUTINE FOR WATER PROPERTIES
14010 FOR i = 1 TO 28
14020 IF T > TW(i) THEN GOTO 14080
14030 LOW = LOW(i - 1) + (LOW(i) - LOW(i - 1)) * (T - TW(i - 1)) / (TW(i) - TW(i - 1))
14040 MUW = MUW(i - 1) + (MUW(i) - MUW(i - 1)) * (T - TW(i - 1)) / (TW(i) - TW(i - 1))
14050  KW = KW(i - 1) + (KW(i) - KW(i - 1)) * (T - TW(i - 1)) / (TW(i) - TW(i - 1))
14060 PRW = PRW(i - 1) + (PRW(i) - PRW(i - 1)) * (T - TW(i - 1)) / (TW(i) - TW(i - 1))
14065 PHI2W = PHI2W(i - 1) + (PHI2W(i) - PHI2W(i - 1)) * (T - TW(i - 1)) / (TW(i) - TW(i - 1))
14067 LHW = LHW(i - 1) + (LHW(i) - LHW(i - 1)) * (T - TW(i - 1)) / (TW(i) - TW(i - 1))
14069 LOV = LOV(i - 1) + (LOV(i) - LOV(i - 1)) * (T - TW(i - 1)) / (TW(i) - TW(i - 1))
14071 SIG = SIG(i - 1) + (SIG(i) - SIG(i - 1)) * (T - TW(i - 1)) / (TW(i) - TW(i - 1))
14079 GOTO 14090
14080 NEXT i
14090 RETURN
14100 REM SUBROUTINE FIND DAIR & CPA
14110 T = TFI + 273.15
14120 FOR i = 1 TO 35
14130 IF T > TA(i) THEN GOTO 14180
14140 LOA = LOA(i - 1) + (LOA(i) - LOA(i - 1)) * (T - TA(i - 1)) / (TA(i) - TA(i - 1))
14150 CP = CP(i - 1) + (CP(i) - CP(i - 1)) * (T - TA(i - 1)) / (TA(i) - TA(i - 1))
14160 DAIR = LOA
14165 CPA = CP
14170 GOTO 14190
14180 NEXT i
14190 RETURN
14200 REM SUBROUTINE FIND DFLUE & CPF
14210 T = TGI + 273.15
14220 FOR i = 1 TO 35
14230 IF T > TA(i) THEN GOTO 14280
14240 LOA = LOA(i - 1) + (LOA(i) - LOA(i - 1)) * (T - TA(i - 1)) / (TA(i) - TA(i - 1))
14250 CP = CP(i - 1) + (CP(i) - CP(i - 1)) * (T - TA(i - 1)) / (TA(i) - TA(i - 1))
14260 DFLUE = LOA
14265 CPF = CP
14270 GOTO 14290
14280 NEXT i
14290 RETURN
```

```
14300 REM SUBROUTINE FOR FRICTION FACTOR (FFE) AT PT=2.0
14305 FOR i = 1 TO 15
14310 IF REE > REN(i) THEN GOTO 14330
14315 FL = FL(i - 1) + (FL(i) - FL(i - 1)) * (REE - REN(i - 1)) / (REN(i) - REN(i - 1))
14325 GOTO 14335
14330 NEXT i
14335 RETURN
14400 REM SUBROUTINE FOR FRICTION FACTOR (FFE) AT PT=2.5
14405 FOR i = 1 TO 15
14410 IF REE > REN(i) THEN GOTO 14425
14415 FH = FH(i - 1) + (FH(i) - FH(i - 1)) * (REE - REN(i - 1)) / (REN(i) - REN(i - 1))
14420 GOTO 14430
14425 NEXT i
14430 RETURN
14500 REM SUBROURTINE FOR FIND FRICTION FACTOR (FFC) AND CORRECTION FACTOR (CFC)
14505 REM FIND FRICTION FACTOR (FFC)
14510 IF PT = 2 THEN GOTO 14520
14515 IF PT = 2.5 THEN GOTO 14535
14520 GOSUB 14930: REM FOR FIND FFC
14525 FFC = FL
14530 GOTO 14545
14535 GOSUB 14965: REM FOR FIND FFC
14540 FFC = FH
14545 REM PRINT "FFC="; FFC
14550 REM FIND CORRECTION FACTOR (CFC)
14555 IF REC <= 100 THEN GOTO 14580
14560 IF REC >= 100000 THEN GOTO 14590
14565 IF 100 < REC AND REC < 1000 THEN GOTO 14605
14570 IF 1000 < REC AND REC < 10000 THEN GOTO 14620
14575 IF 10000 < REC AND REC < 100000 THEN GOTO 14635
14580 CFC3 = .9928 - (.0702 * RA) + (.0857 * RA ^ 2) - (.0083 * RA ^ 3)
14585 GOTO 14640
14590 CFC3 = 1.4615 - (.0688 * RA) - (.0204 * RA ^ 2) + (.004 * RA ^ 3) - (.0002 * RA ^ 4)
14595 GOTO 14640
14605 GOSUB 14700: REM FIND CFC
14610 GOTO 14640
14620 GOSUB 14800: REM FIND CFC
14625 GOTO 14640
14635 GOSUB 14900: REM FIND CFC
14640 RETURN
14700 REM SUBROUTINE FOR INTERPOLATION CFC
14703 REC1 = 100: REC2 = 1000: REC3 = REC
14705 CFC1 = .9928 - (.0702 * RA) + (.0857 * RA ^ 2) - (.0083 * RA ^ 3)
14707 REM PRINT "CFC1="; CFC1
```

```
14710 CFC2 = 1.0121 + (.0186 * RA) - (.022 * RA ^ 2) + (.0056 * RA ^ 3) - (.0003 * RA ^ 4)
14713 REM PRINT "CFC2="; CFC2
14715 CFC3 = CFC1 + (CFC2 - CFC1) * ((REC3 - REC1) / (REC2 - REC1))
14717 REM PRINT "CFC3="; CFC3
14720 RETURN
14800 REM SUBROUTINE FOR INTERPOLATION CFC
14803 REC1 = 1000: REC2 = 10000: REC3 = REC
14805 CFC1 = 1.0121 + (.0186 * RA) - (.022 * RA ^ 2) + (.0056 * RA ^ 3) - (.0003 * RA ^ 4)
14807 REM PRINT "CFC1="; CFC1
14810 CFC2 = 1.1784 - (.0898 * RA) + (.0114 * RA ^ 2) - (.0002 * RA ^ 3) + (.00002 * RA ^ 4)
14813 REM PRINT "CFC2="; CFC2
14815 CFC3 = CFC1 + (CFC2 - CFC1) * ((REC3 - REC1) / (REC2 - REC1))
14817 REM PRINT "CFC3="; CFC3
14820 RETURN
14900 REM SUBROUTINE FOR INTERPOLATION CFC
14903 REC1 = 10000: REC2 = 100000: REC3 = REC
14905 CFC1 = 1.1784 - (.0898 * RA) + (.0114 * RA ^ 2) - (.0002 * RA ^ 3) + (.00002 * RA ^ 4)
14907 REM PRINT "CFC1="; CFC1
14910 CFC2 = 1.4615 - (.0688 * RA) - (.0204 * RA ^ 2) + (.004 * RA ^ 3) - (.0002 * RA ^ 4)
14913 REM PRINT "CFC2="; CFC2
14915 CFC3 = CFC1 + (CFC2 - CFC1) * ((REC3 - REC1) / (REC2 - REC1))
14917 REM PRINT "CFC3="; CFC3
14920 RETURN
14930 REM SUBROUTINE FOR FRICTION FACTOR (FFC) AT PT = 2.0
14935 FOR i = 1 TO 15
14940 IF REC > REN(i) THEN GOTO 14955
14945 FL = FL(i - 1) + (FL(i) - FL(i - 1)) * (REC - REN(i - 1)) / (REN(i) - REN(i - 1))
14950 GOTO 14960
14955 NEXT i
14960 RETURN
14965 REM SUBROUTINE FOR FRICTION FACTOR (FFC) AT PT=2.5
14970 FOR i = 1 TO 15
14975 IF REC > REN(i) THEN GOTO 14990
14980 FH = FH(i - 1) + (FH(i) - FH(i - 1)) * (REC - REN(i - 1)) / (REN(i) - REN(i - 1))
14985 GOTO 14995
14990 NEXT i
14995 RETURN
15000 REM SUBROUTINE FOR C AND M
15002 REM PRINT "SL/DIA = "; SL / DIA; "  ST/DIA = "; ST / DIA: INPUT w$
15003 IF (SL / DIA) > c(5, 1) OR (ST / DIA) > c(1, 5) THEN GOTO 15005
15004 GOTO 15010
15005 IF TUBEARR = 2 THEN GOTO 15008
15006 c = .286: m = .608
15007 GOTO 15125
```

```
15008 c = .428: m = .574: GOTO 15125
15010 FOR i = 1 TO 5
15011 IF (SL / DIA) = c(i, 1) OR (SL / DIA) = m(i, 1) THEN GOTO 15013
15012 GOTO 15019
15013 FOR j = 1 TO 5
15014 IF (ST / DIA) = c(1, j) OR (ST / DIA) = m(1, j) THEN GOTO 15016
15015 GOTO 15018
15016 c = c(i, j): m = m(i, j)
15017 GOTO 15125
15018 NEXT j
15019 NEXT i
15021 REM FOR INTERPOLATION C AND M
15023 FOR i = 1 TO 5
15024 IF (SL / DIA) > c(i - 1, 1) AND (SL / DIA) < c(i, 1) THEN GOTO 15030
15025 GOTO 15120
15030 FOR j = 1 TO 5
15040 IF (ST / DIA) > c(1, j - 1) AND (ST / DIA) < c(1, j) THEN GOTO 15045
15043 GOTO 15110
15045 c1 = c(i - 1, j - 1) + ((SL / DIA) - c(i - 1, 1)) * (c(i, j - 1) - c(i - 1, j - 1)) / (c(i, 1) - c(i - 1, 1))
15050 c2 = c(i - 1, j) + ((SL / DIA) - c(i - 1, 1)) * (c(i, j) - c(i - 1, j)) / (c(i, 1) - c(i - 1, 1))
15055 REM PRINT "c1="; c1; "c2="; c2: INPUT w$
15060 c = c1 + ((ST / DIA) - c(1, j - 1)) * (c2 - c1) / (c(1, j) - c(1, j - 1))
15070 m1 = m(i - 1, j - 1) + ((SL / DIA) - m(i - 1, 1)) * (m(i, j - 1) - m(i - 1, j - 1)) / (m(i, 1) - m(i - 1, 1))
15080 m2 = m(i - 1, j) + ((SL / DIA) - m(i - 1, 1)) * (m(i, j) - m(i - 1, j)) / (m(i, 1) - m(i - 1, 1))
15090 m = m1 + ((ST / DIA) - m(1, j - 1)) * (m2 - m1) / (m(1, j) - m(1, j - 1))
15100 GOTO 15125
15110 NEXT j
15120 NEXT i
15125 REM PRINT "c = "; c; "   m = "; m: INPUT w$
15130 RETURN
16000 REM SUBROUTINE FOR CIRCULAR FIN EFFICIENCY
16005 R2C = ((FINOD / 2) + (FINTHICK / 2)) / (DIA / 2): LC1 = ((FINOD - DIA) / 2) + (FINTHICK / 2): AP = LC1 * FINTHICK
16010 REM PRINT "R2C = "; R2C; " LC1 = "; LC1; "AP="; AP: INPUT w$
16015 IF FINMAT = 1 THEN KFIN = 401
16020 IF FINMAT = 2 THEN KFIN = 237
16025 XA = (LC1) ^ 1.5 * (H / (KFIN * AP)) ^ .5
16030 REM PRINT "VALUE OF X AXIS= "; XA: INPUT w$
16035 IF R2C <= 1 THEN GOTO 16060
16040 IF R2C >= 5 THEN GOTO 16070
16045 IF 1 < R2C AND R2C < 2 THEN GOTO 16080
16050 IF 2 < R2C AND R2C < 3 THEN GOTO 16090
16055 IF 3 < R2C AND R2C < 5 THEN GOTO 16100
16060 EFF = 100.114 - (5.668 * XA) - (57.526 * XA ^ 2) + (33.792 * XA ^ 3) - (5.75 * XA ^ 4)
16065 GOTO 16105
```

```
16070 EFF = 100.526 - (52.057 * XA) - (21.385 * XA ^ 2) + (22.955 * XA ^ 3) - (4.72 * XA ^ 4)
16075 GOTO 16105
16080 GOSUB 17000: REM FIND EFF
16085 GOTO 16105
16090 GOSUB 18000: REM FIND EFF
16095 GOTO 16105
16100 GOSUB 19000: REM FIND EFF
16105 RETURN
17000 REM SUBROUTINE FOR INTERPOLATION EFF
17005 R2C1 = 1: R2C2 = 2: R2C3 = R2C
17010 EFF1 = 100.114 - (5.668 * XA) - (57.526 * XA ^ 2) + (33.792 * XA ^ 3) - (5.75 * XA ^ 4)
17015 EFF2 = 100.495 - (20.239 * XA) - (51.5 * XA ^ 2) + (33.394 * XA ^ 3) - (5.876 * XA ^ 4)
17020 EFF = EFF1 + (EFF2 - EFF1) * ((R2C3 - R2C1) / (R2C2 - R2C1))
17023 REM PRINT "EFF ="; EFF
17025 RETURN
18000 REM SUBROUTINE FOR INTERPOLATION EFF
18005 R2C1 = 2: R2C2 = 3: R2C3 = R2C
18010 EFF1 = 100.495 - (20.239 * XA) - (51.5 * XA ^ 2) + (33.394 * XA ^ 3) - (5.876 * XA ^ 4)
18015 EFF2 = 100.476 - (31.977 * XA) - (44.527 * XA ^ 2) + (32.942 * XA ^ 3) - (6.18 * XA ^ 4)
18020 EFF = EFF1 + (EFF2 - EFF1) * ((R2C3 - R2C1) / (R2C2 - R2C1))
18023 REM PRINT "EFF ="; EFF
18025 RETURN
19000 REM SUBROUTINE FOR INTERPOLATION EFF
19005 R2C1 = 3: R2C2 = 5: R2C3 = R2C
19010 EFF1 = 100.476 - (31.977 * XA) - (44.527 * XA ^ 2) + (32.942 * XA ^ 3) - (6.18 * XA ^ 4)
19015 EFF2 = 100.526 - (52.057 * XA) - (21.385 * XA ^ 2) + (22.955 * XA ^ 3) - (4.72 * XA ^ 4)
19020 EFF = EFF1 + (EFF2 - EFF1) * ((R2C3 - R2C1) / (R2C2 - R2C1))
19023 REM PRINT "EFF ="; EFF
19025 RETURN
20000 DATA 100,150,200,250,300,350,400,450,500,550,600,650,700,750,800,850,900,950,1000,1100,1200,1300,1400,1500,
1600, 1700,1800,1900,2000,2100,2200,2300,2400,2500,3000
20010 DATA 3.5562,2.3364,1.7458,1.3947,1.1614,0.9950,0.8711,0.7740,0.6964,0.6329,0.5804,0.5356,0.4975, 0.4643, 0.4354,
0.4097, 0.3868,0.3666,0.3482,0.3166,0.2902,0.2679,0.2488,0.2322,0.2177,0.2049,0.1935, 0.1833,0.1741,0.1658,0.1582,0.1513,
0.1448,0.1389,0.1135
20020 DATA 71.1E-7,103.4E-7,132.5E-7,159.6E-7,184.6E-7,208.2E-7,230.1E-7,250.7E-7,270.1E-7,288.4E-7,305.8E-7,322.5E-
7,338.8E-7,354.6E-7,369.8E-7,384.3E-7,398.1E-7,411.3E-7,424.4E-7,449.0E-7,473.0E-7,496.0E-7,530E-7,557E-7,584E-7,611E-
7,637E-7,663E-7,689E-7,715E-7,740E-7,766E-7,792E-7,818E-7,955E-7
20030 DATA 9.34E-3,13.8E-3,18.1E-3,22.3E-3,26.3E-3,30.0E-3,33.8E-3,37.3E-3,40.7E-3,43.9E-3,46.9E-3,49.7E-3,52.4E-3,54.9E-
3,57.3E-3,59.6E-3,62.0E-3,64.3E-3,66.7E-3,71.5E-3,76.3E-3,82E-3,91E-3,100E-3,106E-3,113E-3,120E-3,128E-3,137E-3,147E-
3,160E-3,175E-3,196E-3,222E-3,486E-3
20040 DATA 0.786,0.758,0.737,0.720,0.707,0.700,0.690,0.686,0.684, 0.683,0.685,0.690,0.695,0.702,0.709,0.716, 0.720, 0.723,
0.726,0.728,0.728,0.719,0.703,0.685,0.688,0.685,0.683,0.677,0.672,0.667,0.655,0.647,0.630,0.613,0.536
20045 DATA 1032,1012,1007,1006,1007,1009,1014,1021,1030,1040,1051,1063,1075,1087, 1099,1110,1121,1131, 1141,1159,
1175, 1189,1207,1230,1248,1267,1286,1307,1337,1372,1417,1478,1558,1665,2726
```

```
20050 DATA 363.15,373.15,383.15,393.15,403.15,413.15,423.15,433.15,443.15,453.15,463.15,473.15, 483.15,493.15,503.15,
513.15, 523.15,533.15,543.15,553.15,563.15, 573.15,583.15,593.15,603.15,613.15,623.15,633.15
20060 DATA 963.5,957.0,950.0,942.6,934.8,926.6,917.9,908.7,899.0,888.7,878.0,866.7,854.7,842.2,829.0, 815.0,800.3,784.7,
768.2,750.6,731.8,711.6,689.8,665.9,639.3,609.0,573.1,527.0
20070 DATA 0.312E-3,0.28E-3,0.253E-3,0.231E-3,0.212E-3,0.196E-3,0.182E-3,0.17E-3,0.16E-3,0.151E-3,0.142E-3,0.135E-
3,0.128E-3,0.122E-3,0.116E-3,0.111E-3,0.106E-3,0.102E-3,0.098E-3,0.093E-3,0.090E-3,0.086E-3,0.082E-3,0.078E-3,0.074E-
3,0.070E-3,0.066E-3,0.061E-3
20080 DATA 0.6744,0.6789,0.6821,0.6841,0.6850,0.6840,0.6836,0.6814,0.6782,0.6741,0.6690,0.6631,0.6562,0.6484,0.6396,
0.6299,0.6192, 0.6075,0.5947,0.5807, 0.5656,0.5492,0.5314,0.5122,0.4915,0.4691,0.4450,0.4190
20090 DATA 1.95,1.76,1.56,1.43,1.31,1.21,1.14,1.07,1.02,0.98,0.94,0.91,0.855,0.867,0.857,0.847,0.843,0.853,0.863, 0.879,
0.913,0.956,1.009,1.078,1.190,1.369,1.602,2.441
20100 DATA
6756,6935,7089,7219,7325,7410,7474,7516,7539,7542,7526,7491,7437,7365,7275,7166,7038,6890,6723,6533,6322,6085,5822,
5529,5199,4824,4386,3837
20110 DATA 2284E3,2257E3,2230E3,2202E3,2174E3,2144E3,2113E3,2081E3,2048E3,2013E3,1977E3,1939E3,1900E3, 1858E3,
1814E3,1767E3,1717E3,1663E3,1606E3,1544E3,1476E3,1401E3,1318E3,1225E3,1119E3,993.4E3,841.0E3,642.1E3
20120 DATA .42272,.59632,.82431,1.1187,1.4930,1.9624,2.5440,3.2564,4.1207,5.1601,6.4004,7.8708,9.6039,11.637,14.013,
16.783,20.005,23.753,28.113,33.199,39.156,46.176,54.530,64.608,77.016,92.773,113.82,144.78
20130 DATA 60.83E-3,58.93E-3,56.98E-3,54.99E-3,52.95E-3,50.88E-3,48.76E-3,46.61E-3,44.43E-3,42.21E-3,39.97E-3,37.70E-3,
35.41E-3,33.09E-3,30.76E-3,28.42E-3,26.07E-3,23.72E-3,21.37E-3, 19.02E-3,16.70E-3,14.39E-3,12.12E-3,9.895E-3,7.733E-
3,5.655E-3,3.693E-3,1.902E-3
20140 DATA 200,400,600,800,1000,2000,4000,6000,8000,10000,20000,40000,60000,80000,100000
20150 DATA 0.76,0.60,0.525,0.50,0.475,0.45,0.40,0.3714,0.357,0.3428,0.30,0.2429,0.2,0.1929,0.1786
20160 DATA 0.63,0.50,0.45,0.425,0.4125,0.3857,0.3714,0.3428,0.3286,0.3143,0.2714,0.2143,0.1929,0.1786,0.1643
20170 DATA 1032,1012,1007,1006,1007,1009,1014,1021,1030,1040,1051,1063,1075,1087,1099,1110,1121,1131,1141,1159,
1175,1189,1207,1230,1248,1267,1286,1307,1337,1372,1417,1478,1558,1665,2726
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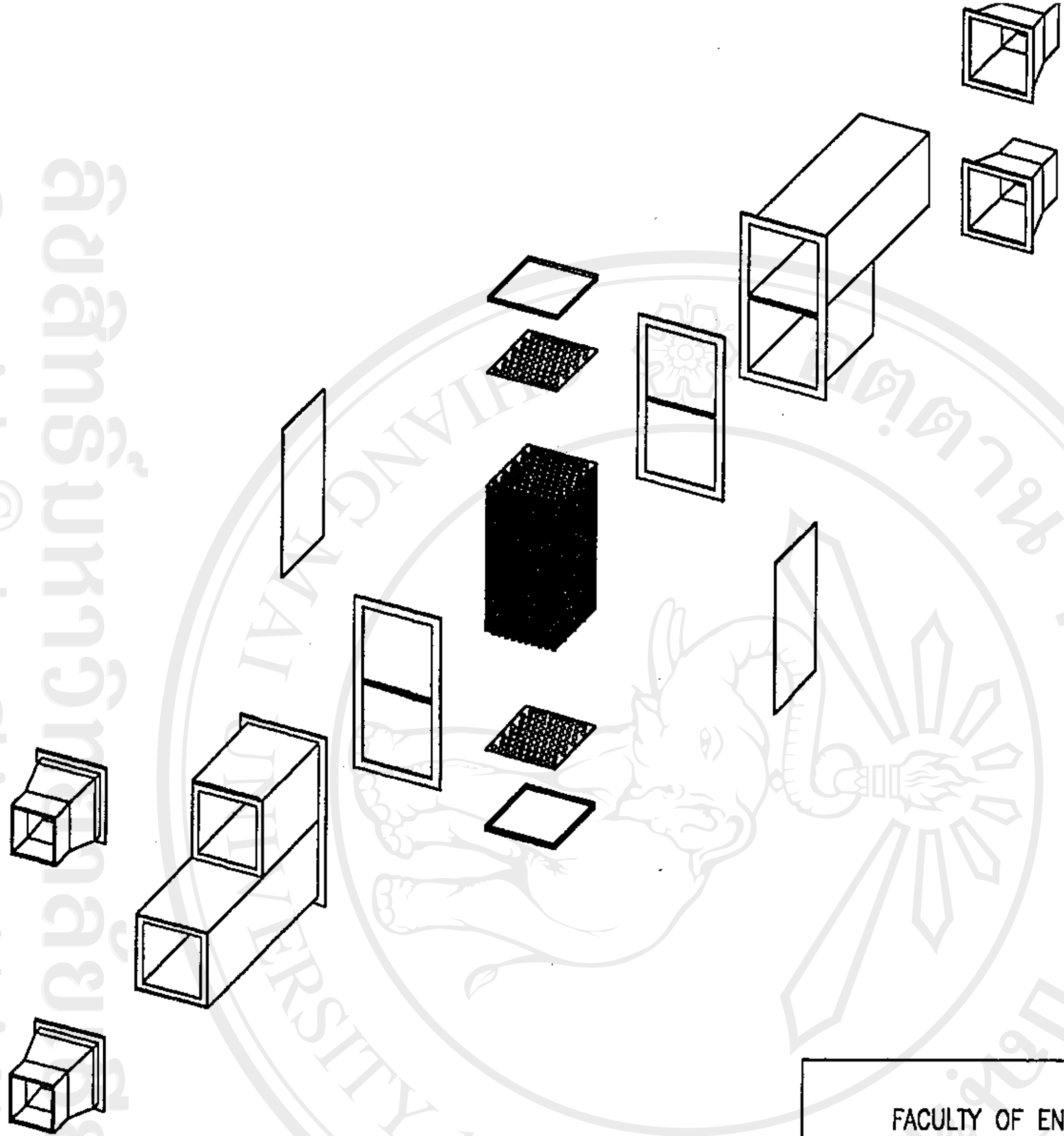
ภาคผนวก ค

แบบเครื่องอุ่นอากาศและอุปกรณ์ทดสอบ



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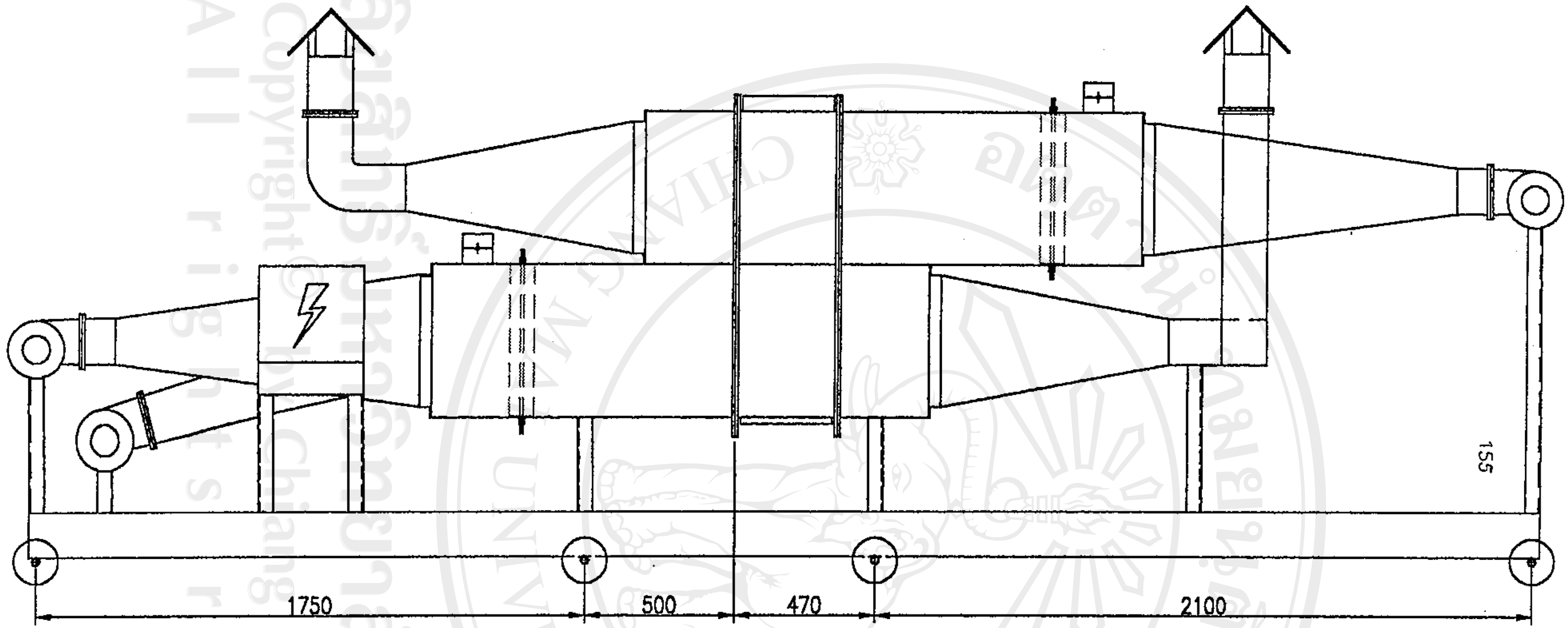
				TITLE. HEAT PIPE AIR PREHEATER ARRG'T.		
				SCALE :	DWG.NO : 001	DWN : P. Khantha
ITEM	PART NAME	Q'TY	MATERIAL	DATE : 14/02/99	DIM : MM.	APP : P. Khantha

UNIT:mm.



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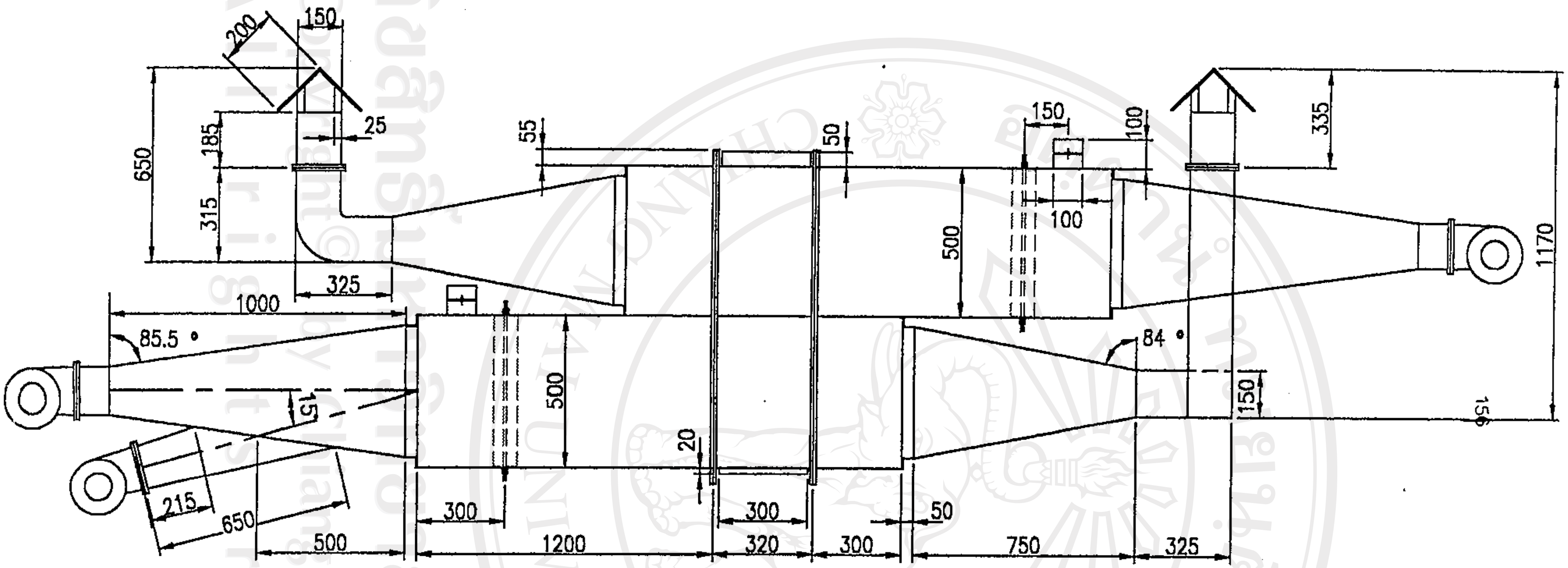
ITEM	PART NAME	Q'TY	MATERIAL	DATE : 14/02/00	DIM : MM.	APP : P.Khantha.



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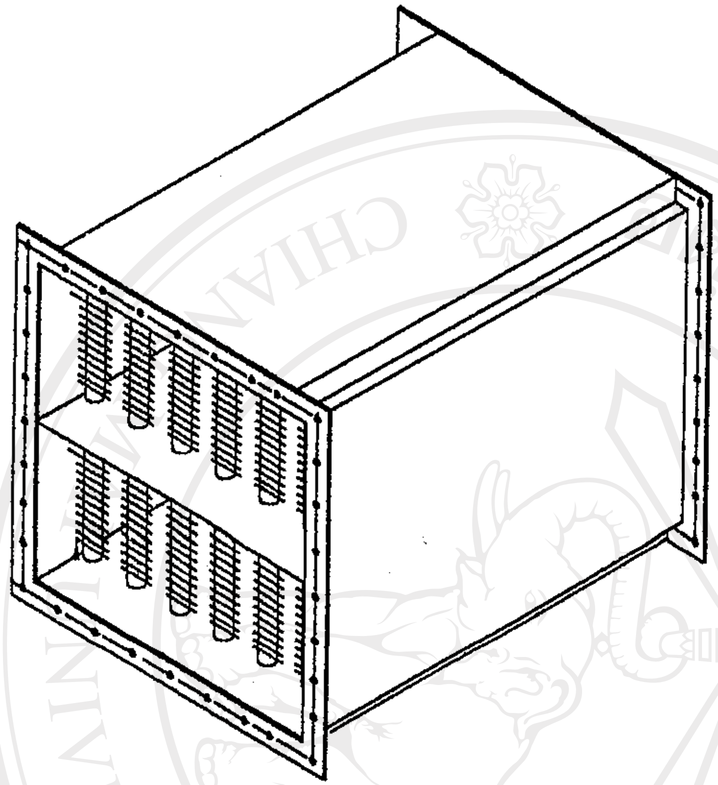

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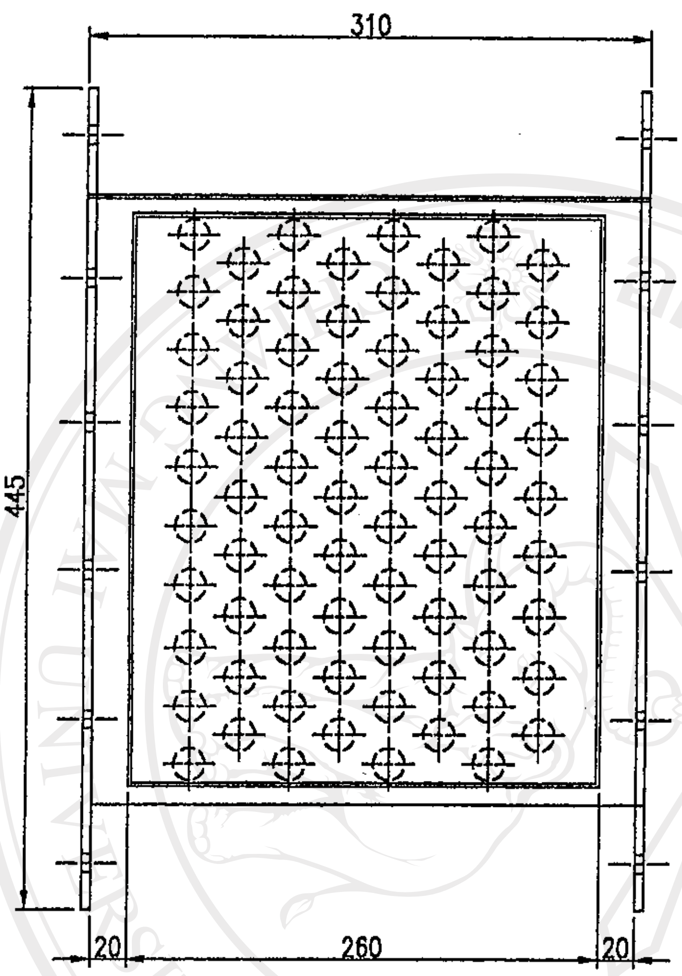
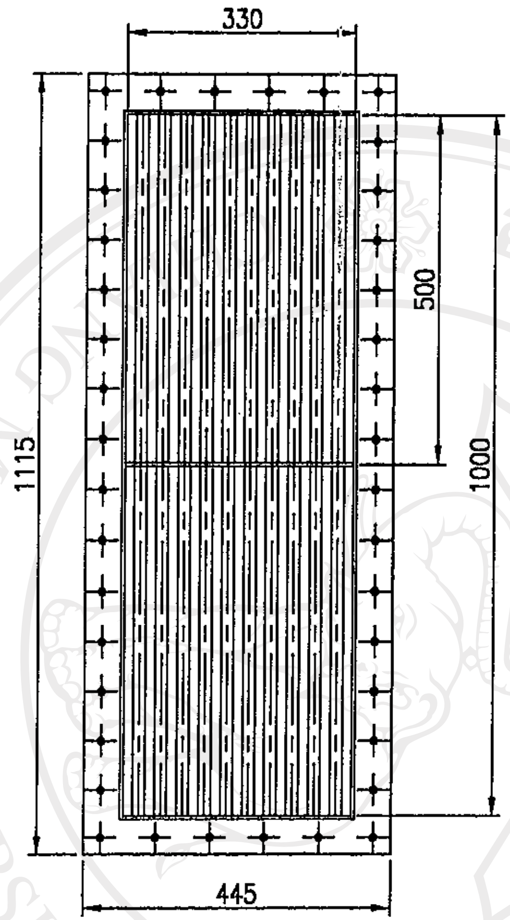


PLAN VIEW

HEAT PIPE PROJECT FACULTY OF ENGINEERING CHIANG MAI UNIVERSITY			
TITLE. HEAT PIPE AIR PREHEATER			
SCALE :	DWG.NO : 005	DWN : P.Khantha	
DATE : 14/02/99	DIM : MM.	APP : P. Khantha	

ITEM	PART NAME	Q'TY	MATERIAL

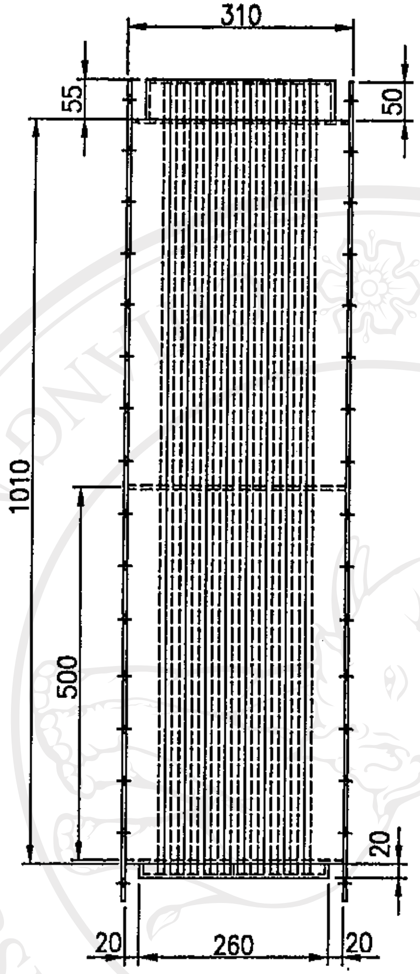
UNIT:mm.



FRONT VIEW

				HEAT PIPE PROJECT FACULTY OF ENGINEERING CHIANG MAI UNIVERSITY		
				TITLE. HEAT PIPE AIR PREHEATER		
				SCALE :	DWG.NO : 006	DWN : P. Khantha
ITEM	PART NAME	Q'TY	MATERIAL	DATE : 14/02/99	DIM : MM.	APP : P.Khantha

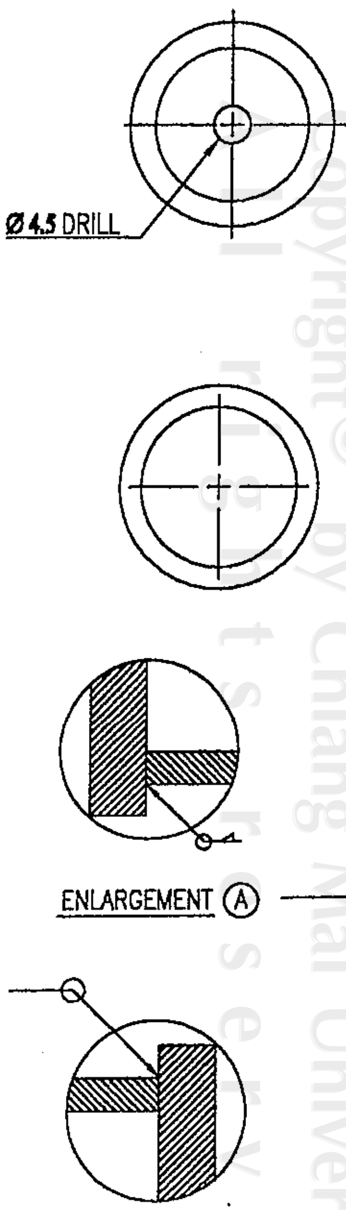
UNIT:mm.

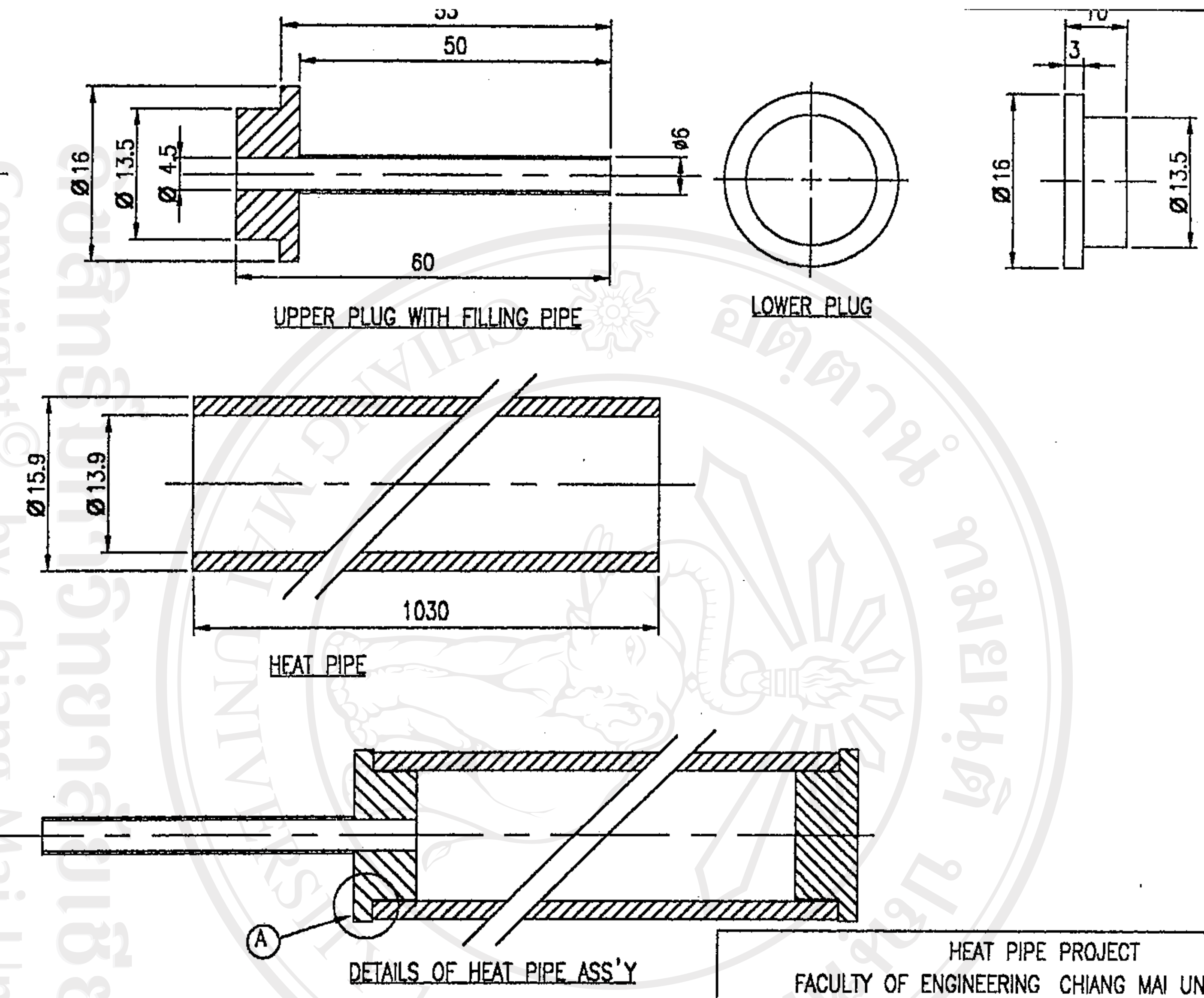


SIDE VIEW

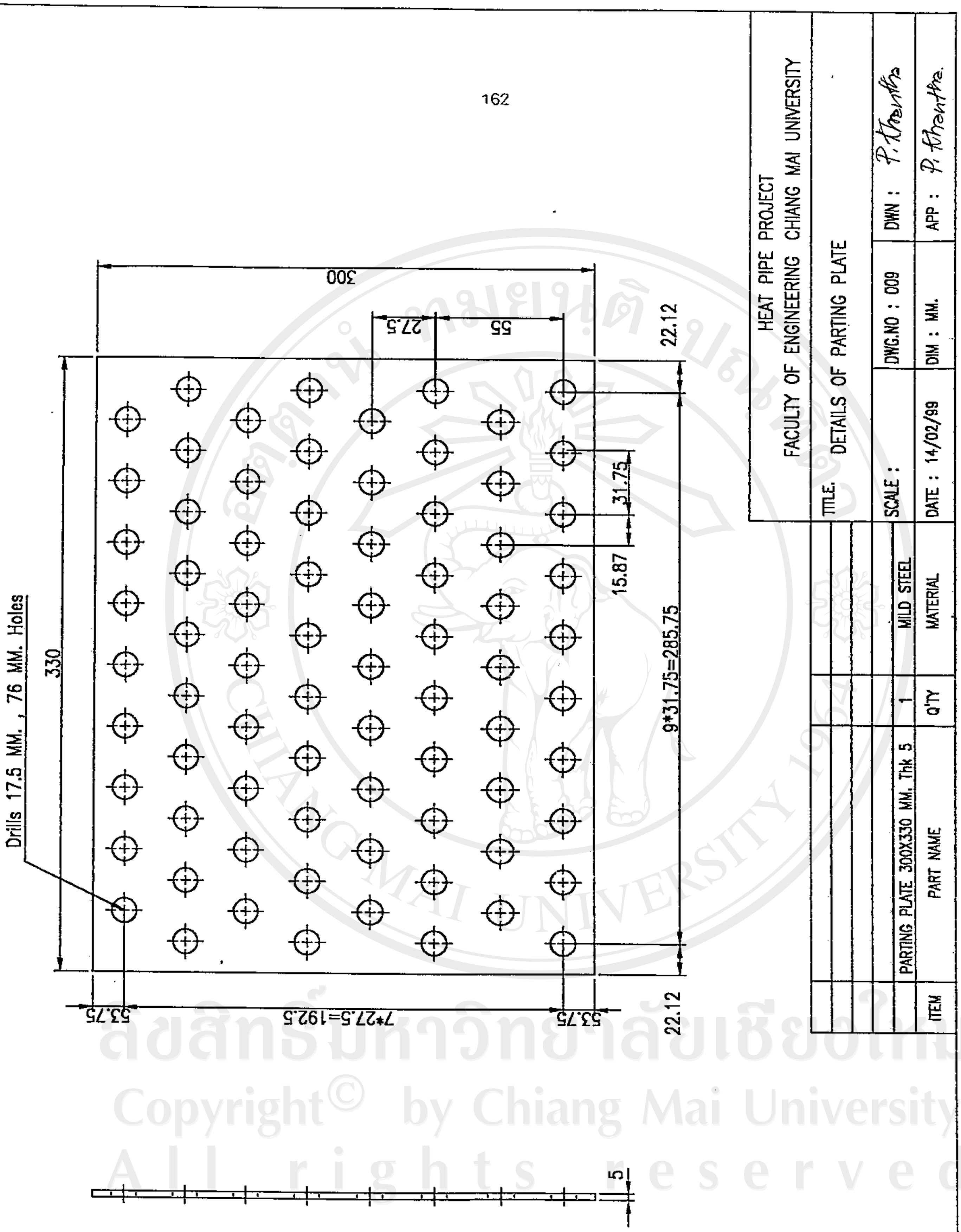
				HEAT PIPE PROJECT FACULTY OF ENGINEERING CHIANG MAI UNIVERSITY		
				TITLE. HEAT PIPE AIR PREHEATER		
				SCALE :	DWG.NO : 007	DWN : P. Khantha
ITEM	PART NAME	Q'TY	MATERIAL	DATE : 14/02/99	DIM : MM.	APP : P. Khantha

UNIT:mm.



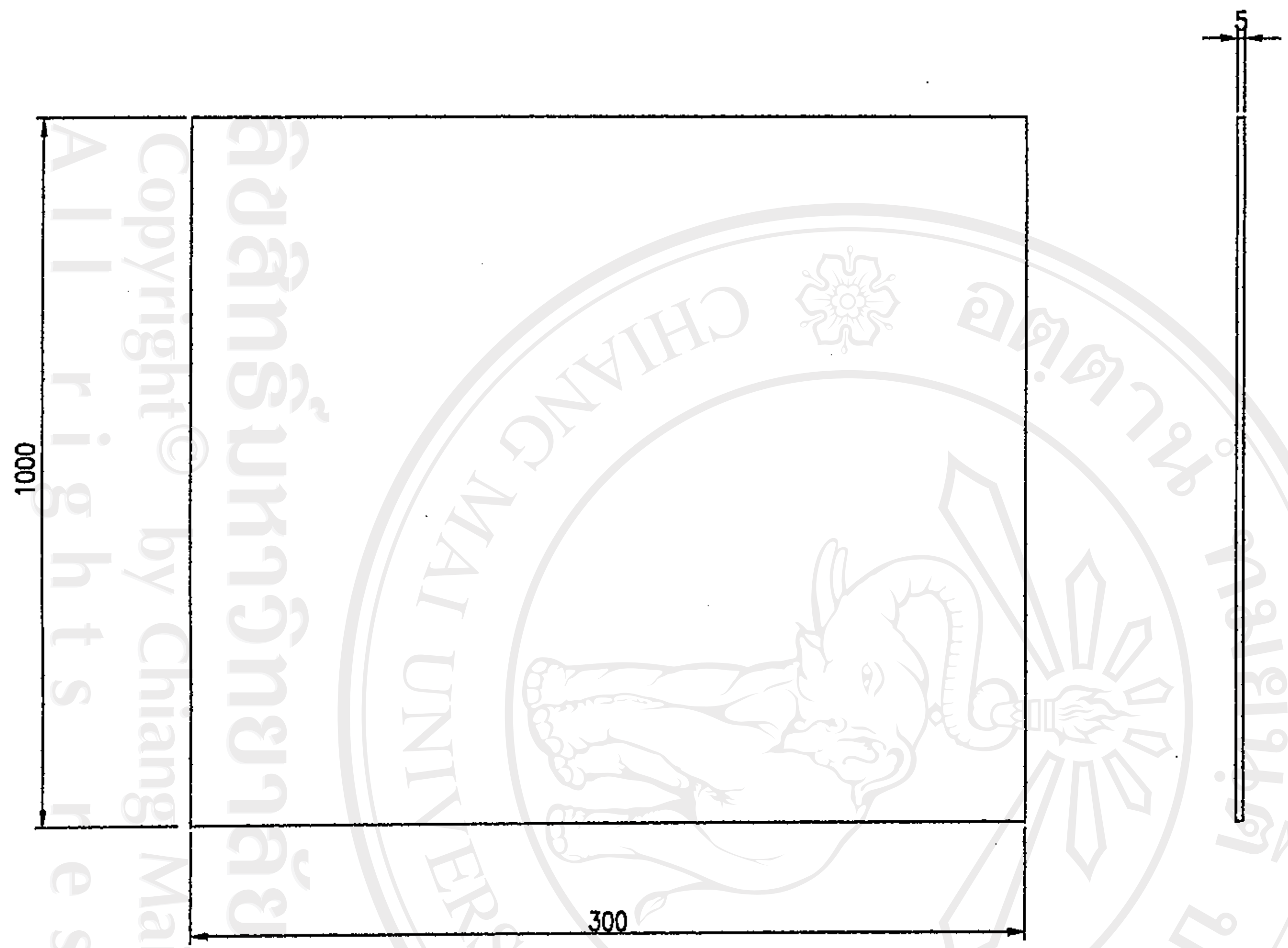


				HEAT PIPE PROJECT FACULTY OF ENGINEERING CHIANG MAI UNIVERSITY		
				TITLE. HEAT PIPE ASS'Y.		
	HEAT PIPE	76	COPPER	SCALE :	DWG.NO : 008	DWN : P. Khantha
ITEM	PART NAME	Q'TY	MATERIAL	DATE : 14/02/99	DIM : MM.	APP : P. Khantha



300
27.5
55
330
22.12
31.75
15.87
9*31.75=285.75
22.12
53.75
7*27.5=192.5
53.75
5
Drills 17.5 MM. , 76 MM. Holes
HEAT PIPE PROJECT
FACULTY OF ENGINEERING CHIANG MAI UNIVERSITY
TITLE. DETAILS OF PARTING PLATE
SCALE :
DWG.NO : 009
DWN : P. Khantha
DATE : 14/02/99
DIM : MM.
APP : P. Khantha
PARTING PLATE 300X330 MM. Thk 5
1
MILD STEEL
ITEM
PART NAME
Q'TY
MATERIAL

UNIT:mm.



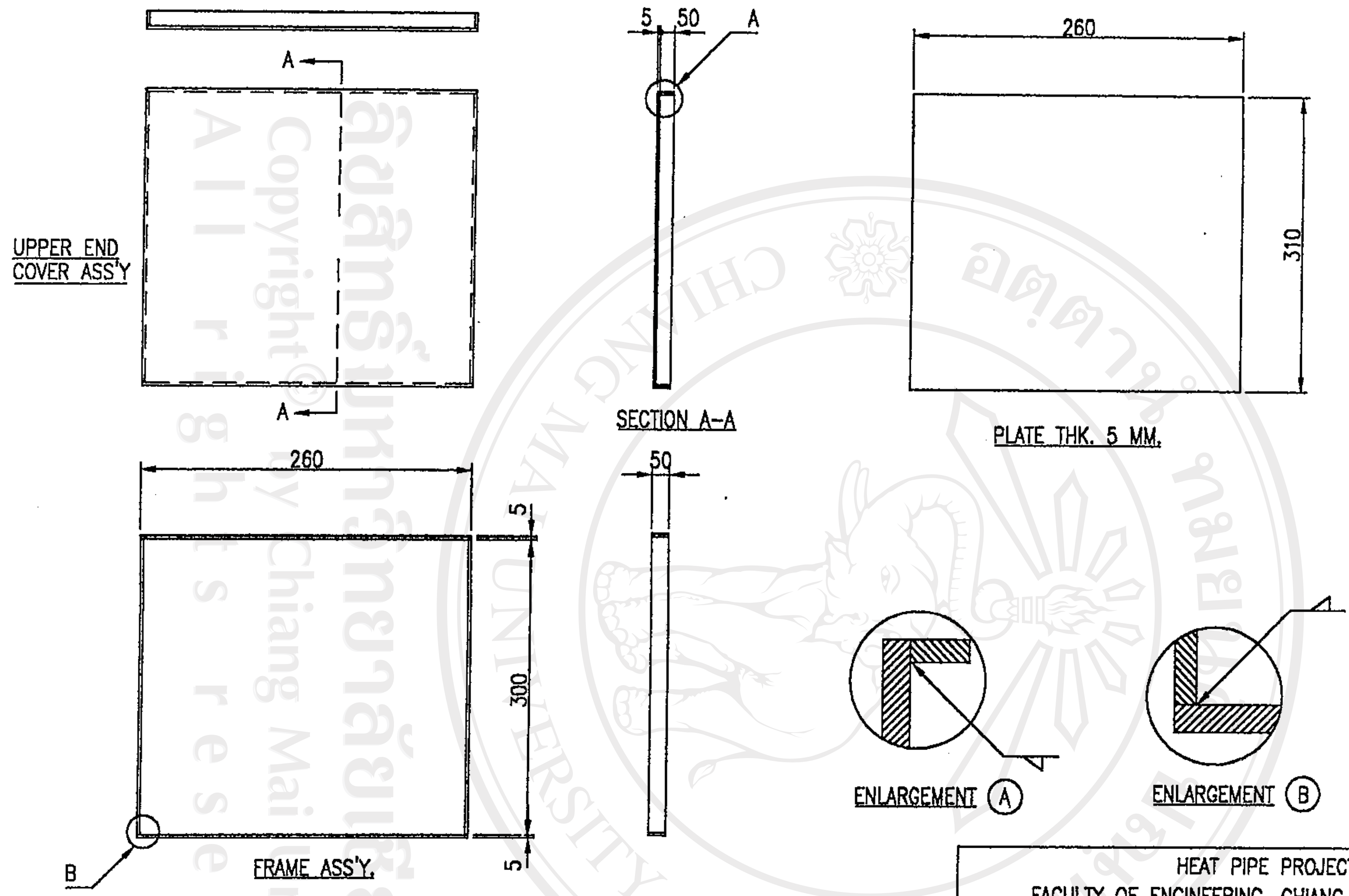
	SIDE PLATE 300X1000 MM. Thk. 5	2 SE	MILD STEEL
ITEM	PART NAME	Q'TY	MATERIAL

HEAT PIPE PROJECT
FACULTY OF ENGINEERING CHIANG MAI UNIVERSITY

TITLE. DETAILS OF SIDE PLATE

SCALE :	DWG.NO : 010	DWN : P. Khantha
DATE : 14/02/99	DIM : MM.	APP : P. Khantha

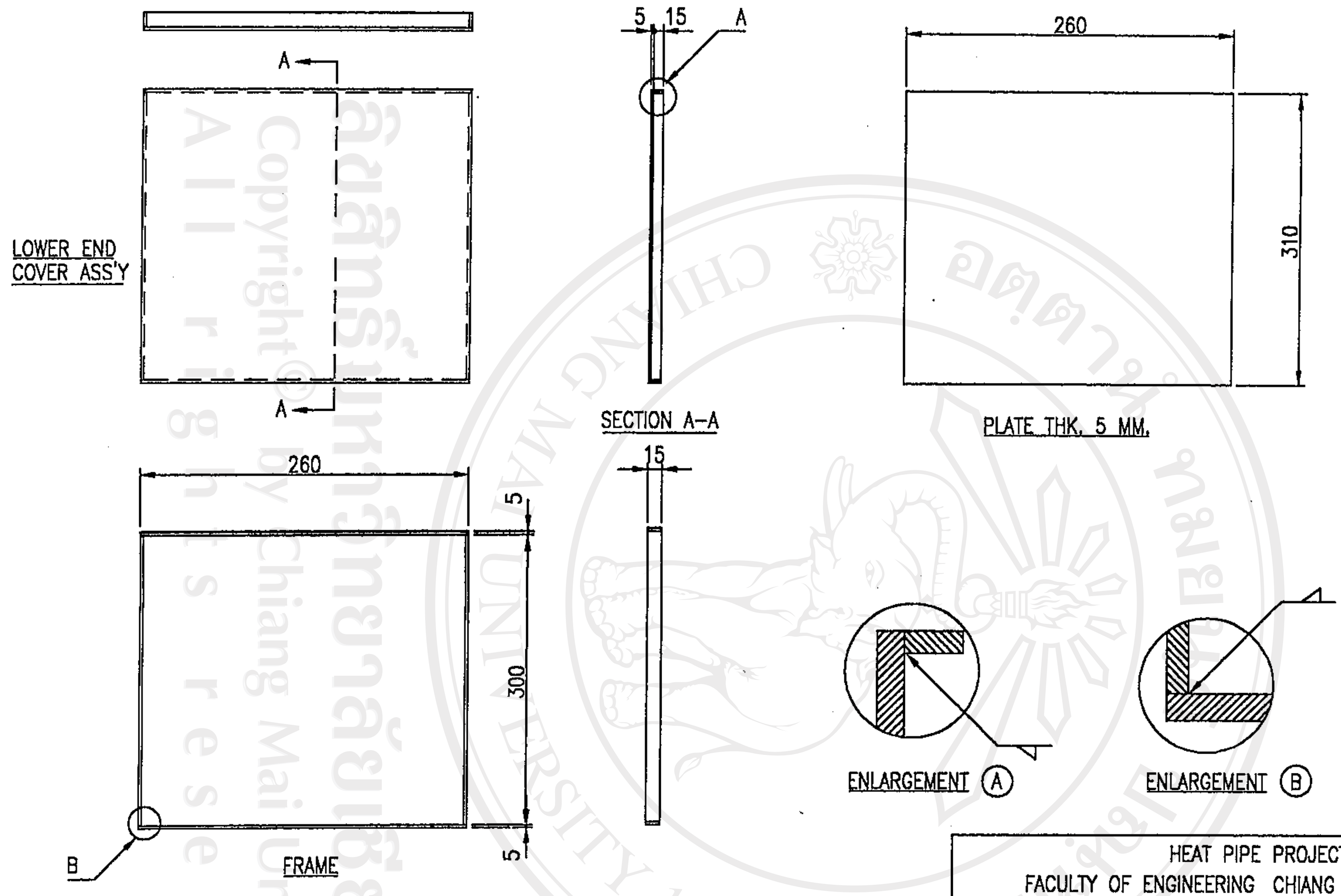
UNIT:mm.



	UPPER END COVER 260X300MM.Thk.5	1SE	MILD STEEL
ITEM	PART NAME	Q'TY	MATERIAL

HEAT PIPE PROJECT FACULTY OF ENGINEERING CHIANG MAI UNIVERSITY		
TITLE. DETAILS OF UPPER END COVER		
SCALE :	DWG.NO : 011	DWN : P. Khantha
DATE : 14/02/99	DIM : MM.	APP : P. Khantha.

UNIT:mm.

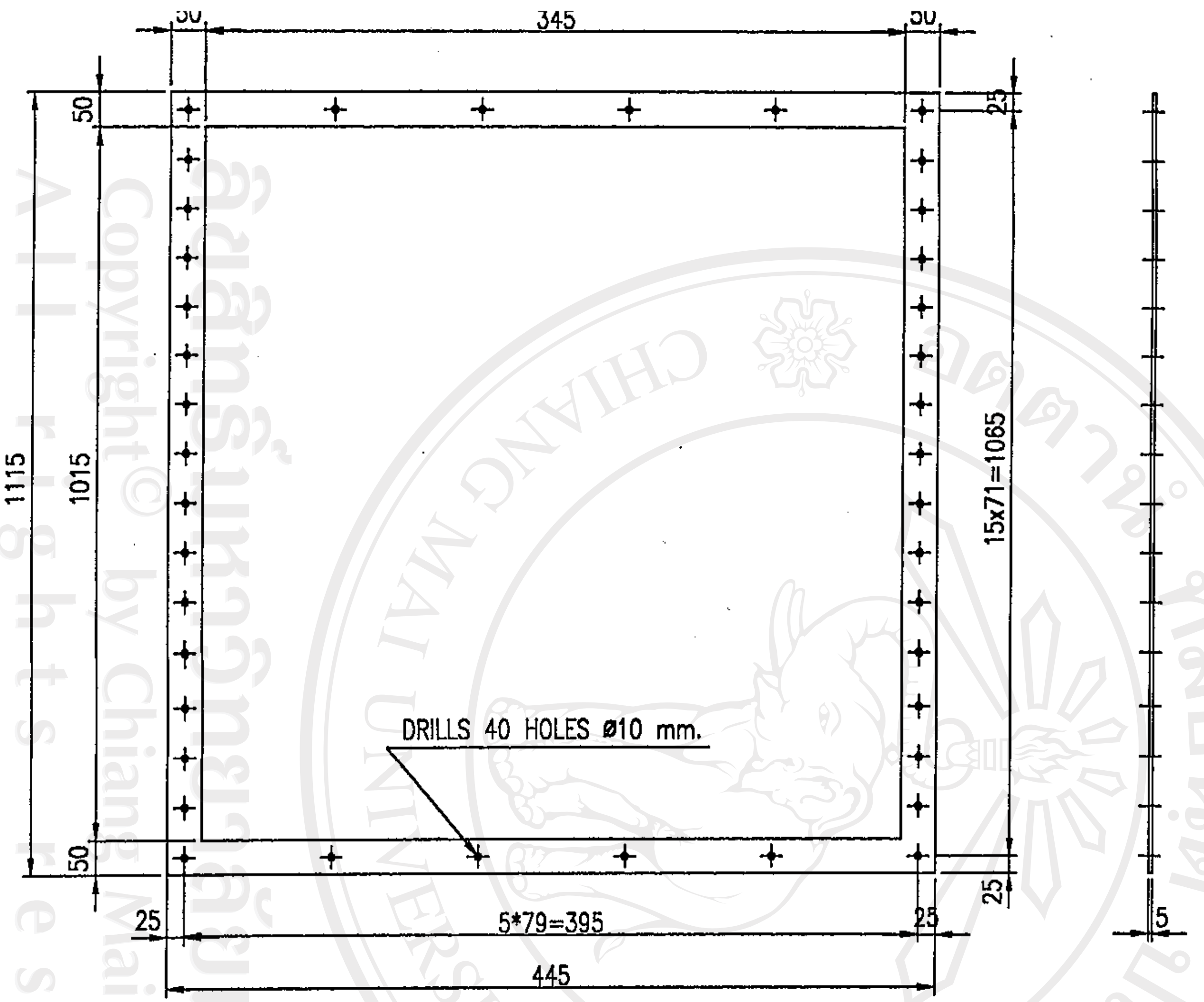


ITEM	PART NAME	Q'TY	MATERIAL
	LOWER END COVER 260X310MM.Thk.5	1 SE	MILD STEEL

HEAT PIPE PROJECT

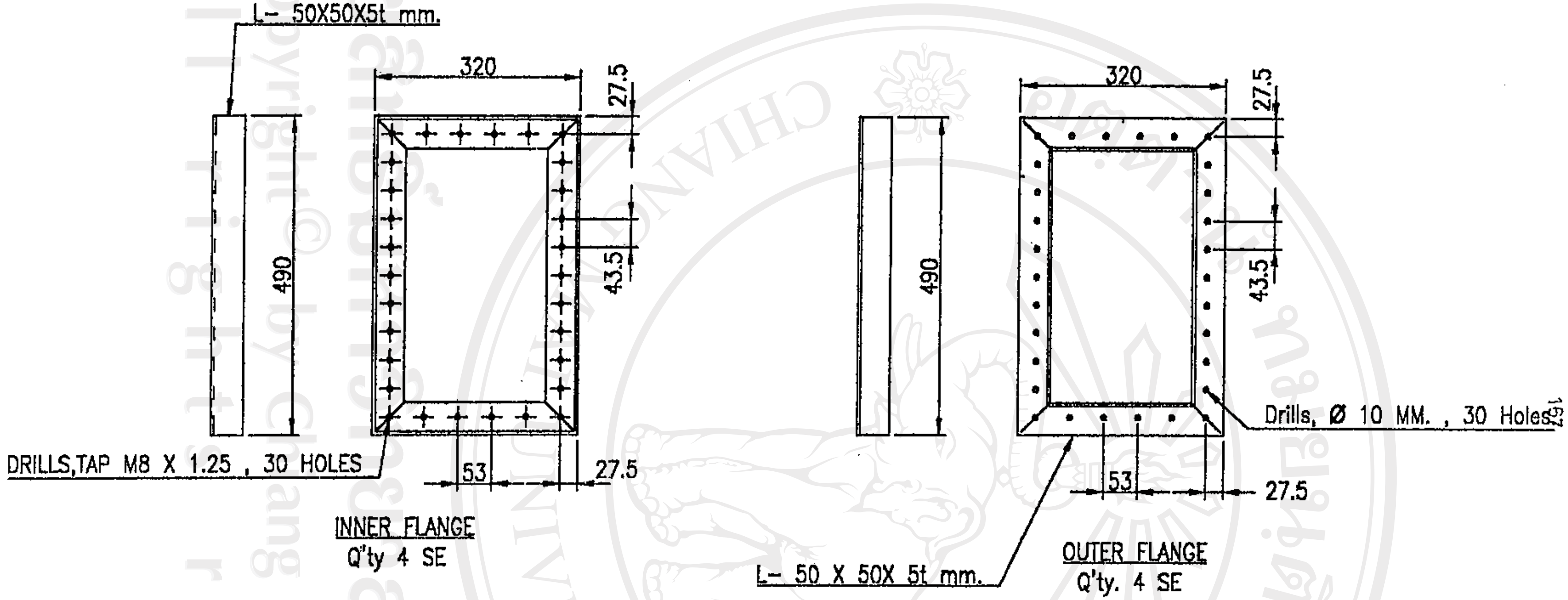
FACULTY OF ENGINEERING CHIANG MAI UNIVERSITY

TITLE. DETAILS OF LOWER END COVER		
SCALE :	DWG.NO : 012	DWN : P. Khantha
DATE : 14/02/99	DIM : MM.	APP : P. Khantha

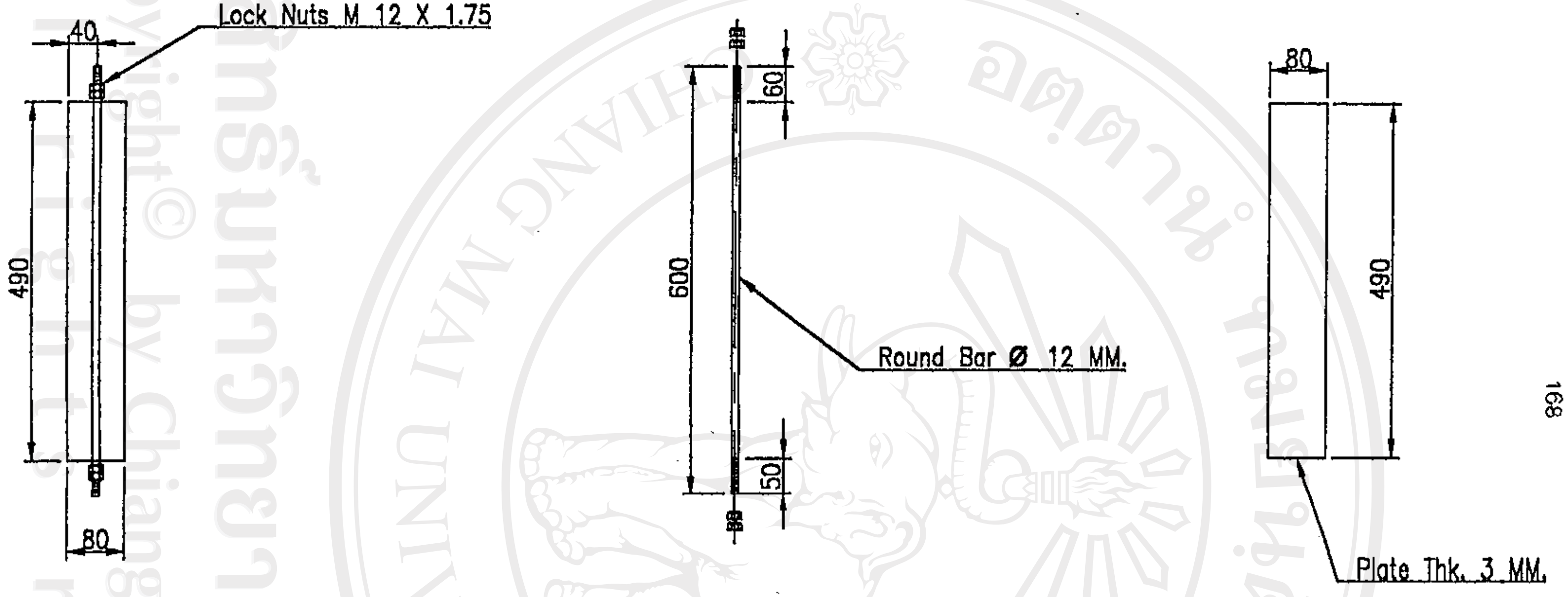


				HEAT PIPE PROJECT FACULTY OF ENGINEERING CHIANG MAI UNIVERSITY		
				TITLE. DETAILS OF DUCT FLANGE		
	DUCT FLANGE 445X1115 MM. Thk 5	4 SE	MILD STEEL	SCALE :	DWG.NO : 013	DWN : P. Kheantha
ITEM	PART NAME	Q'TY	MATERIAL	DATE : 14/02/99	DIM : MM.	APP : P. Khantha.

UNIT:mm.



				HEAT PIPE PROJECT FACULTY OF ENGINEERING CHIANG MAI UNIVERSITY
				TITLE. DETAILS OF FLANGE
	FLANGE	8 SE	MILD STEEL	SCALE : / DWG.NO : 014 / DWN : P. Khantha
ITEM	PART NAME	Q'TY	MATERIAL	DATE : 14/02/99 / DIM : MM. / APP : P. Khantha



				HEAT PIPE PROJECT FACULTY OF ENGINEERING CHIANG MAI UNIVERSITY		
				TITLE. DETAILS OF FLOW CONTROLLED PLATE		
	FLOW CONTROLLED PLATE	5 SE.	MILD STEEL	SCALE :	DWG.NO : 015	DWN : P. Khantha
ITEM	PART NAME	Q'TY	MATERIAL	DATE : 14/02/99	DIM : MM.	APP : P. Khantha.

ภาคผนวก ง

ข้อมูลจำเพาะของระบบอบแห้งยิปซั่ม

ข้อมูลการทดสอบหาเส้นลักษณะเฉพาะของการอบแห้งยิปซั่มที่อุณหภูมิ 113 และ 150 $^{\circ}C$

Experiment #2

Date: 11 /6 /41 Time:08:10 Amb.Temp. 26 °C

น้ำหนักของถาด เท่ากับ 1399.8 กรัม

น้ำหนักของยิปซั่ม เท่ากับ 200 กรัม

Predrying Sample at 45 °C ,Time ~24 hrs.

Weight before = 1599.8 g.

Weight after = 1566.9 g.

น้ำหนักของถาดและยิปซั่ม

Drying at 113 °C

	1	2	3	4	5	6	7	8
Weight before (g)	1566.9	1566.6	1566.4	1566	1565.5	1564.3	1561.9	1559.5
Weight after (g)	1566.6	1566.4	1566	1565.5	1564.3	1561.9	1559.5	1557.6
Wt. of Gypsum (g)	166.8	166.6	166.2	165.7	164.5	162.1	159.7	157.8
Amb. Temp. (°C)	26.5	27	27	28	28	28	28	27
Drying Temp. (°C)	115	113	113	112	113	113	113	113
Time (Hr:Min)	11:05	12:20	13:40	15:00	16:20	18:00	18:30	19:40

Experiment #2

Date: 5 /56/41 Time:16:23 Amb.Temp. 29°C

น้ำหนักของถาด เท่ากับ 1399.8 กรัม

น้ำหนักของยิปซั่ม เท่ากับ 200 กรัม

Predrying Sample at 45 °C ,Time ~24 hrs.

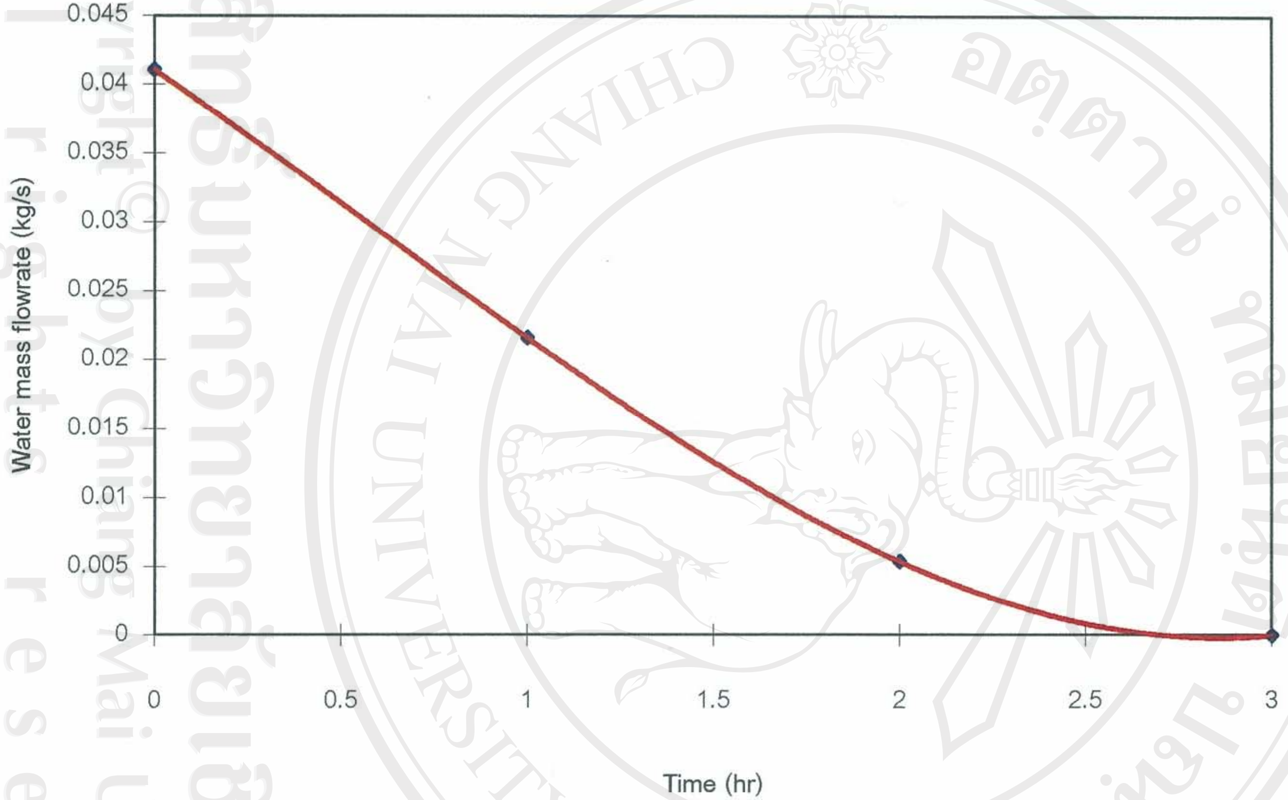
Weight before = 1599.8 g.

Weight after = 1570.6 g.

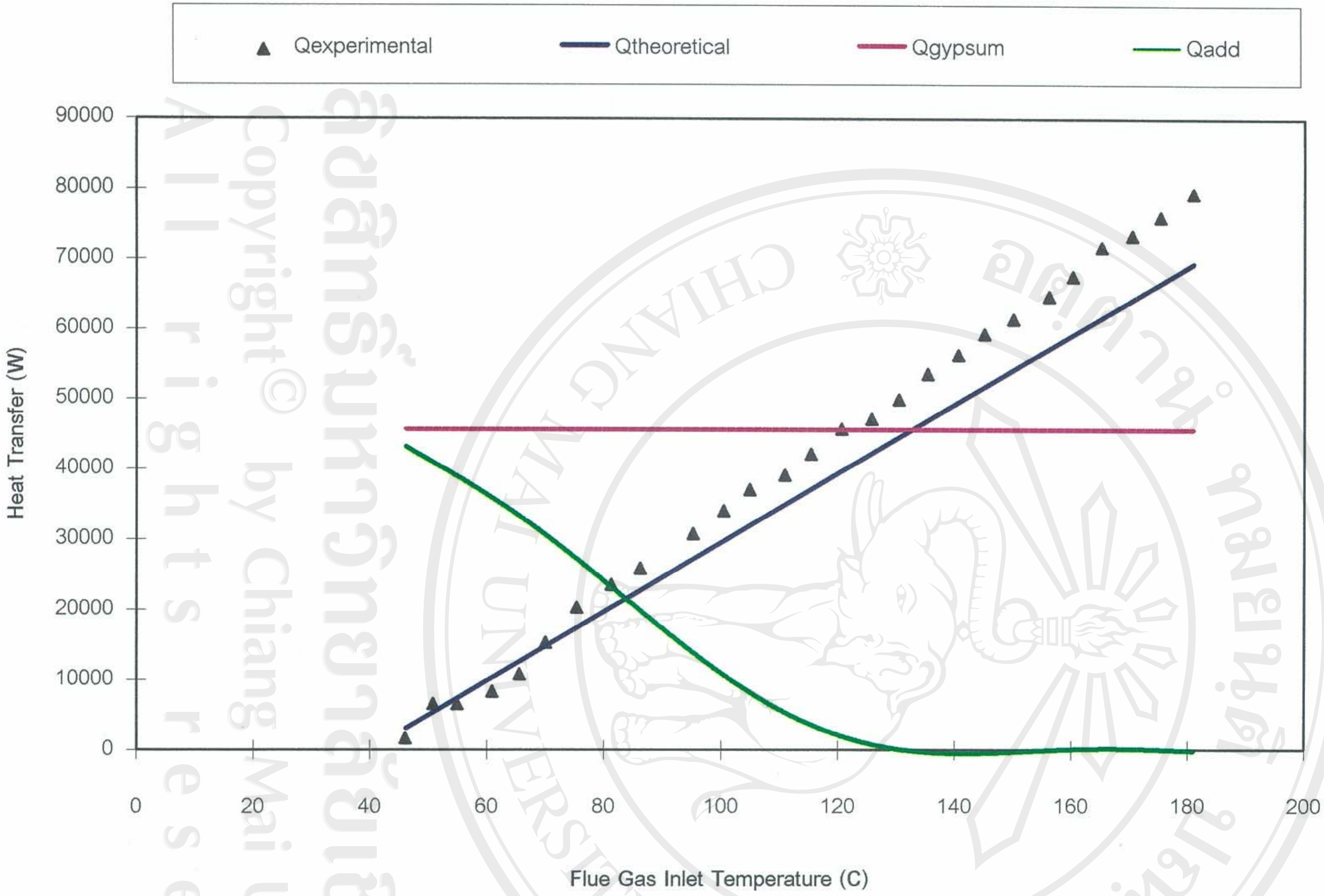
น้ำหนักของถาดและยิปซั่ม

Drying at 150 °C

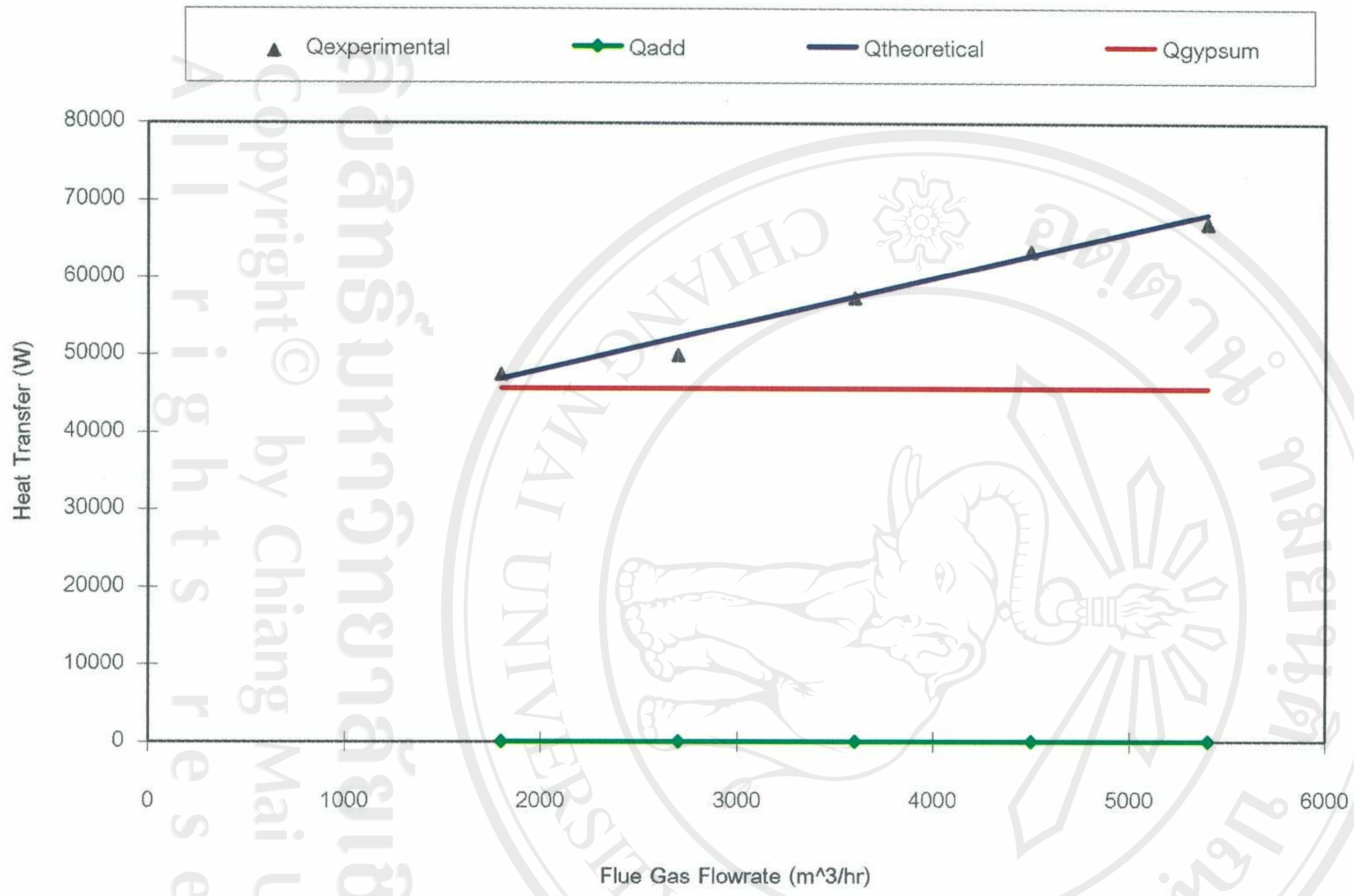
	1	2	3	4	5	6	7	8
Weight before (g)	1570.6	1557.5	1548	1544.2	1542.7	1540.5	1539.5	1538.8
Weight after (g)	1557.5	1548	1544.2	1542.7	1540.5	1539.5	1538.8	1538.2
Wt. of Gypsum (g)	157.7	148.2	144.4	142.9	140.7	139.7	139	138.4
Amb. Temp. (°C)	26	26	26	26	26	26.5	26	26.5
Drying Temp. (°C)	153	149	150	149	150	150	151	151
Time (Hr:Min)	9:10	10:25	11:40	12:55	14:25	15:40	16:55	18:10



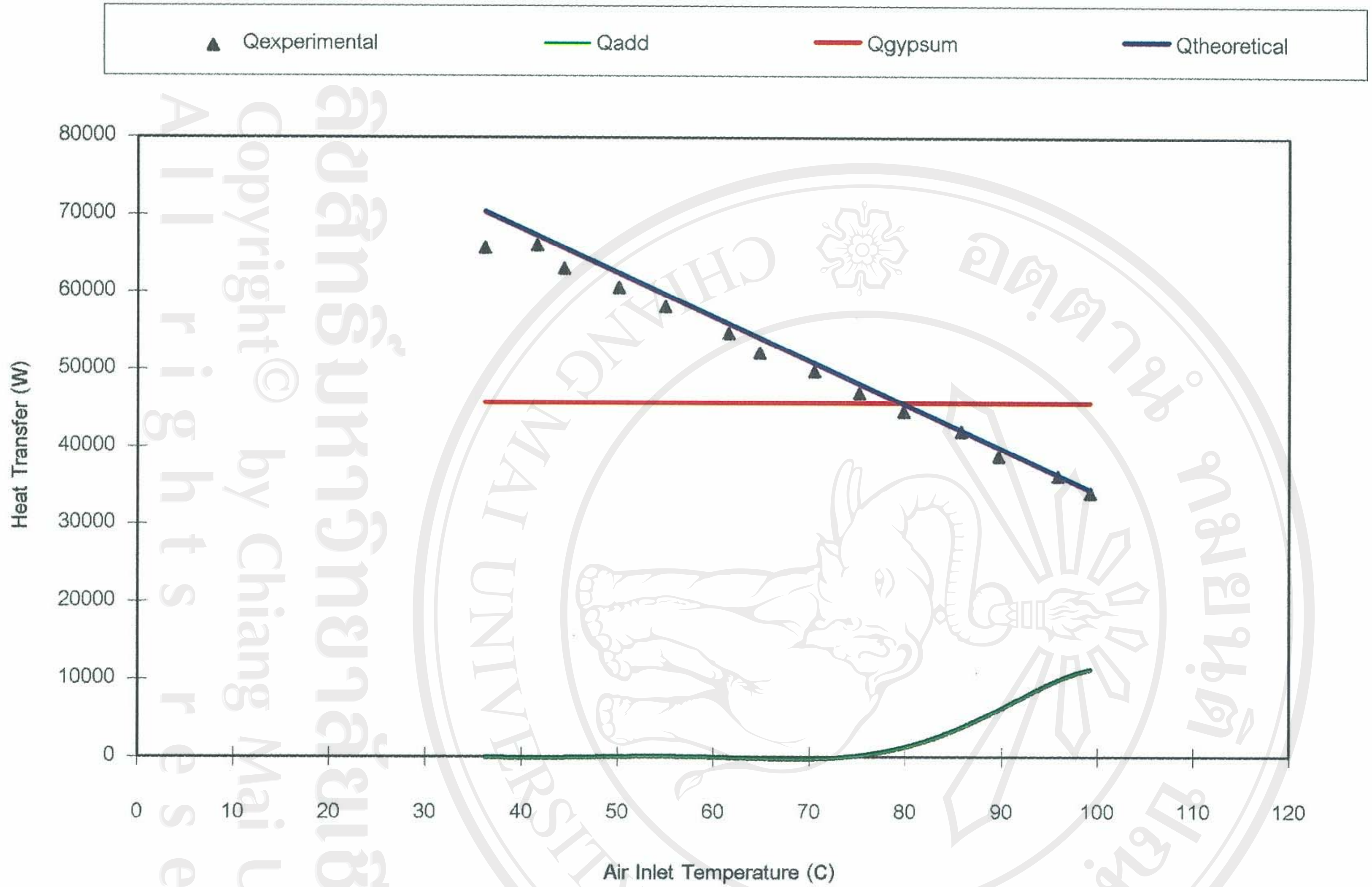
รูปแสดงปริมาณน้ำในยิปซั่มที่หายไปกับเวลาที่ใช้ในการอบแห้งที่อุณหภูมิ 150 C



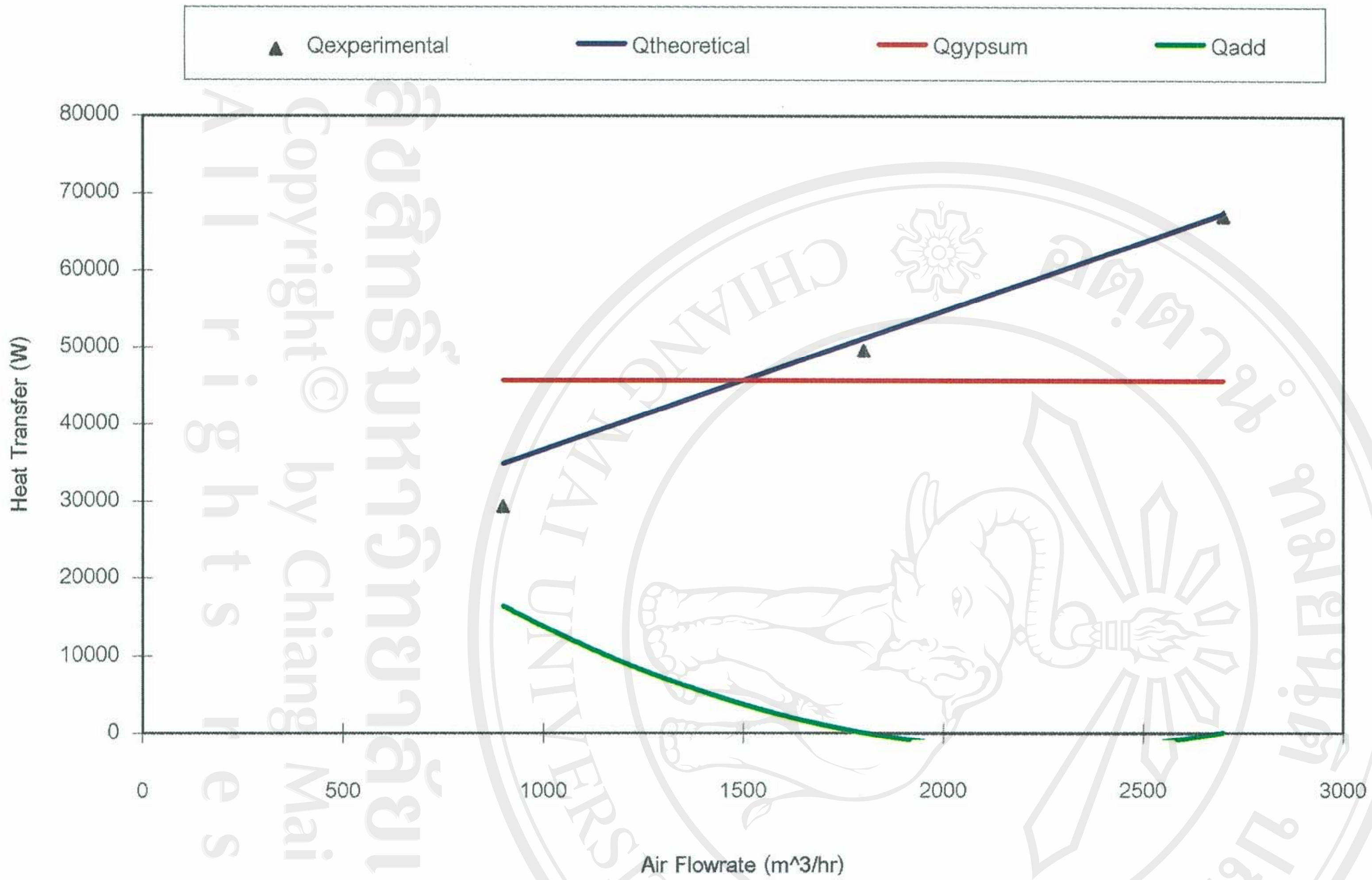
รูปแสดงความสัมพันธ์ระหว่างอุณหภูมิขาเข้าของก๊าซร้อนกับการถ่ายเทความร้อน ณ ชั่วโมงที่ 1



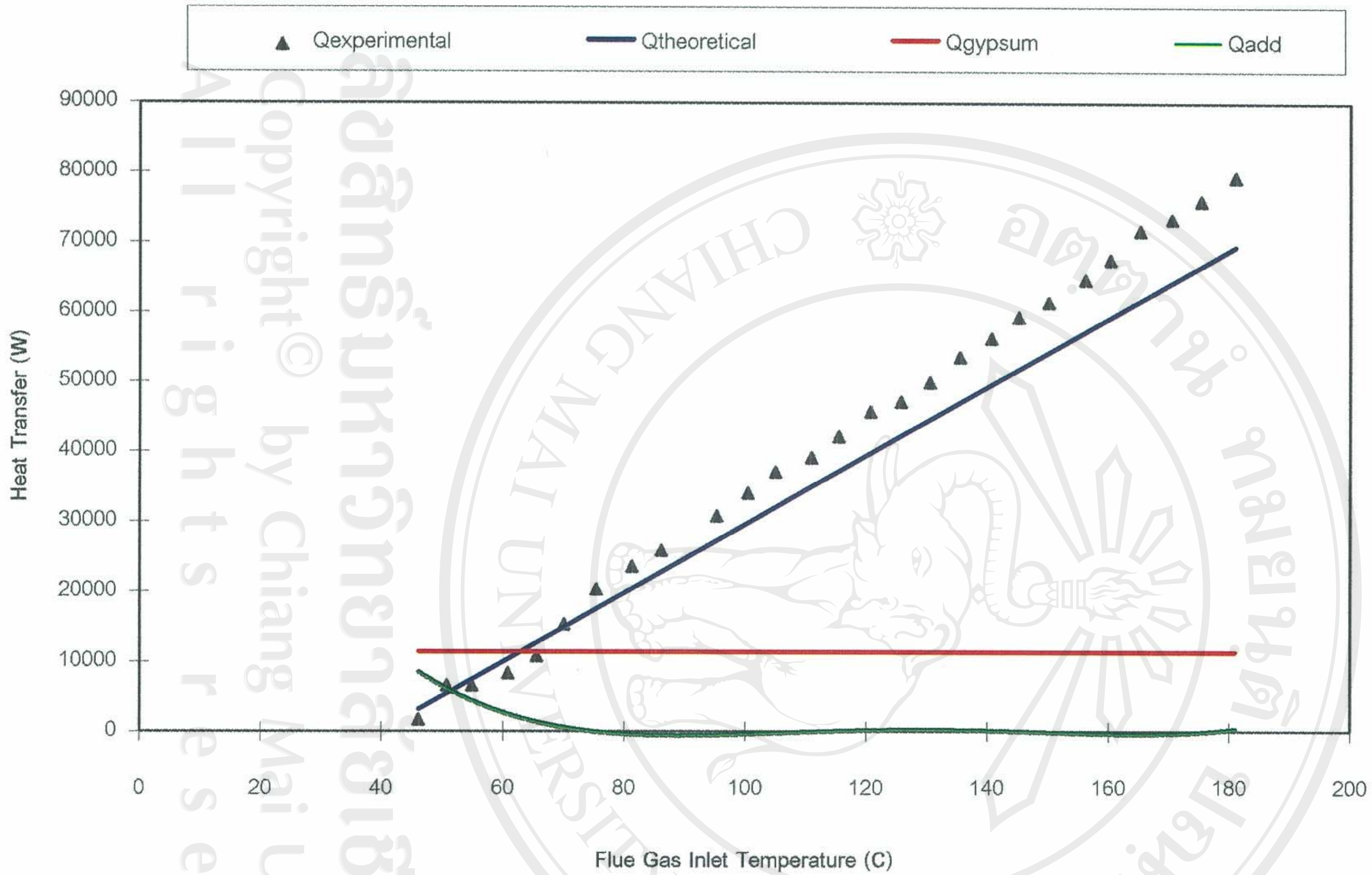
รูปแสดงความสัมพันธ์ระหว่างอัตราการไหลของก๊าซร้อนกับการถ่ายเทความร้อน ณ ชั่วโมงที่ 1



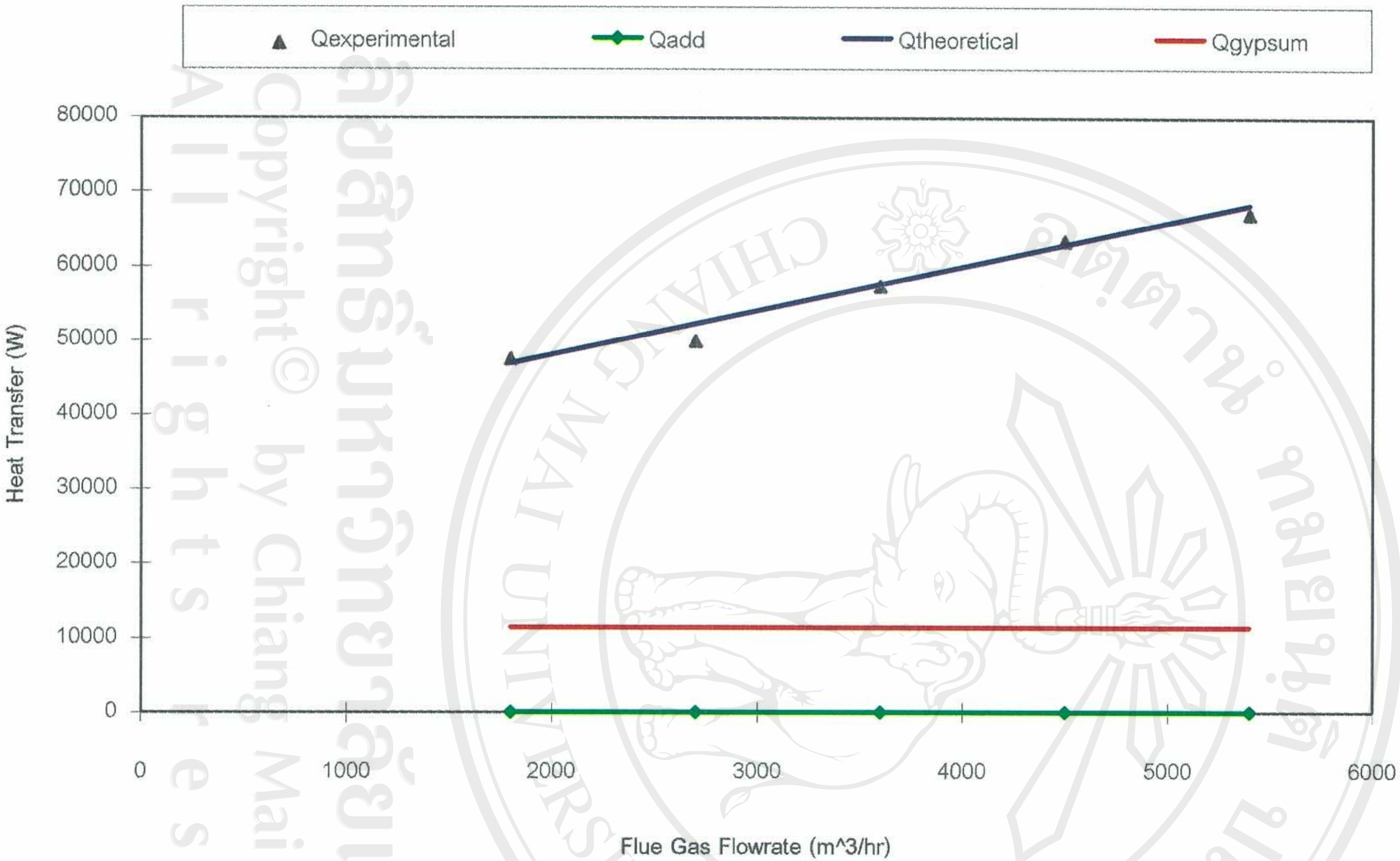
รูปแสดงความสัมพันธ์ระหว่างอุณหภูมิขาเข้าของอากาศกับการถ่ายเทความร้อน ณ ชั่วโมงที่ 1



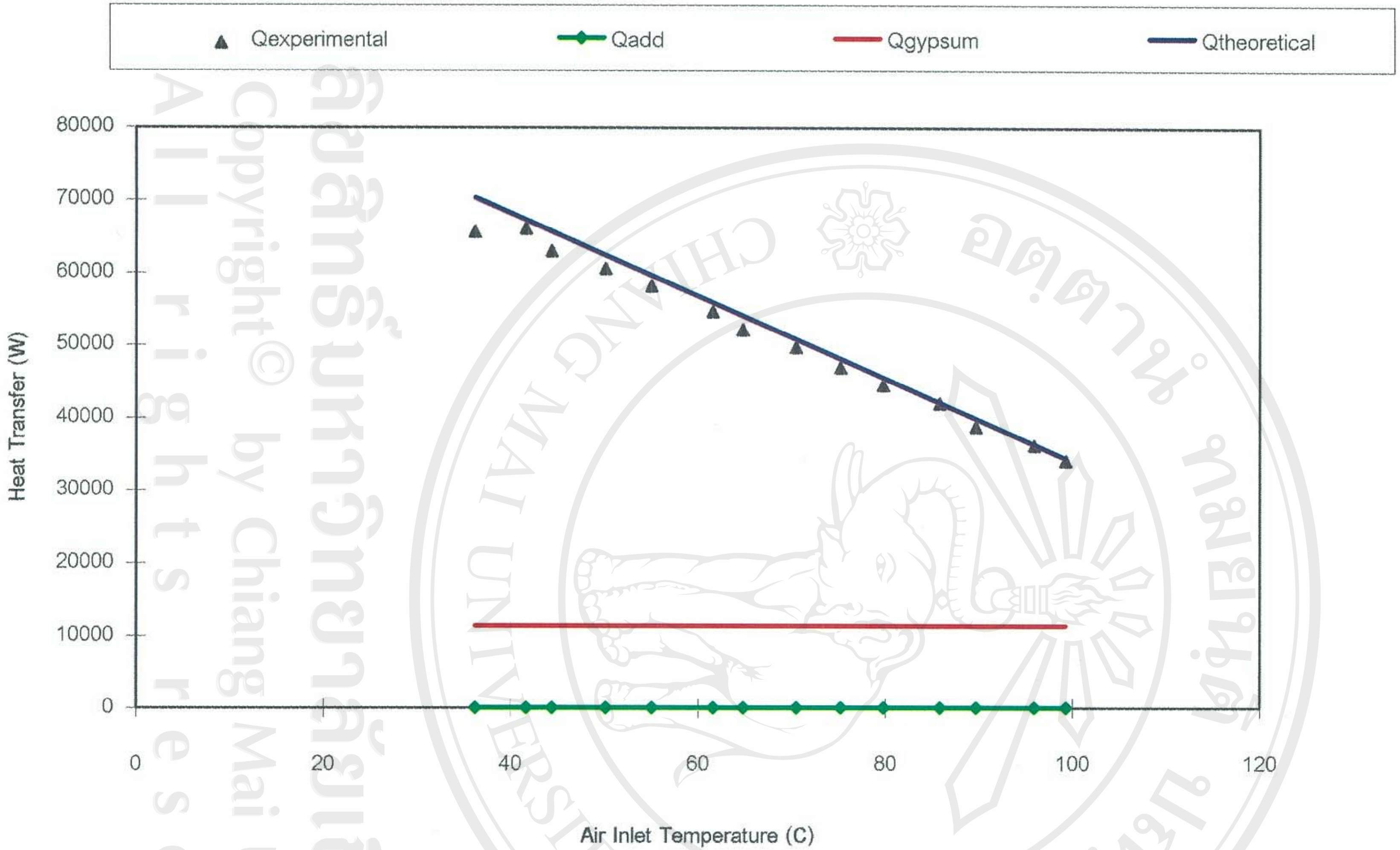
รูปแสดงความสัมพันธ์ระหว่างอัตราการไหลของอากาศกับการถ่ายเทความร้อน ณ ชั่วโมงที่1



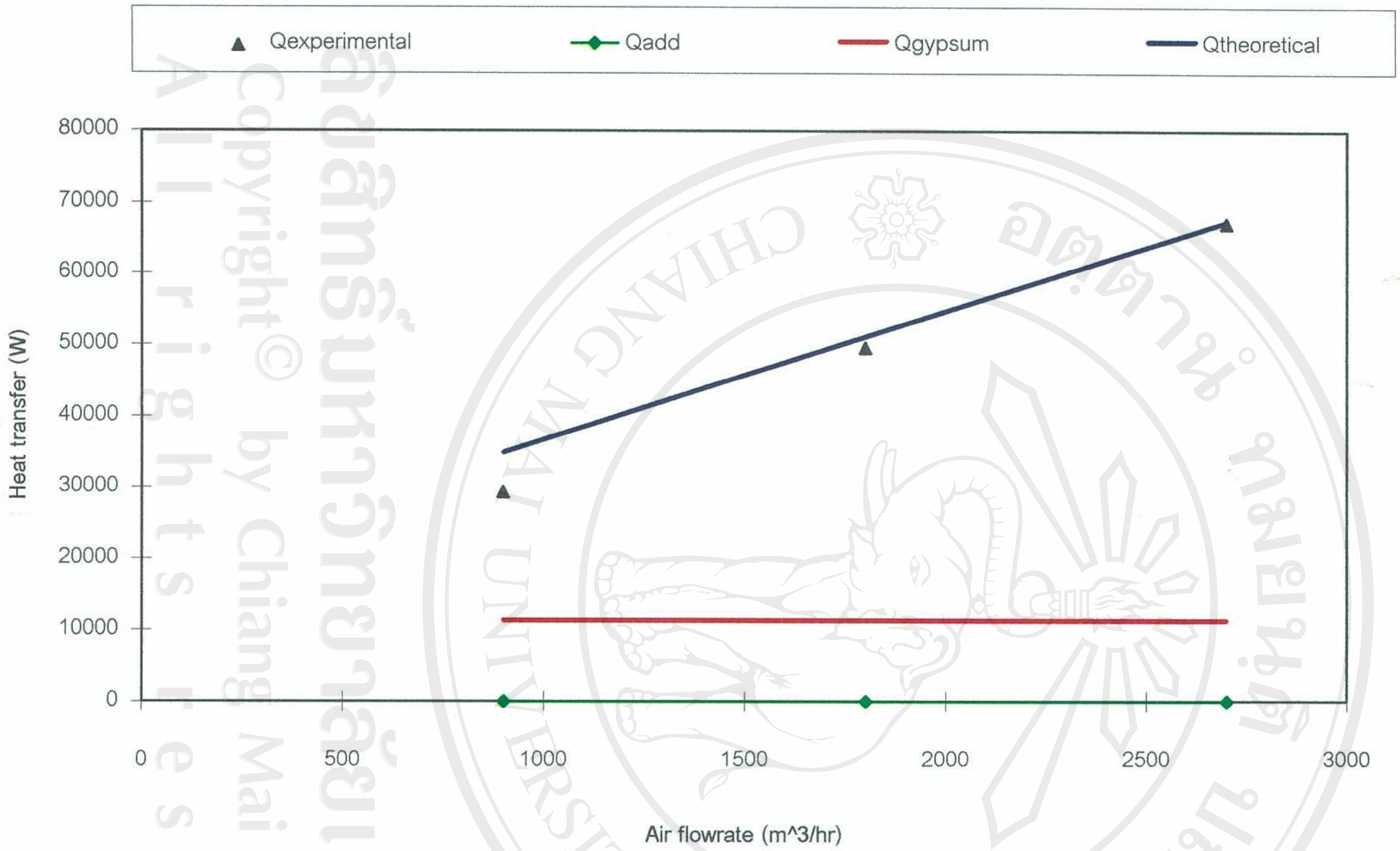
รูปแสดงความสัมพันธ์ระหว่างอุณหภูมิขาเข้าของก๊าซร้อนกับการถ่ายเทความร้อน ณ ชั่วโมงที่ 2



รูปแสดงความสัมพันธ์ระหว่างอัตราการไหลของก๊าซร้อนกับการถ่ายเทความร้อน ณ ชั่วโมงที่ 2



รูปแสดงความสัมพันธ์ระหว่างอุณหภูมิขาเข้าของอากาศกับการถ่ายเทความร้อน ณ ชั่วโมงที่ 2

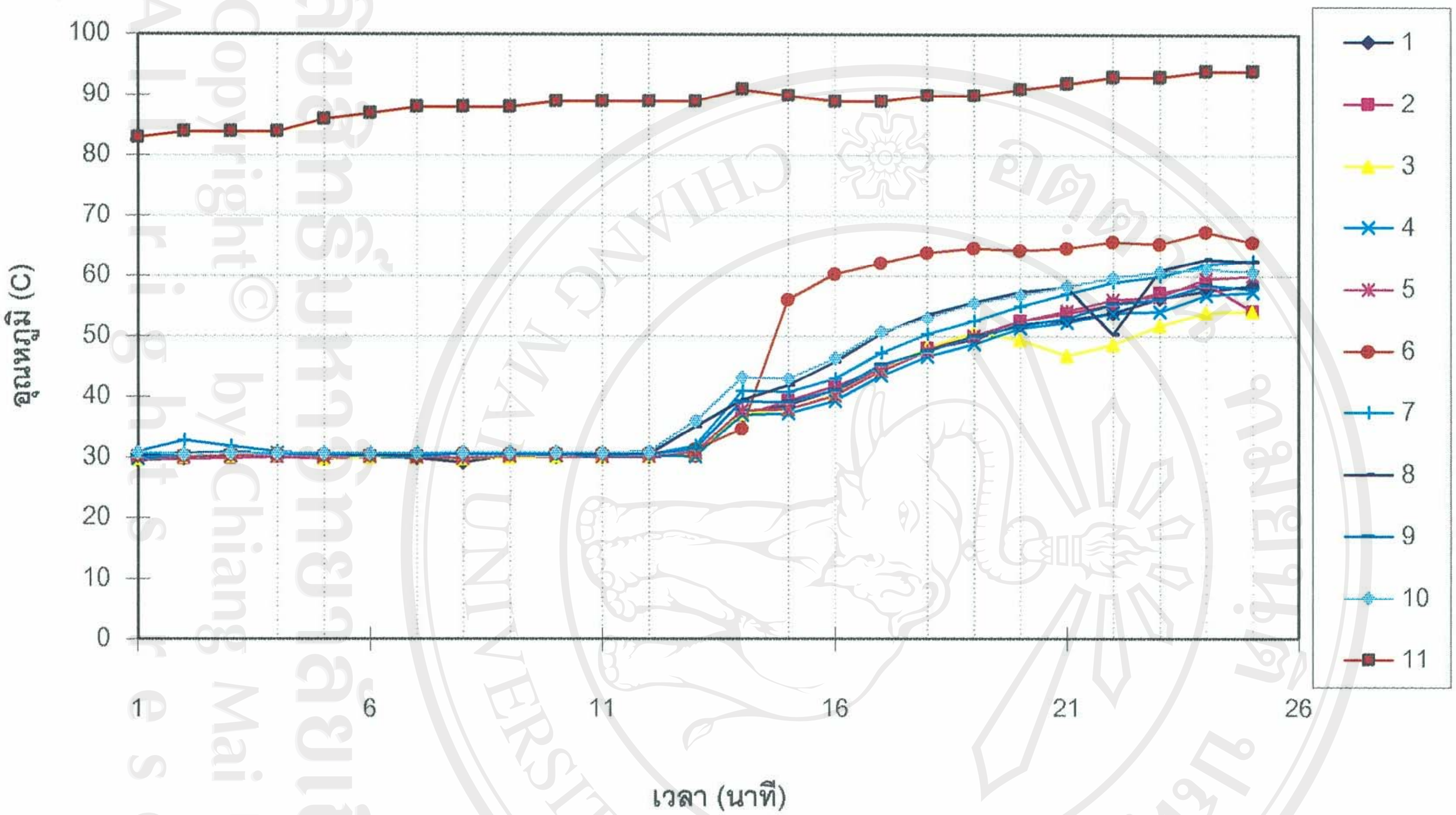


รูปแสดงความสัมพันธ์ระหว่างอัตราการไหลของอากาศกับการถ่ายเทความร้อน ณ ชั่วโมงที่ 2

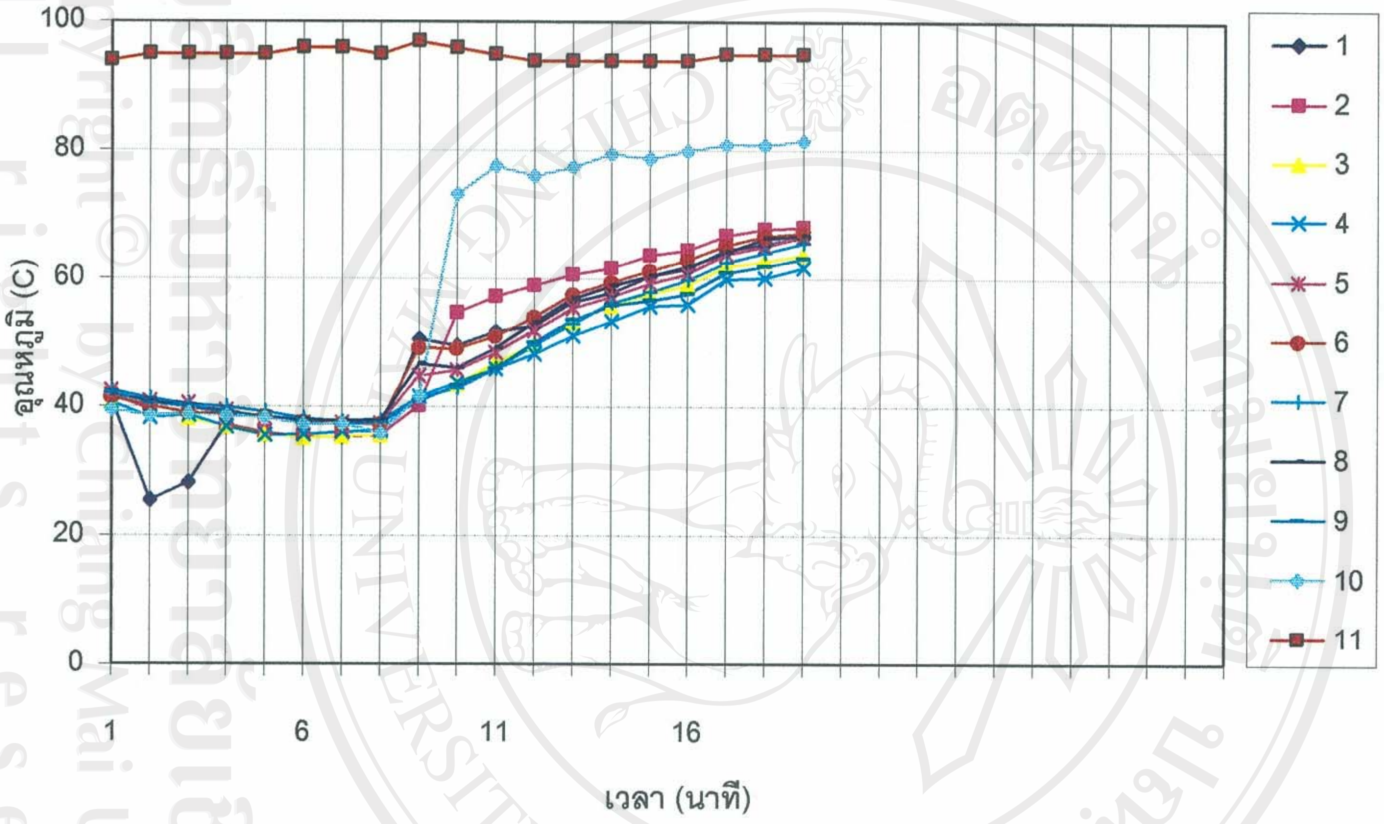
ภาคผนวก จ

ข้อมูลการทดสอบการทำงานของเครื่องอุ่นอากาศแบบท่อความร้อนจำลอง

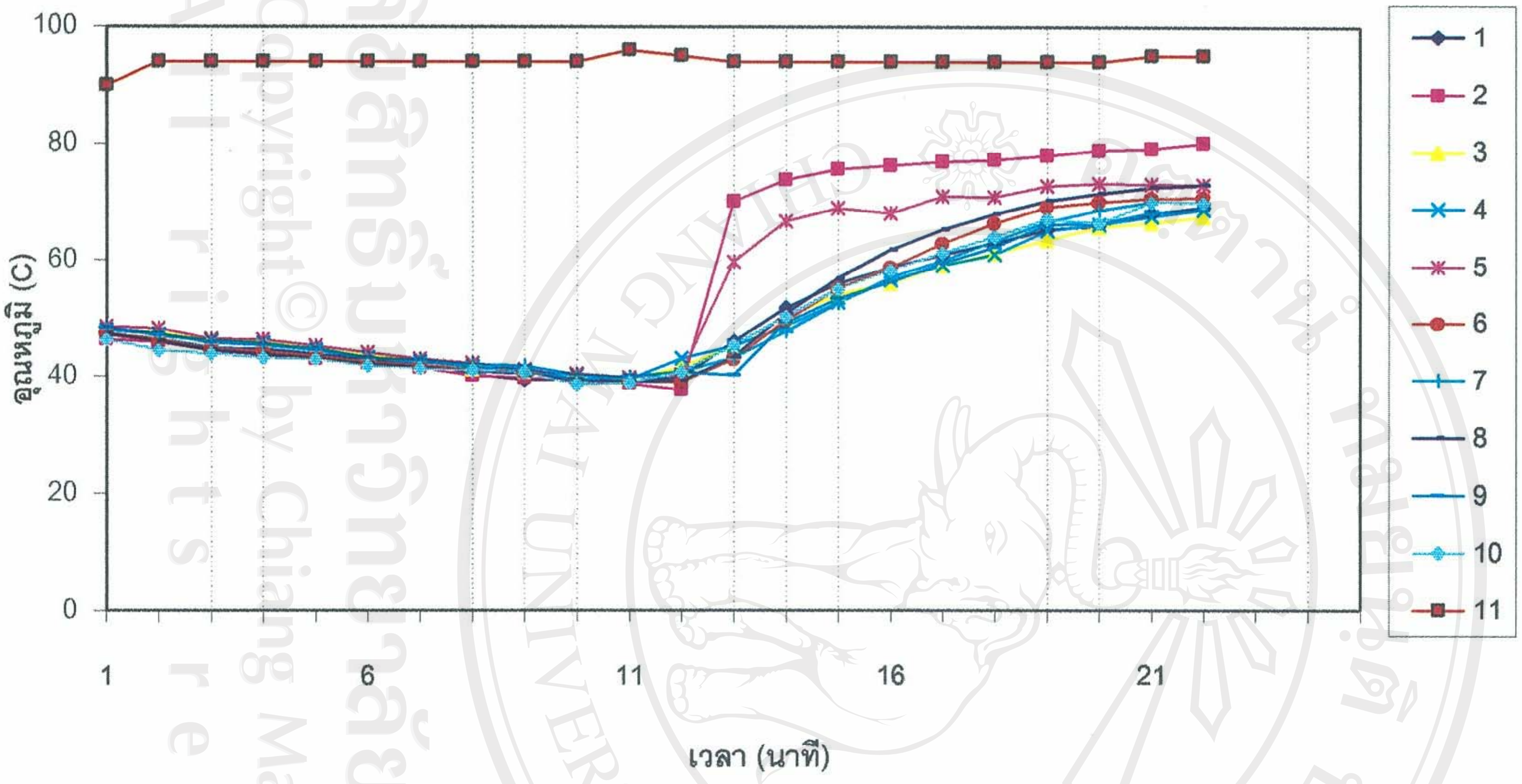
ข้อมูลการทดสอบอุณหภูมิของท่อเทอร์โมไซฟอนในแต่ละแถว



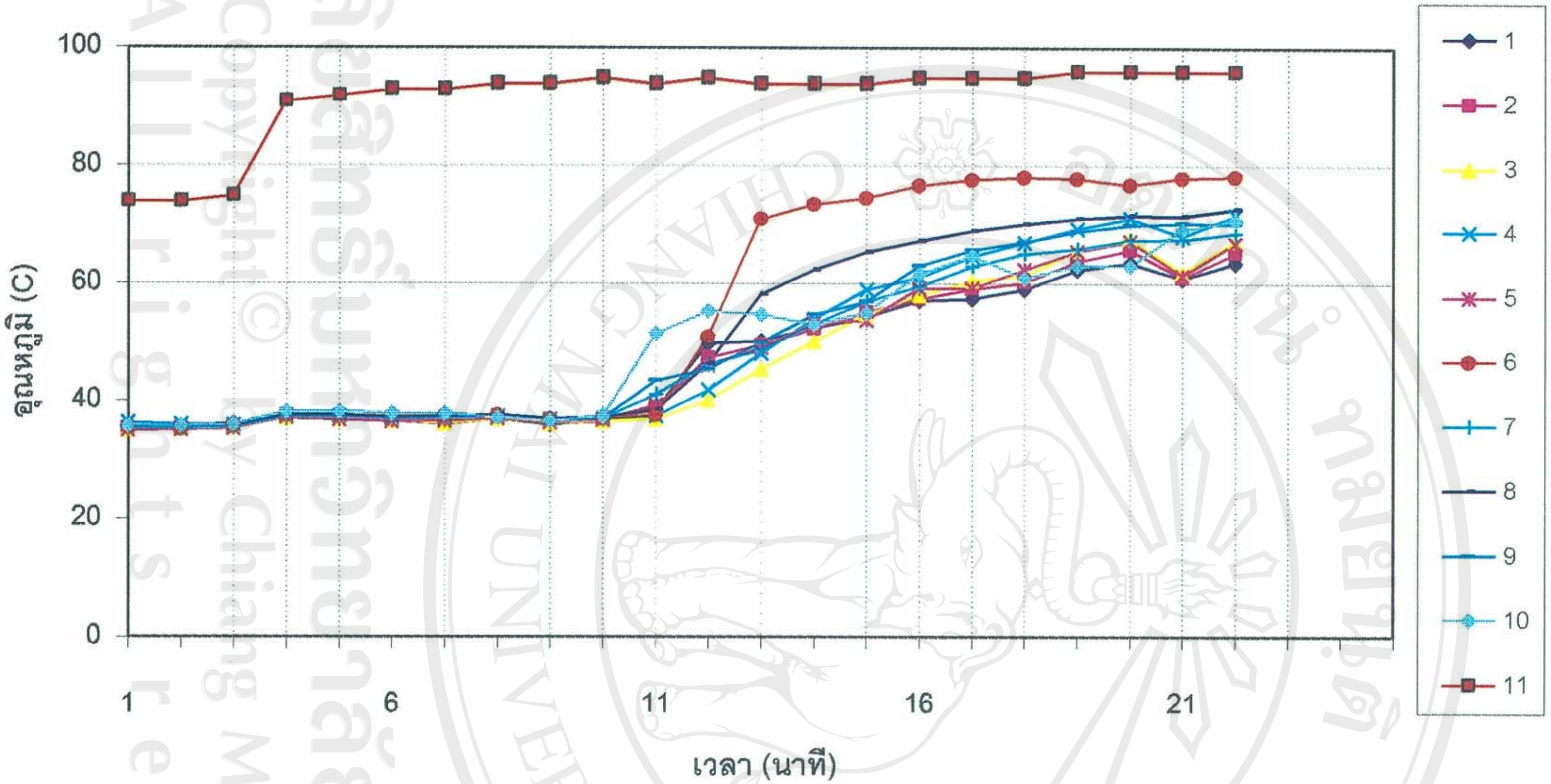
รูปแสดงผลการตรวจสอบอุณหภูมิของเทอร์โมไซฟอนแถวที่ 1



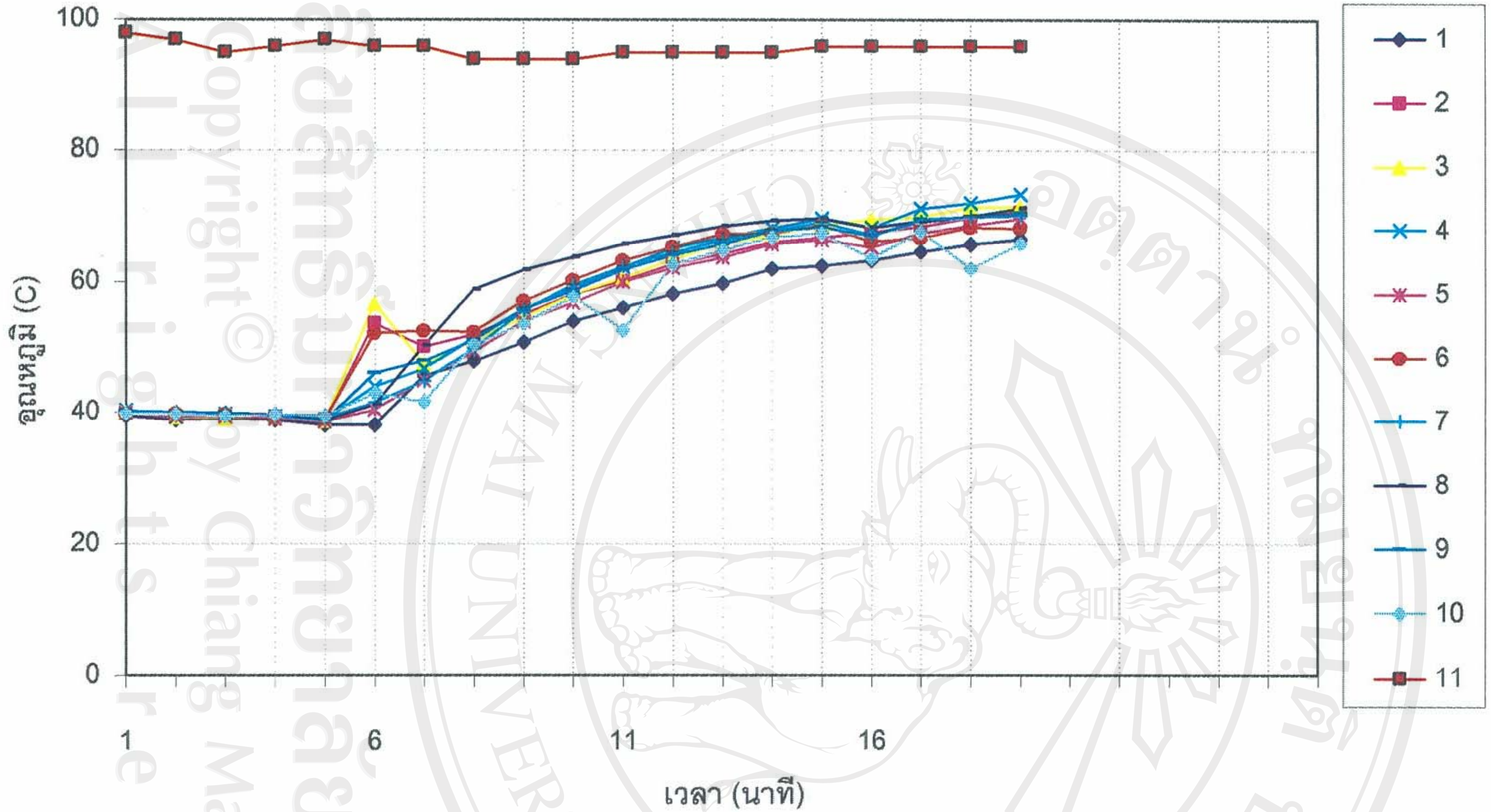
รูปแสดงผลการตรวจสอบอุณหภูมิเทอร์โมไซฟอน แถวที่ 2



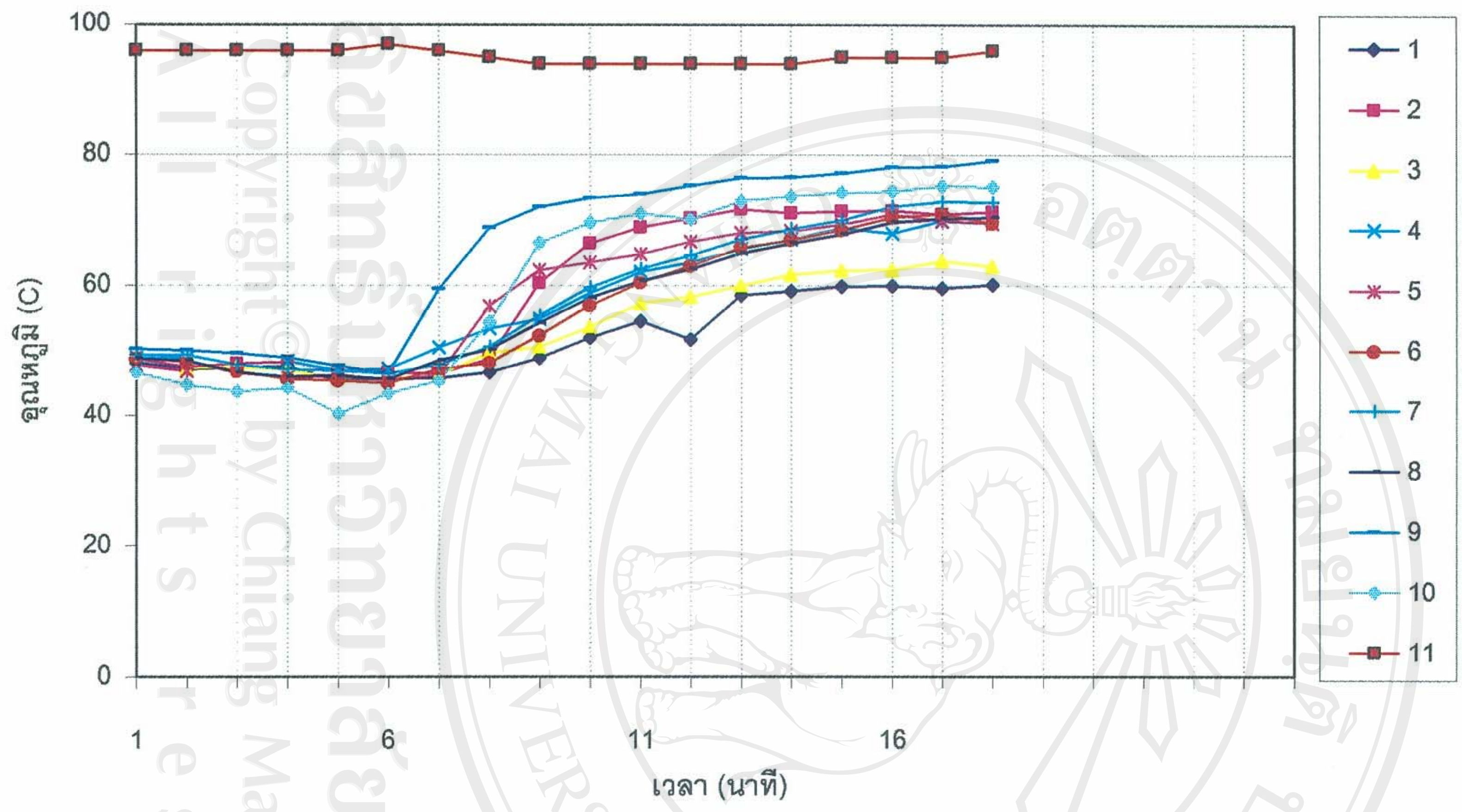
รูปแสดงผลการตรวจสอบอุณหภูมิเทอร์โมไซฟอนแถวที่ 3



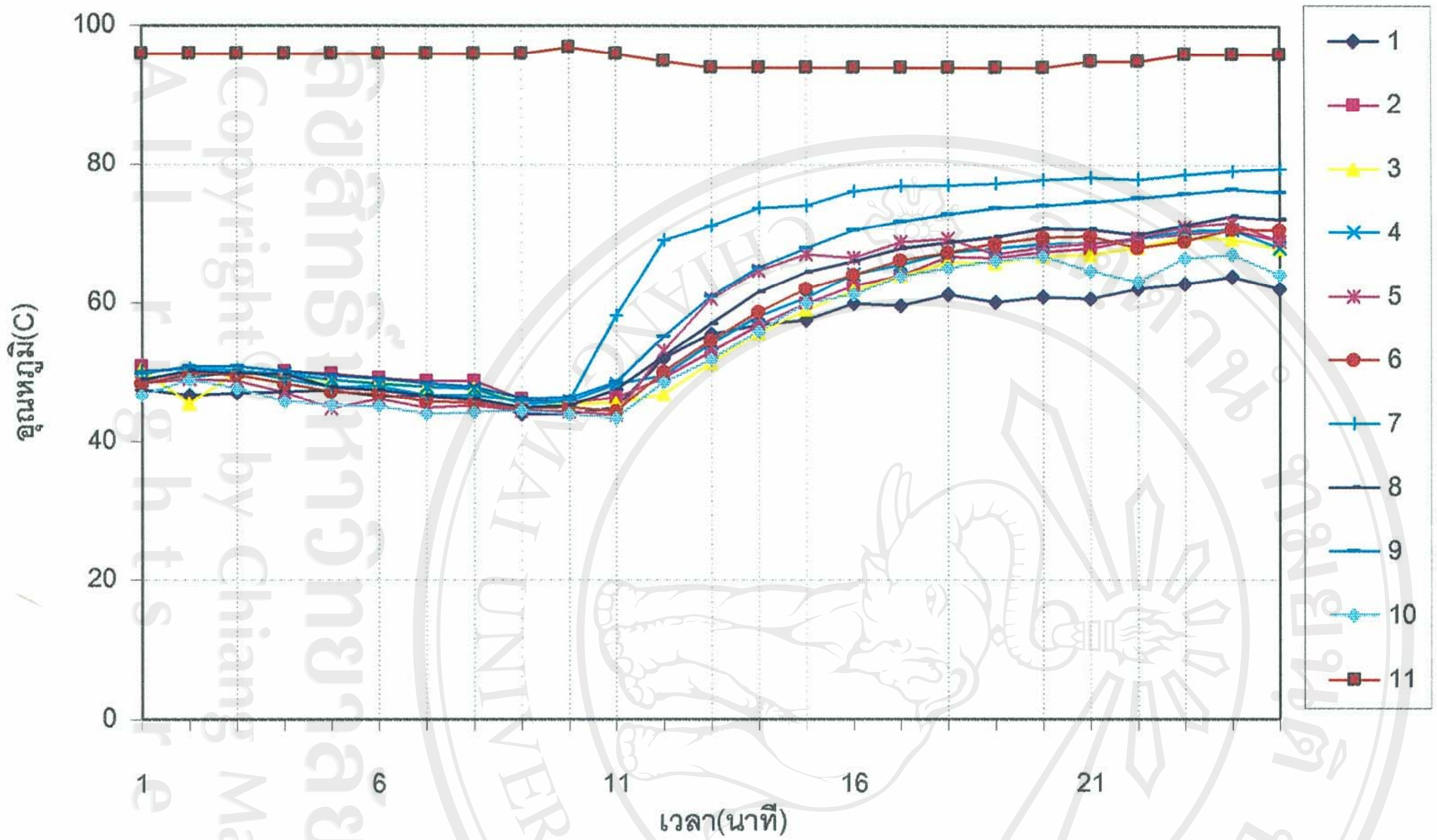
รูปแสดงผลการตรวจสอบอุณหภูมิเทอร์โมไซฟอนแถวที่ 4



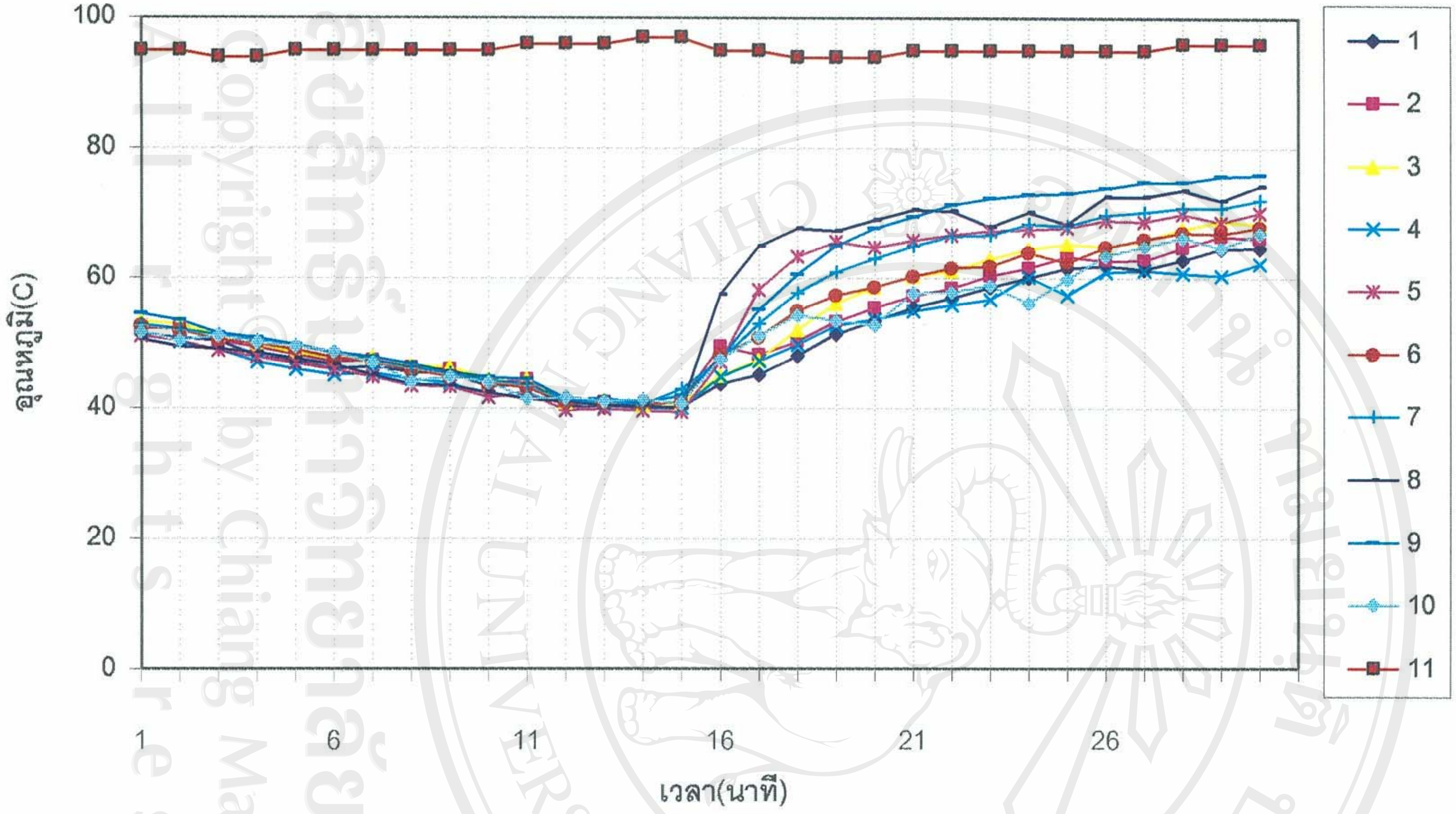
รูปแสดงผลการตรวจสอบอุณหภูมิเทอร์โมไซฟอนแถวที่ 5



รูปแสดงผลการตรวจสอบอุณหภูมิเทอร์โมไซฟอนแถวที่ 6



รูปแสดงผลการตรวจสอบอุณหภูมิเทอร์โมไซฟอนแถวที่ 7



รูปแสดงผลการตรวจสอบอุณหภูมิเทอร์โมไซฟอนแถวที่ 8

ความหมายของสัญลักษณ์ในการวัดอุณหภูมิ

สัญลักษณ์	ความหมาย
T1-1	Inlet temperature of flue gas point 1
T1-2	Inlet temperature of flue gas point 2
T1-3	Inlet temperature of flue gas point 3
T1-4	Inlet temperature of flue gas point 4
T2-1	outlet temperature of flue gas point 1
T2-2	outlet temperature of flue gas point 2
T2-3	outlet temperature of flue gas point 3
T3-4	outlet temperature of flue gas point 4
T3-1	Inlet temperature ofair gas point 1
T3-2	Inlet temperature of air point 2
T3-3	Inlet temperature of air point 3
T3-4	Inlet temperature of air point 4
T4-1	outlet temperature of air point 1
T4-2	outlet temperature of air point 2
T17	Inside wall temperature (left side condenser)
T18	Inside wall temperature (left side evaporator)
T19	Inside wall temperature (right side condenser)
T20	Inside wall temperature (right side evaporator)
T21	Outside wall temperature (left side condenser)
T22	Outside wall temperature (left side evaporator)
T23	Outside wall temperature (right side condenser)
T24	Outside wall temperature (right side evaporator)
T25	Upper side splitter plate temperature (front side condenser)
T26	Lower side splitter plate temperature (front side condenser)
T27	Upper side splitter plate temperature (black side condenser)
T28	Lower side splitter plate temperature (black side condenser)

สัญลักษณ์	ความหมาย
T29	Upper pipe temperature of row 1 (right side condenser)
T30	Lower pipe temperature of row 1 (right side evaporator)
T31	Upper pipe temperature of row 7 (right side condenser)
T32	Lower pipe temperature of row 7 (right side evaporator)
T33	Upper pipe temperature of row 3 (left side condenser)
T34	Lower pipe temperature of row 3 (left side evaporator)
T35	Upper pipe temperature of row 5 (left side condenser)
T36	Lower pipe temperature of row 5 (left side evaporator)

ข้อมูลการทดสอบโดยการแปรค่าอุณหภูมิขาเข้าของก๊าซร้อนที่

อุณหภูมิขาเข้าของอากาศ	30	$^{\circ}C$
อัตราการไหลของก๊าซร้อน	5400	m^3/hr.
อัตราการไหลของอากาศ	2700	m^3/hr.

Recorder #1							Recorder #2							Recorder #3							
T1-1	T1-2	T1-3	T1-4	T1av	TA1	TA2	T2-1	T2-2	T2-3	T2-4	T2av	T3-1	T3-2	T3-3	T3-4	T3av	T4-1	T4-2	T4-3	T4-4	T4av
180.7	180.3	180	180	180.25	48.9	48.9	113.6	112.6	104.4	105.4	109	45.9	45.7	47	47.4	46.5	128.6	130.1	128.4	129.8	129.225
176.6	175.7	175	174.9	175.55	48.8	48.5	113.2	112.2	104.6	105.2	108.8	45.7	45.1	44.7	45.7	45.3	127.4	128.8	126.8	128.4	127.85
171.3	170.7	169.9	169.7	170.4	48.5	48.3	112.6	110.5	102.9	104	107.5	43.6	44.6	45.6	45.4	44.8	124.3	127.3	123.5	126.5	125.4
165.6	165.8	165.3	165	165.425	47.8	47.8	108.6	107	100	101	104.15	43.1	43.2	44.4	45.2	43.975	120.1	123.1	119.4	123	121.4
160.9	160.8	160.8	160.6	160.775	48.2	47.8	106.2	105.1	98.1	99.1	102.125	42.5	43.9	44.5	44.7	43.9	116.8	120.3	116.2	120.1	118.35
155.8	155.4	155.4	155.1	155.425	48	47.9	104.3	102.1	95.7	95.9	99.5	42.6	42.8	44.1	44.4	43.475	113.3	117.3	112.9	117	115.125
150.8	150.3	150.7	150.2	150.5	46.5	47.8	101.8	99.7	93.5	94.5	97.375	42.5	44.3	44	43.7	43.625	109.3	113.9	109.5	113.6	111.575
145.9	145.1	144.8	144.5	145.075	45.9	46.9	99.4	97.7	92	93	95.525	42.5	42.5	43	43.2	42.8	106	111.5	106.4	111.3	108.8
140.8	140.6	140.2	140.2	140.45	46.1	47.7	97.3	95	90	91	93.325	41.3	42.2	44.2	42.7	42.6	103.4	108.7	103	108.5	105.9
135.9	135.9	135.6	135.4	135.7	45.2	46.8	94.5	92.4	87.7	88.7	90.825	42.7	42.4	42.8	42.7	42.65	99.8	105	99.7	104.7	102.3
130.9	130.9	130.8	130.4	130.75	44.3	44.8	92.4	89.7	85	86.5	88.4	40.9	41.3	42.8	42.4	41.85	96.6	101.8	96.1	101.7	99.05
125.9	125.6	125.7	125.1	125.575	44.5	46.5	90.2	88.4	84	85.5	87.025	40.7	41.7	42.5	42.2	41.775	94	100.2	93.1	99.1	96.6
120.8	120.7	120.2	119.7	120.35	44.3	45	87.6	85.5	82.1	82.9	84.525	40.5	42.6	42.6	42.3	42	89.7	97.1	89.6	96.7	93.275
115.5	115.4	115.3	115.7	115.475	43.5	43.8	85.5	83.6	80.3	81.4	82.7	40.1	41.1	42.3	42.6	41.525	88	94.5	88.2	94.8	91.375
110.9	110.8	110.9	110.6	110.8	43.6	43.3	83	80.9	77.8	78.3	80	40.2	41.5	42.1	41.1	41.225	84.5	90.6	84.1	90.4	87.4
105.9	105.2	105.7	104.9	105.425	43.5	43.5	80.2	78.7	75.7	76.4	77.75	39.9	40.3	41.1	41.9	40.8	81.4	87.3	81.1	87.5	84.325
100.8	100.5	100.1	100	100.35	42.4	42.4	77	75.6	72.9	74	74.875	39.4	40	41.3	40.8	40.375	77.2	83.6	76.8	83.1	80.175
95.6	95	95.1	94.9	95.15	41.3	41.5	75.1	73.5	70.9	72.3	72.95	40	39.3	40.3	40.5	40.025	74.3	80.7	74.1	79.9	77.25
90.7	90.3	90.8	90.2	90.5	40.6	40.6	72.3	71.1	69.2	70.4	70.75	38.9	39.5	40.6	40.1	39.775	71.4	77.4	71.6	77.1	74.375
85.9	85.6	85.4	85.2	85.525	39.8	39.7	69.8	68.7	66.6	68.3	68.35	38.7	39.1	40.7	40	39.625	68.4	73.9	68	73.7	71
80.1	79.9	79.8	79.3	79.775	38.8	38.7	66.5	65.7	64.1	65.9	65.55	38.5	38.6	40.7	39.5	39.325	64.2	70	64.5	69.9	67.15
75.6	75.8	75.8	75.5	75.675	38.5	38.4	64.7	63.3	62.4	64.4	63.7	38.2	38.4	39.8	39.3	38.925	61.6	66.7	60.5	66.5	63.825
70.8	70.8	70.2	70.1	70.475	38.1	38.2	62.5	62.1	60.9	62.7	62.05	38	38.6	40.3	39.3	39.05	56.2	63.5	54.1	62.3	59.025
65.9	65.5	65.8	65.3	65.625	36.9	37.1	59.2	58.9	57.3	60.2	58.9	38.1	37.8	39.2	39.4	38.625	51.1	57.2	51.5	57	54.2
60.9	60.6	60.6	60.3	60.6	37.1	36.7	57.2	56.7	56.1	58.1	57.025	37.2	37.5	38.9	38.3	37.975	48.6	53.1	47.6	52.1	50.35
55.3	55.7	55.2	55.4	55.4	36.2	36	54.5	54.2	53.4	55.2	54.325	36.9	37.2	38.9	38.3	37.825	45.6	48.6	45.1	48.4	46.925
50.9	50.7	51	50.7	50.825	36.3	35.7	50.7	50.6	50.7	50.8	50.7	36.8	36.8	38.2	37.4	37.3	42.3	44.5	41	43.8	42.9
45.9	45.7	45.5	45.1	45.55	35.3	35.2	46.4	46.1	45.6	46.5	46.15	35	35.7	37	37.3	36.25	38.4	40.7	38.2	40.3	39.4
41.4	40.9	41.8	41.6	41.425	34.3	33.9	41.1	40.9	41.7	41.9	41.4	33.6	34.7	35.8	34.8	34.725	36.2	37.4	35.9	37.3	36.7

DATA # 2 , Fixed Ma , Mf , T3 Var. T1

Temp.	Data logger #1									
	T29	T31	T19	T30	T32	T27	T25	T28	T26	T23
180	118.7	72.9	73	151	108.2	79.6	187.6	104.4	196.9	193
175	117.5	72.4	71.9	150	107.7	77.9	187.4	104.2	196.3	193
170	114.9	71.7	69.6	147.4	106.3	73.5	184.5	103.1	193.2	190.6
165	111.2	69.6	67.3	144	103.5	69.9	177.5	100.2	185.7	185.6
160	108.6	68.5	66.1	140.4	101.7	67.7	171.7	98.2	179.5	181.5
155	104.8	66.8	64.4	136.5	99.1	65.2	165.2	95.4	173.6	175.8
150	101.5	65.7	63	132.4	96.9	62.8	159.5	93.7	167.5	170.1
145	98.7	64.4	60.9	128.2	95.1	59.8	153.3	90.7	160.3	162.7
140	96.5	64.1	60.4	125.3	93.4	59.1	142.3	89.8	156.1	159.5
135	93.2	62.5	59.2	120.9	90.9	57.4	114.1	87.2	149.5	153.9
130	90.9	60.7	58	117.4	88.9	56.1	85.6	85.4	144.1	147.5
125	89.8	59.7	57.3	113.5	87.9	55.2	62.2	84	139.3	142.7
120	86.4	57	56.7	108.3	86.1	54.6	59.6	81.7	131.4	137.2
115	84.4	55.8	56.1	105.3	84	54.1	67.6	80.3	127.6	132.4
110	81.2	53	54.8	100.9	81.3	53.1	58.2	77.4	121	125.6
105	78.5	50.4	53.8	96.5	78.9	52	54.3	75.7	116.4	120.2
100	74.9	48.2	53	92.5	76.4	51.4	55.7	72.8	107.6	114
95	73.1	47.3	52.6	89.1	74.4	50.7	51.6	70.8	103.8	108.3
90	70.5	45.2	51.5	85.1	71.7	49.7	51.1	68.8	98.2	102.9
85	67.9	44.3	50.4	81.9	69.7	49.1	47.7	67.3	93.9	98.9
80	60.2	42.9	49.3	77.1	66.5	48.3	47.1	64.7	87.4	93.5
75	54.6	42.2	48.2	73.7	64.1	47.5	46.3	63	83.4	88.6
70	51.7	42.1	47.7	70.5	62.2	47.2	46.3	61.9	80.7	85.2
65	48.9	41.3	46.9	66.2	58.9	46.7	43.7	59.2	74.1	79.8
60	47.1	40.6	46.1	62.8	56.9	46.3	42.7	57.3	68.5	73.9
55	43.9	39.9	45.1	58.7	54.5	45.7	41.5	54.6	63.7	69
50	41.6	39.3	44.3	53.9	50.4	45	38.9	49.8	56.3	63.1
45	39.3	38.3	42.4	47.9	45.7	43.5	37.8	44.9	48.6	54.4
40	36.6	35.8	38.8	42.1	40.8	40.3	35.5	40.1	42.4	45.6

DATA # 2, Fixed Ma , Mf , T3 Var T1

Temp.	Data logger #2									
	T33	T35	T34	T36	T17	T21	T22	T18	T20	T24
180	109	99.5	145	134.5	202.6	86.5	53	49	55.3	57.3
175	108	99	144	134.4	201.2	85.4	53	48.9	55.6	57.3
170	107	97.4	140	129.5	197.3	83.6	52.3	49	55.5	57.5
165	105	95.1	137	123	191.7	80.9	52	48.9	54.9	57.4
160	103	93.2	133	119	186.1	79.6	51.7	48.5	54.6	56.9
155	101	91.2	129	116	180.4	77.8	51.4	48.5	54.2	56.7
150	98.8	89.4	125	112.9	173.8	76.2	50.6	48	53.6	56.1
145	97.8	87.9	121	109.5	165.3	74.5	49.4	47.4	52.7	55.5
140	96.4	86.4	118	107.3	161.9	73.7	49.2	47.2	52.4	54.9
135	93.5	84	115	104.2	156.3	71.9	48.7	46.7	51.9	54.3
130	91.5	81.9	111	101.4	150.3	70.4	47.6	46.2	50.8	53.6
125	91.3	80.9	107	98.6	143.5	69.9	47.3	45.8	50.8	53.1
120	89.8	78.5	103	95.6	137.6	70.5	47	45.9	50.6	53
115	87.3	76.5	99.9	92.9	132.6	69.1	46.9	45.9	49.6	52.9
110	83.8	73.2	96	89.6	126.3	67.1	46.1	45	48.7	51.7
105	81.6	70.8	91.5	86.5	119.7	66.2	45.1	44.3	48	50.9
100	78.8	68.3	88	83.2	114.4	65	44.6	44	47.1	50.5
95	76.5	66	84.9	80.6	108.3	64.1	43.9	43.4	46.3	49.6
90	74.2	61.9	81.6	77.8	103.6	62.8	43.4	43	45.4	48.8
85	70.8	57.6	77.8	75.1	98.3	61.3	42.9	42.4	44.6	48.1
80	67.1	54.1	73.3	71.4	91.6	60.1	42.1	42	43.4	47.2
75	64.1	52.7	70.7	69.3	86.7	58.2	41.5	41.5	42.4	46.1
70	61.7	51.1	67.4	66.9	81.7	57.7	41.2	41.1	42	45.8
65	58.5	48.5	63.2	63.7	76.4	56.1	40.6	40.6	41.5	45
60	55.5	46.9	59.2	59.5	69.7	54.3	40.2	40.3	40.6	44
55	51.8	45.5	54.7	55.5	62.9	52.5	39.5	39.7	39.9	43.4
50	48.5	43.5	51	51.7	58.2	50.3	38.9	39.2	38.6	42.2
45	43.6	39.9	45.5	46	51.1	46.7	37.9	37.9	37.8	39.7
40	39.5	37.6	41	41.5	44.7	41.2	34.6	34.4	35	36.5

ข้อมูลการทดสอบโดยการแปรค่าอัตราการไหลของก๊าซร้อนขาเข้า ที่

อุณหภูมิขาเข้าของก๊าซร้อน	170	$^{\circ}C$
อุณหภูมิขาเข้าของอากาศ	30	$^{\circ}C$
อัตราการไหลของอากาศ	2700	m^3/hr.

DATA # 3 , Fixed Mf , T1 , T3 Var. Ma

Recorder #1						Recorder #2						Recorder #3						Vel	Vel
T1-1	T1-2	T1av	TA1	TA2	T2-1	T2-2	T2-3	T2-4	T2av	T3-1	T3-2	T3-3	T3-4	T3av	T4-1	T4-2	T4av	Gas	Air
170.1	169.9	170	47.7	46.3	110	108	101	102.8	105.3	39.6	39.2	40.9	40.8	40.1	123	133	128.2	8.59	2.86
170.5	170.6	170.6	44.7	45.1	124	125	120	119.2	121.8	39.4	40.6	41.3	42.1	40.9	142	148.6	145.5	8.59	1.43

DATA # 3 , Fixed Mf , T1 , T3 Var. Ma

Data logger #1										Vel	Vel
T29	T31	T19	T30	T32	T27	T25	T28	T26	T23	Gas	Air
116.7	76.3	59.4	144.7	111.1	50.7	183	100	190.6	183.6	8.59	2.86
139.4	95.5	75.3	154	125.5	53.3	198	117	201.9	189.6	8.59	1.43

DATA # 3 , Fixed Mf , T1 , T3 Var. Ma

Data logger #2										Vel	Vel
T33	T35	T34	T36	T17	T21	T22	T18	T20	T24	Gas	Air
115.6	100.5	140.3	124.9	193	79.1	46.4	45.7	50.8	52.3	8.59	2.86
139.2	126.7	154.3	143.7	200.1	125	47.4	46.1	51.1	52	8.59	1.43

ข้อมูลการทดสอบโดยการแปรค่าอุณหภูมิขาเข้าของอากาศ ที่

อุณหภูมิขาเข้าของก๊าซร้อน	170	$^{\circ}C$
อัตราการไหลของก๊าซร้อน	5400	m^3/hr.
อัตราการไหลของอากาศ	2700	m^3/hr.

DATA # 3 , Fixed Ma , Mf , T1 Var T3

Recorder #1						Recorder #2							Recorder #3						
T1-1	T1-2	T1av	TA1	TA2	T2-1	T2-2	T2-3	T2-4	T2av	T3-1	T3-2	T3-3	T3-4	T3av	T4-1	T4-2	T4-3	T4-4	T4av
170	170.6	170.4	42.8	40.1	133	133.9	136.6	133.1	134.2	103.8	100.2	101.3	100.2	101.4	146.4	146.5	136.7	136.4	141.5
170	170.7	170.5	44.9	41.5	132	131.9	129.9	130.6	131.1	95.7	95	94.9	93.4	94.75	145.5	145.7	137.5	138	141.7
170	170.3	170.1	46.2	42.5	131	130.9	129	127.8	129.6	90.5	90.4	90.1	90.1	90.28	142.5	143	137.8	138	140.3
170	170.3	170.2	48.2	44.9	130	130.3	127	126.3	128.4	85.1	85.2	85.1	84.7	85.03	141.8	141.5	138.9	139.1	140.3
170	170.1	170	49.1	45.7	128	127.9	123.7	123.2	125.7	80.9	80.5	80.4	80.7	80.63	139	139.5	137.9	138.1	138.6
170	170.6	170.5	49.6	47.1	124	124	118.3	118.2	121.1	69.7	69.4	70.5	70.2	69.95	136.4	136.9	133.5	134.4	135.3
170	170.1	170.1	49.7	47.8	124	123.5	117.6	117.7	120.7	70.8	70.5	70.8	70.7	70.7	135.3	134.6	133.7	134.1	134.4
17[illegible]	170.3	170.5	49.5	47.5	121	120.8	115.1	114.5	117.9	64.9	65.4	65.5	65.7	65.38	132.8	133.3	130.9	131.4	132.1
171	170.8	170.7	49.4	47.2	120	119.9	112.9	112.1	116.1	60.1	60.4	60.5	60.9	60.48	133.3	133.1	130.1	130.5	131.8
170	170.1	170	49.6	48.4	116	116.3	109.2	109.4	112.6	55.7	55.9	56	56.7	56.08	130.4	130	127.2	126.9	128.6
171	170.5	170.6	49.8	48.8	115	115.6	107.1	107.3	111.2	50.6	50.5	50.7	50.5	50.58	129.4	130	125.3	125.6	127.6

DATA # 3, Fixed Ma , Mf , T1 Var T3

Data logger #1									
T29	T31	T19	T30	T32	T27	T25	T28	T26	T23
129.1	115.8	95.1	147.1	129.3	52.7	196.3	146.1	200.3	176.7
129.5	111.9	102	149.5	129	62.7	196.3	147.1	200.5	176.9
127.5	107.4	105	149	126.5	73.4	193.9	142.1	199	182.8
127.6	105.1	106.3	150.9	125.2	85.2	193.2	139.8	198.3	188.5
126.2	101.7	104.7	144.9	123.7	88.3	192.2	136.1	197	188.3
121.1	93.4	98.2	149.1	118.9	89.5	190.1	127.9	196.2	189.4
120.7	92.9	96.3	148	117.2	89.5	188.3	124.2	194.4	189
118.5	88.7	90.9	147.3	114.8	87	186.8	120.1	193.9	189.4
117.2	85.6	87.3	147.5	113.5	85.5	187.1	118.2	194.3	189.7
113.5	82.4	79.7	145.5	109.8	77.8	184.6	110.7	192.4	188.4
112.8	79.4	76.9	144.5	109.1	76.4	184.9	110.7	193.1	189.4

Data logger #2									
T33	T35	T34	T36	T17	T21	T22	T18	T20	T24
115	112.5	141.3	134.1	187.8	102.7	39.4	38.6	45.8	44.5
119.5	116.1	148.3	141.9	193.7	109.7	42.1	40.5	47.4	46.3
118.5	114.1	146.2	138.9	195.7	113.5	46.3	43	49.8	50.1
123.7	113.1	144	138.7	196.4	116.7	50.8	46.3	53.4	54.6
118.3	111	140.3	138.5	196.7	115	52.3	48.2	55.2	55.8
107.3	101.1	131.4	127.1	196.6	110.6	55.8	51.1	55.6	55.2
114.7	109.4	143.5	139.7	197.2	105.7	51.8	41	54.6	56.2
108.9	103.7	134.6	130	195.5	102.1	54	50.9	56.8	58.2
107.2	103.7	139.1	134.5	195.8	98.8	54.2	50.8	56.4	58.1
104.3	98.1	137	126.9	196	91.6	54	51.3	56.6	58.1
102.7	94.1	136	125.9	195.9	88.4	53.8	51.5	56.4	58.5

ข้อมูลการทดสอบโดยการแปรค่าอัตราการไหลของอากาศขาเข้า ที่

อุณหภูมิขาเข้าของก๊าซร้อน	170	$^{\circ}C$
อัตราการไหลของก๊าซร้อน	5400	m^3/hr.
อุณหภูมิขาเข้าของอากาศ	30	$^{\circ}C$

DATA # 3 , Fixed Mf , T1 , T3 Var. Ma

Recorder #1						Recorder #2						Recorder #3						Vel	Vel
T1-1	T1-2	T1av	TA1	TA2	T2-1	T2-2	T2-3	T2-4	T2av	T3-1	T3-2	T3-3	T3-4	T3av	T4-1	T4-2	T4av	Gas	Air
170.1	169.9	170	47.7	46.3	110	108	101	102.8	105.3	39.6	39.2	40.9	40.8	40.1	123	133	128.2	8.59	2.86
170.5	170.6	170.6	44.7	45.1	124	125	120	119.2	121.8	39.4	40.6	41.3	42.1	40.9	142	148.6	145.5	8.59	1.43

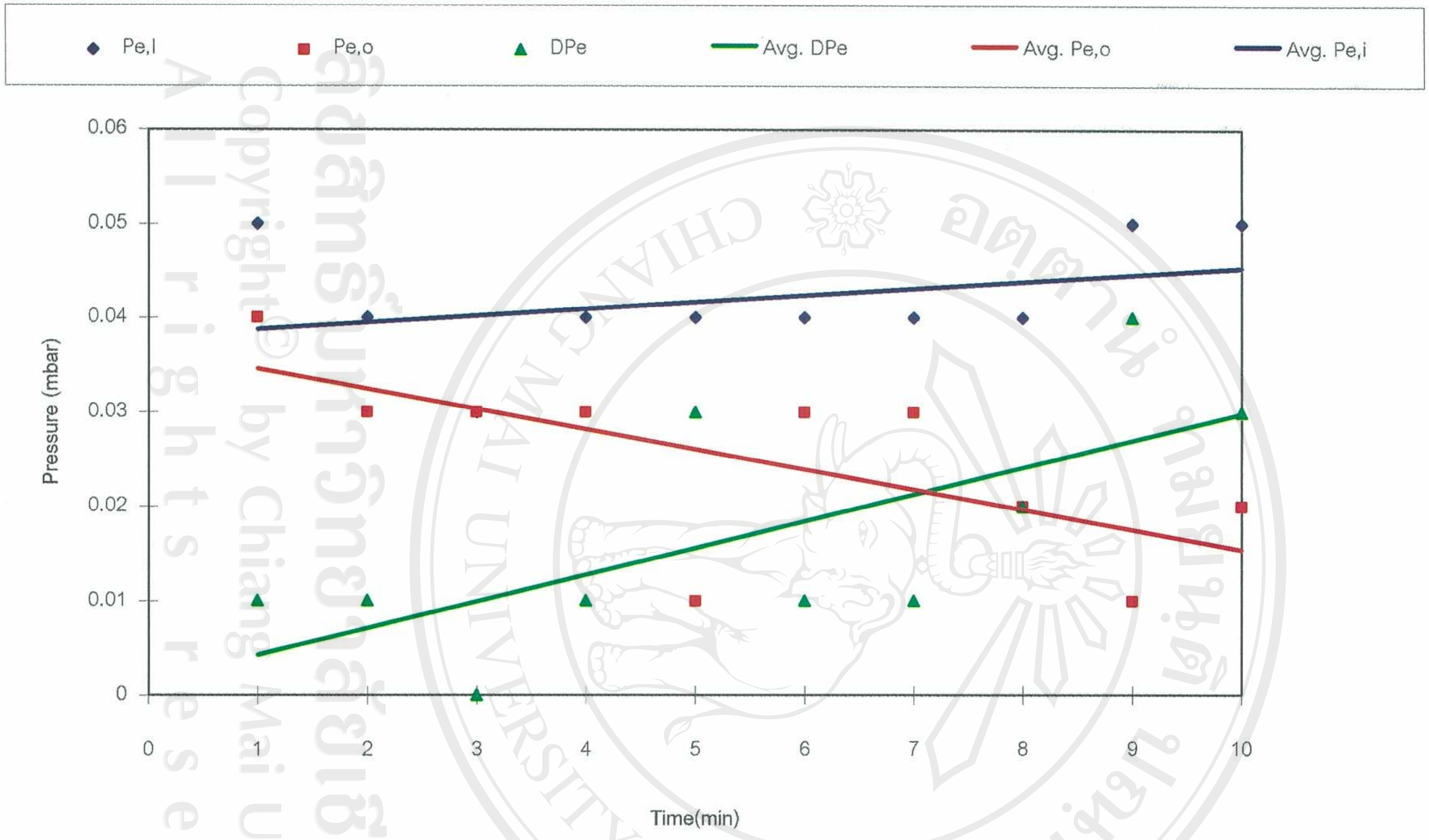
DATA # 3 , Fixed Mf , T1 , T3 Var. Ma

Data logger #1										Vel	Vel
T29	T31	T19	T30	T32	T27	T25	T28	T26	T23	Gas	Air
116.7	76.3	59.4	144.7	111.1	50.7	183	100	190.6	183.6	8.59	2.86
139.4	95.5	75.3	154	125.5	53.3	198	117	201.9	189.6	8.59	1.43

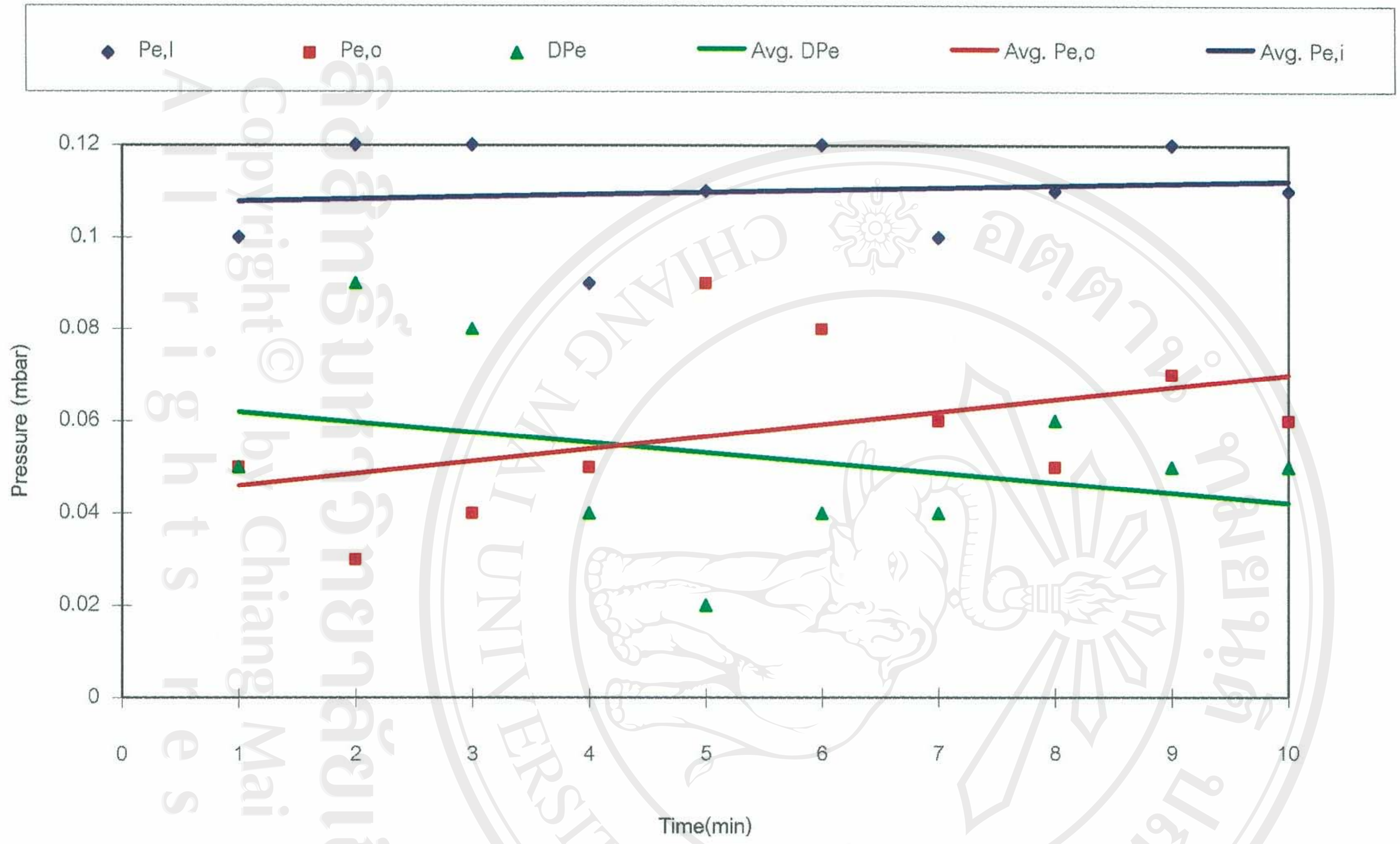
DATA # 3 , Fixed Mf , T1 , T3 Var. Ma

Data logger #2										Vel	Vel
T33	T35	T34	T36	T17	T21	T22	T18	T20	T24	Gas	Air
115.6	100.5	140.3	124.9	193	79.1	46.4	45.7	50.8	52.3	8.59	2.86
139.2	126.7	154.3	143.7	200.1	125	47.4	46.1	51.1	52	8.59	1.43

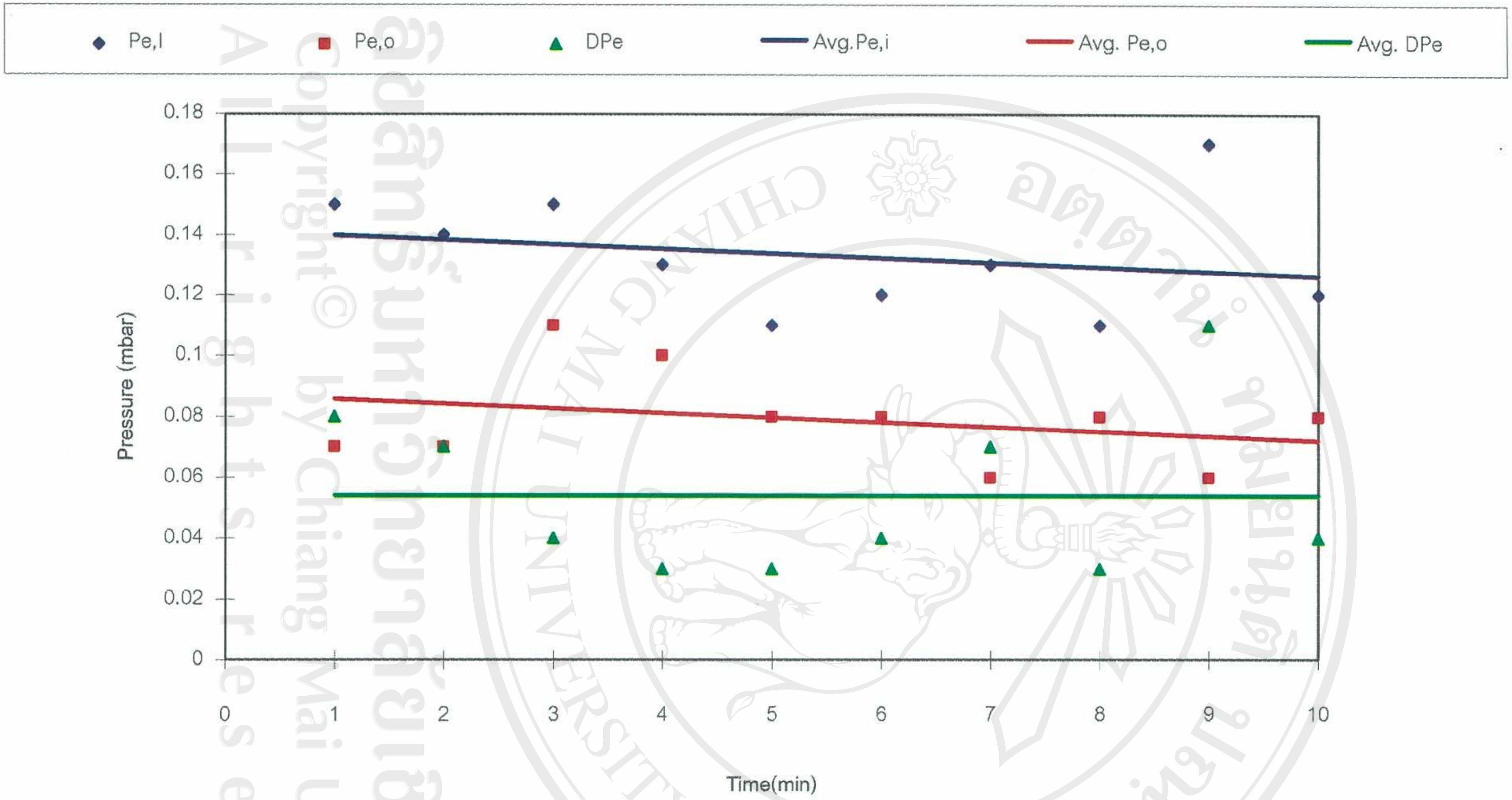
รูปแสดงค่าความดันและความดันตกคร่อมที่ได้จากการทดสอบ



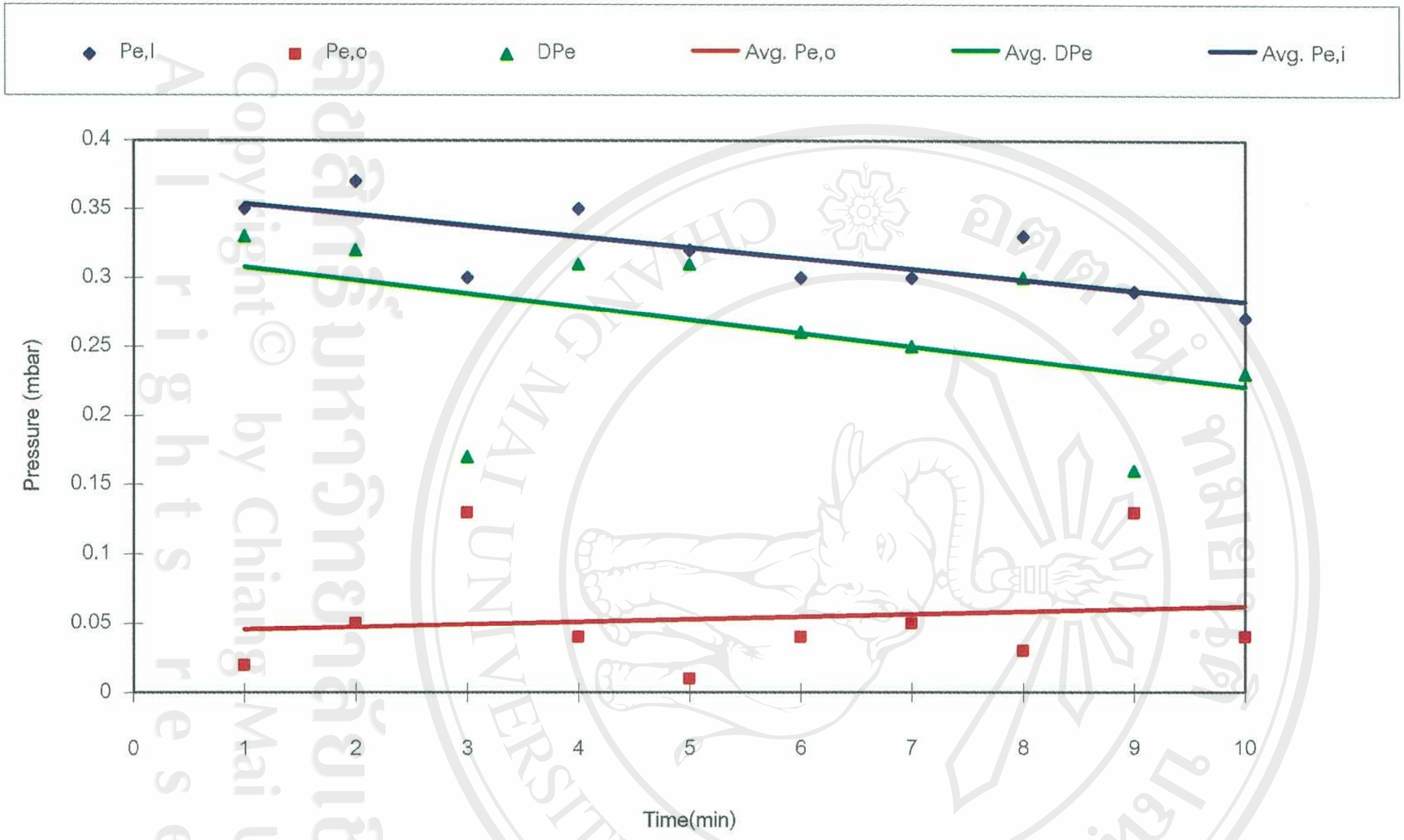
รูปแสดงค่าความดันและความดันตกคร่อมบริเวณส่วนทำระเหยกับเวลา ณ Vf = 2.86 m/s



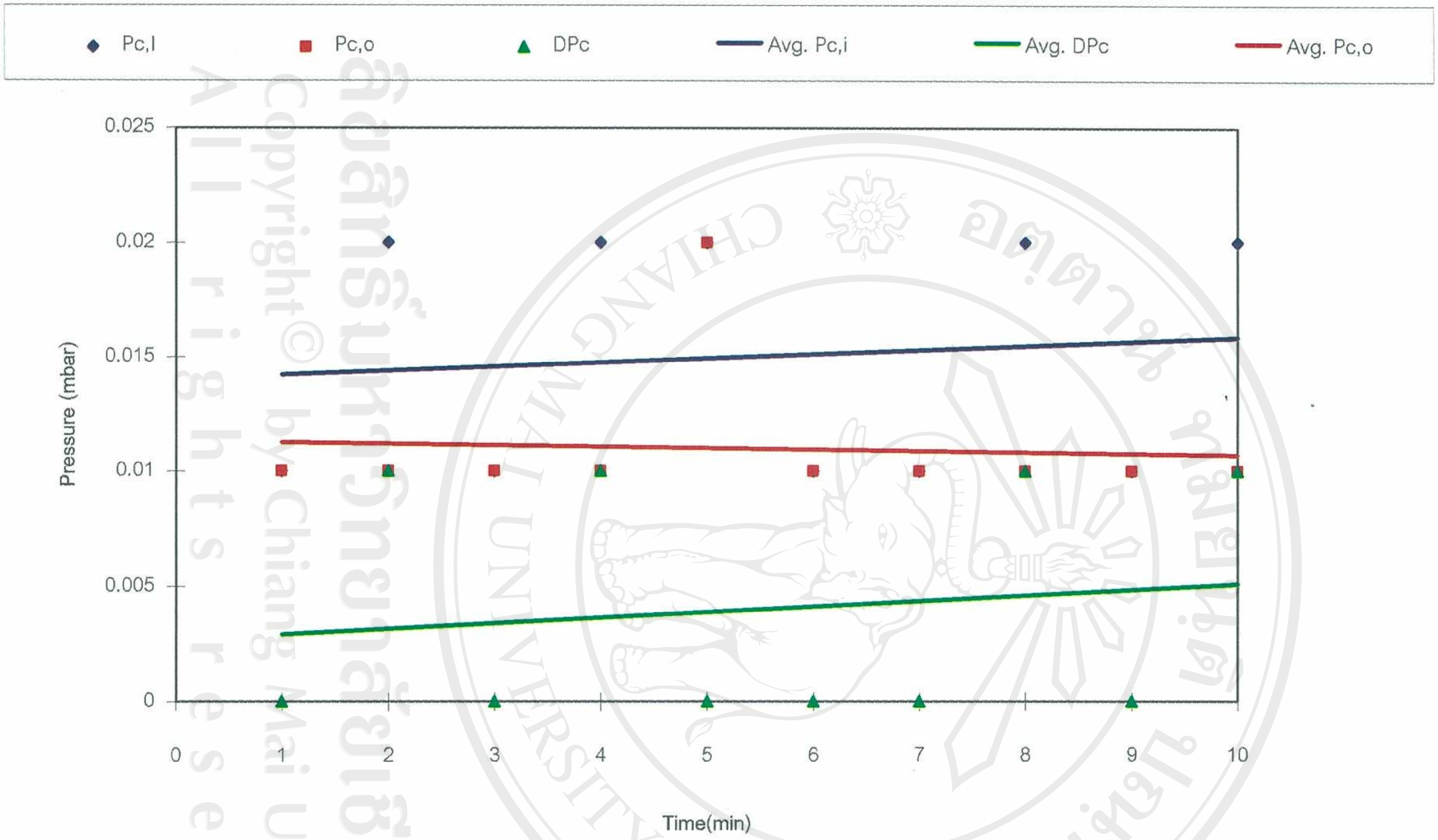
รูปแสดงค่าความดันและความดันตกคร่อมบริเวณส่วนทำระเหยกับเวลา ณ Vf = 4.29 m/s



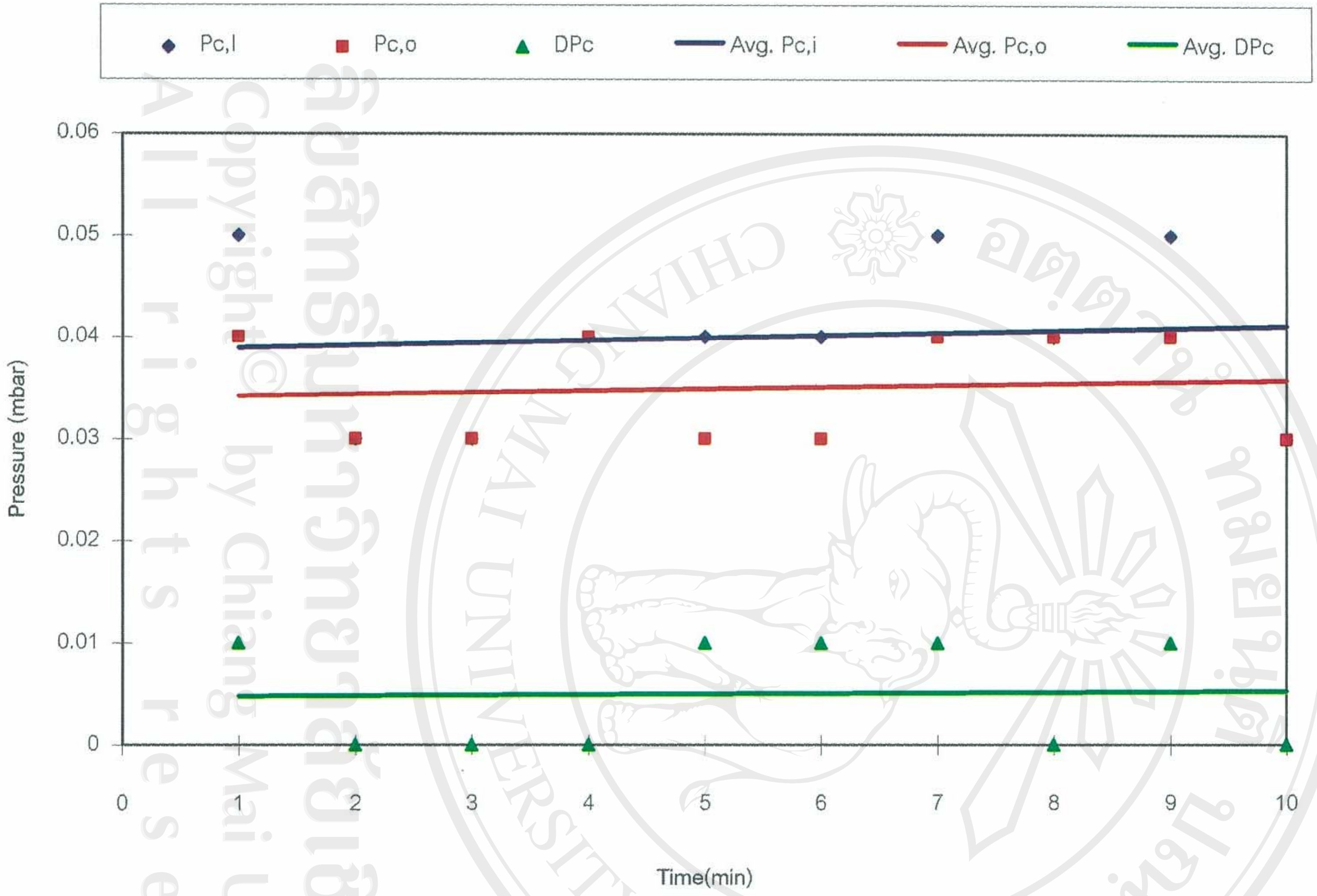
รูปแสดงค่าความดันและความดันตกคร่อมบริเวณส่วนทำระเหยกับเวลา ณ Vf = 5.73 m/s



รูปแสดงค่าความดันและความดันตกคร่อมบริเวณส่วนทำระเหยกับเวลา ณ Vf = 7.16 m/s



รูปแสดงค่าความดันและความดันตกคร่อมบริเวณส่วนควบแน่นกับเวลา ณ Va = 1.43 m/s



รูปแสดงค่าความดันและความดันตกคร่อมบริเวณส่วนควบแน่นกับเวลา ณ Va = 2.86 m/s

ประวัติผู้เขียน

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