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**An Experimental Study on Understanding of Production
Mechanism of a Mist from Fin-Tube Heat Exchanger**

2001 2

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Abstract	

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**An Experimental Study on Understanding of Production
Mechanism of a Mist from Fin-Tube Heat Exchanger**

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Abstract

As an improvement in the standard of living and economic growth, the demand for air conditioning equipment is increasing rapidly. Nowadays, air conditioning equipments are being used for industry, large building, house and car. These equipments were concentrated on improving heat efficiency of economic aspects while they design heat exchanger for cooling and heating. These air conditioning equipments using heat exchanger cause a discomfort to user due to generating mist at the beginning of operating. Therefore, the user demand air of high quality. In this experimental study, to acquire elementary data for development of heat exchanger which be able to supply air of high

quality, that is to say, possess a restraint effect of mist generation. We estimate an effect on cooling plate quality, supply air velocity, supply air temperature, cooled plate temperature and supply air relative humidity which have an influence on outlet air condition of heat exchanger.

A	:		[m ²]
h_m	:		[kg / m ² ·]
h_h	:		[W / m ² ·]
L_H	:		[J / kg]
T_i	:		[]
T_w	:		[]
T	:		[]
Q_t	:		[W]
Q_s	:		[W]
Q_l	:		[W]
U	:		[m / s ²]
W_i	:		[kg / kg']
W	:		[kg / kg']

()

: [%]

1

1.1

20

가

Fig. 1.1

가

. Fig. 1.2

IMF

1998 , 1999

가

. Fig. 1.3

가

. Table. 1.1

	1991	1994	1997	1999	2000
(%)	8.0	12.0	21.0	23.0	24.0

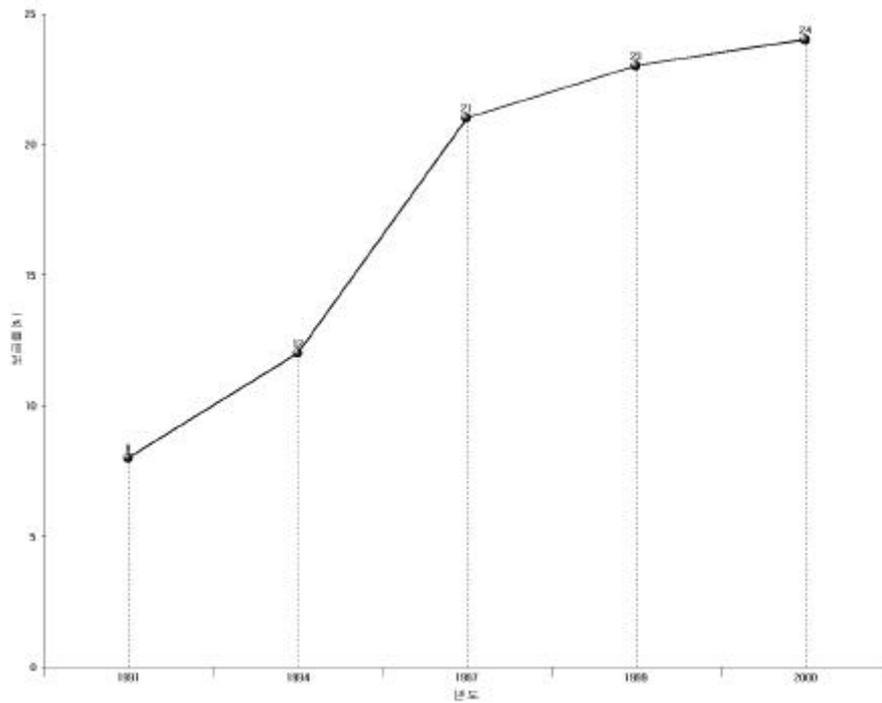


Fig. 1.1 Supply rate of an air conditioner within a country

	1996	1997	1998	1999	2000
()	120	132	74	63	110

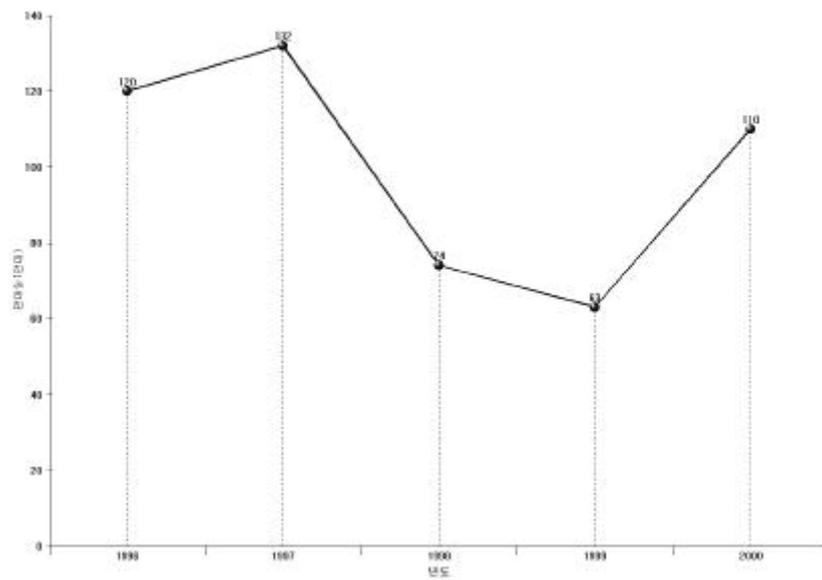
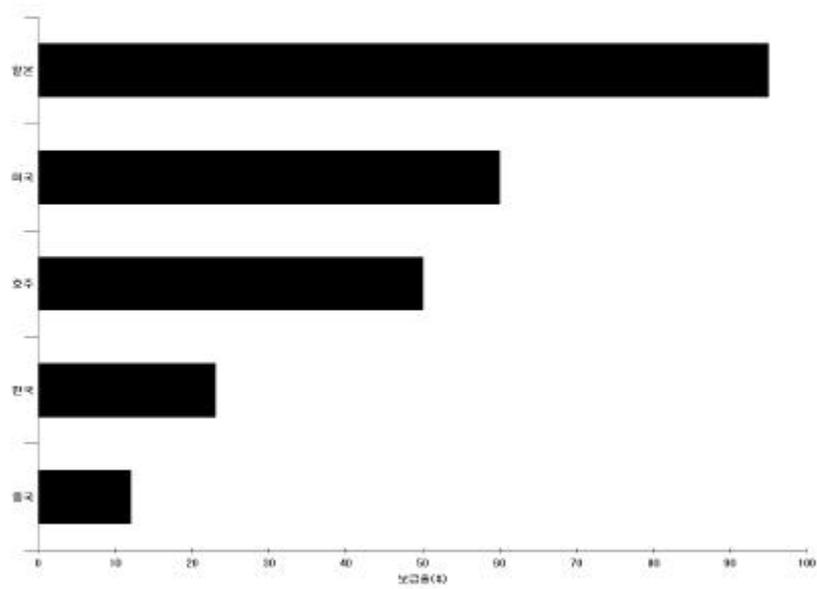


Fig. 1.2 The market scale of an air conditioner within a country

가					
(%)	95	60	50	23	12



**Fig. 1.3 Supply rate of an air conditioner
the main nation(1999)**

	, 가 ,
	, , 가
AHU	, ,
	,
FCU	, ,
	,
	,
	Rotor ,
	, ,
	, ,
	, ,
	,
	CFC , ,
	,
	, ,

**Table. 1.1 The present conditions of a technical development
the latest**

가 가 ,

1.2

, 가

가

80 85%

가

가

¹⁾ 15)

Yamada ¹⁸⁾

가

(爐)

가

가

가

가

가

¹⁶⁾ ¹⁷⁾

Yamada ¹⁸⁾

가

가

, 3mm 가 ,
0.5m/s , 가 가

(Quality)

가

(Mist)

, , ,
, , ,
, .

2

2.1

-
0.3m/s, 0.5m/s 0.7m/s
, 20, 25 30 ,
70%, 80% 90% .
-3, 0 3

.(Table. 2.1)

, 가 가

가

, ±0.5 ,
± 1% .

가 ,

Digital Video Camera(DCR-VX1000)

CACTUS 2000

Table 2.1 An experimental condition

Condition	Range
Cooling Plate	Copper, Aluminum
(%)	80 90
T_w ()	- 3 3
T ()	20 30
U (m/s)	0.3 0.7

2.2

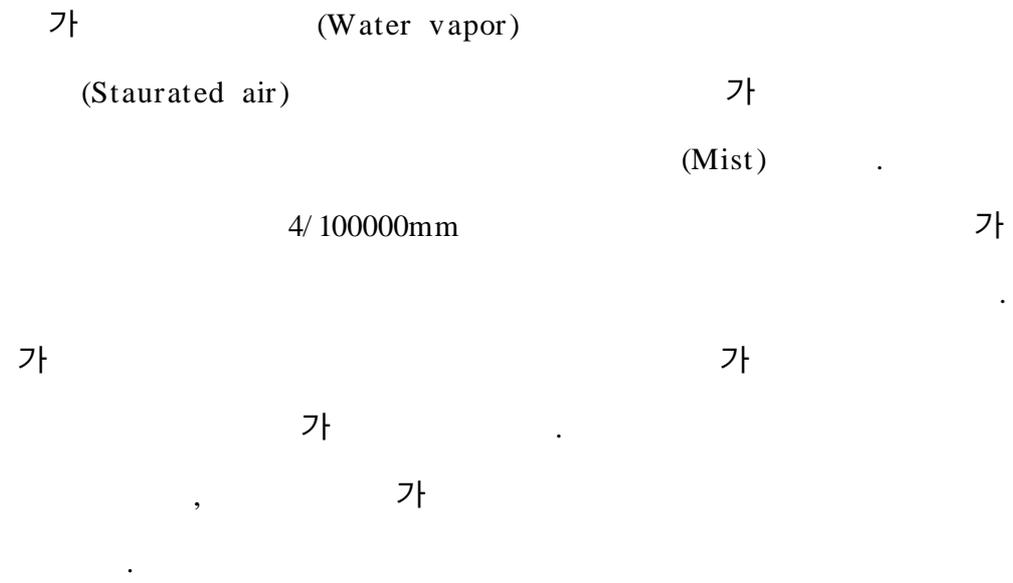


Fig. 2.1 가 가 가
0 4.8g/m³ 20
17.3g/m³ 가
가 가

가 . .

()	0	10	20	30
(g/m ³)	4.8	9.4	17.3	30.3

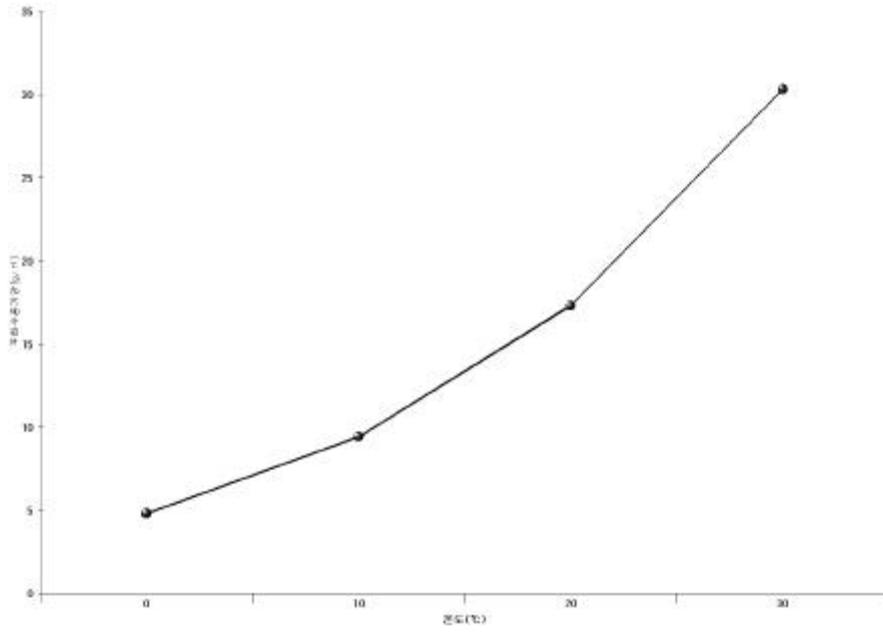


Fig. 2.1 Inclusion limit capacity of water vapor

2.3

(0)

()

$$Q_t = Q_s + Q_l$$

$$= \{h_h \cdot (T - T_i) + h_m \cdot (W - W_i) \cdot L_H\} \cdot A$$

$$Q_t : \quad [W]$$

$$Q_s : \quad [W]$$

$$Q_l : \quad [W]$$

$$h_h : \quad [W / m^2 \cdot]$$

$$h_m : \quad [kg / m^2 \cdot s]$$

$$L_H : \quad [J / kg]$$

$$T , T_i : \quad []$$

$W, W_i :$ $[kg / kg']$

$A :$ $[m^2]$

, 가 ,
.
가 ,

가 .

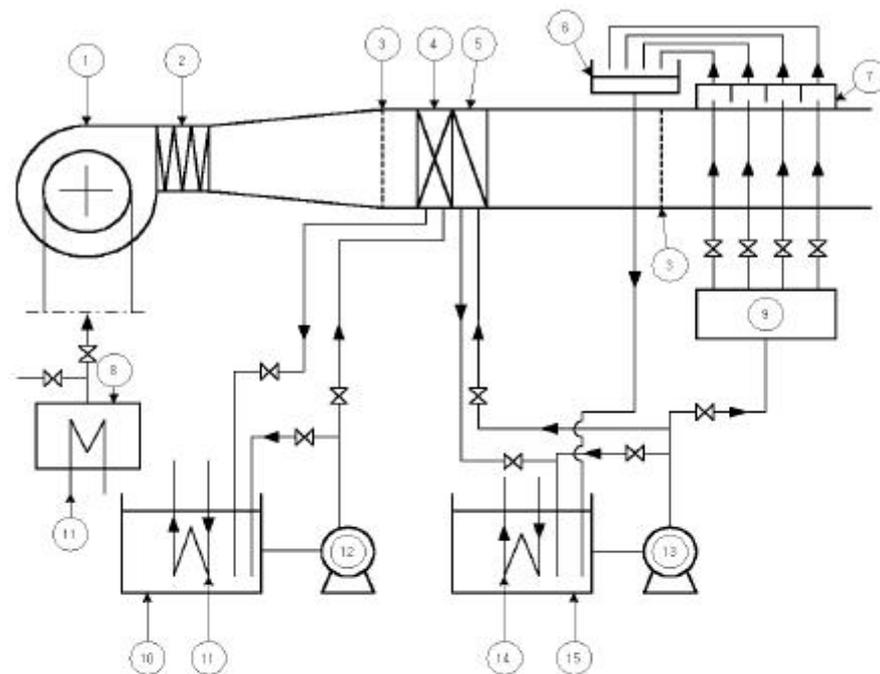
3

3.1

Fig. 3.1

가 , 가
(brine) , 가
1.5kw 3 1750rpm
가 470mm,
400mm, 9 4 - 가
kw 가 2
가
(test section) 가 430mm, 100mm, 70mm
3mm ,
가

. 50mm 8
 (C-A type) . Fig. 3.2 .
 가
 20mm 가
 가
 (K-type) 2
 (HMP - 234) , (pitot
 tube)
 Fig. 3.3 .



- | | |
|--------------------------------|--------------------------------|
| ① BLOWER | ② CANVAS |
| ③ SCREEN | ④ HEAT EXCHANGER(HEATING COIL) |
| ⑤ HEAT EXCHANGER(COOLING COIL) | ⑥ DISTRIBUTOR(RETURN) |
| ⑦ COOLING SECTION | ⑧ HUMIDIFIER |
| ⑨ DISTRIBUTOR(SUPPLY) | ⑩ WATER TANK |
| ⑪ HEATER | ⑫ WATER PUMP |
| ⑬ BRINE PUMP | ⑭ REFRIGERATOR |
| ⑮ BRINE TANK | |

Fig. 3.1 Schematic diagram of experimental apparatus

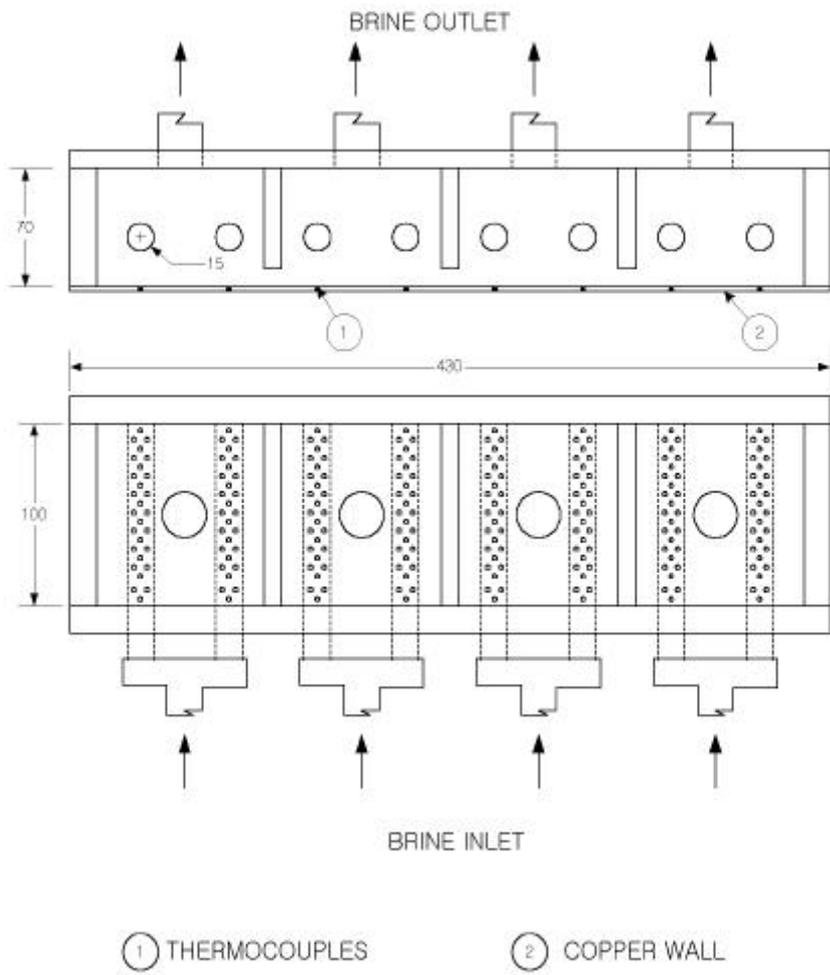


Fig. 3.2 Diagram of test section apparatus(Plate)



Fig. 3.3 Photo of experimental apparatus

3.2

가

가

가

3.5W

Digital Video Camera(DCR-VX1000)

(DT3155)

-

30 가

5

30

30

(pixel)

(pixel)

(Histogram)

(Histogram)

()가

가

2

CACTUS 2000 8 (256 Grey Level)

(Histogram)

가 0, 가 255 ,

가 가 .

(Mean value of density) 2.5 .

3.3

Fig. 3.4 3.5 =90%, $T = 25$, $T_w = -3$

가

가

. Fig. 3.6

가

가

가

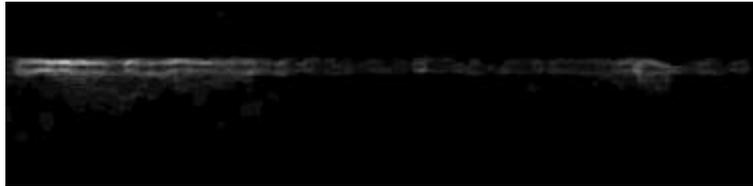
가

가

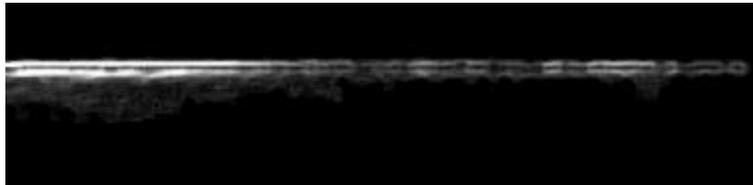
Fig. 3.7 3.8 90%, 20 , 25 30 ,

0 -3

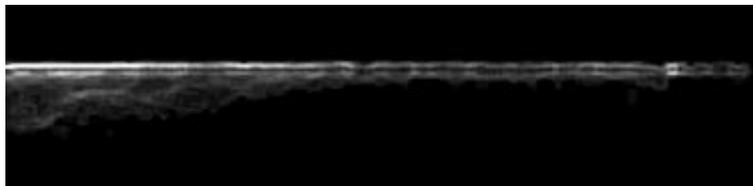
가



(a) $U = 0.3\text{m/s}$



(b) $U = 0.5\text{m/s}$



(c) $U = 0.7\text{m/s}$

Fig. 3.4 Effect on supply air velocity (Copper Plate)

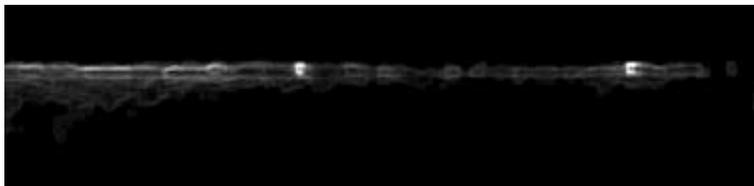
; $\phi = 90\%$, $T = 25$, $T_w = -3$



(a) $U = 0.3\text{m/s}$



(b) $U = 0.5\text{m/s}$



(c) $U = 0.7\text{m/s}$

Fig. 3.5 Effect on supply air velocity (Aluminum Plate)

; $\phi = 90\%$, $T = 25$, $T_w = -3$

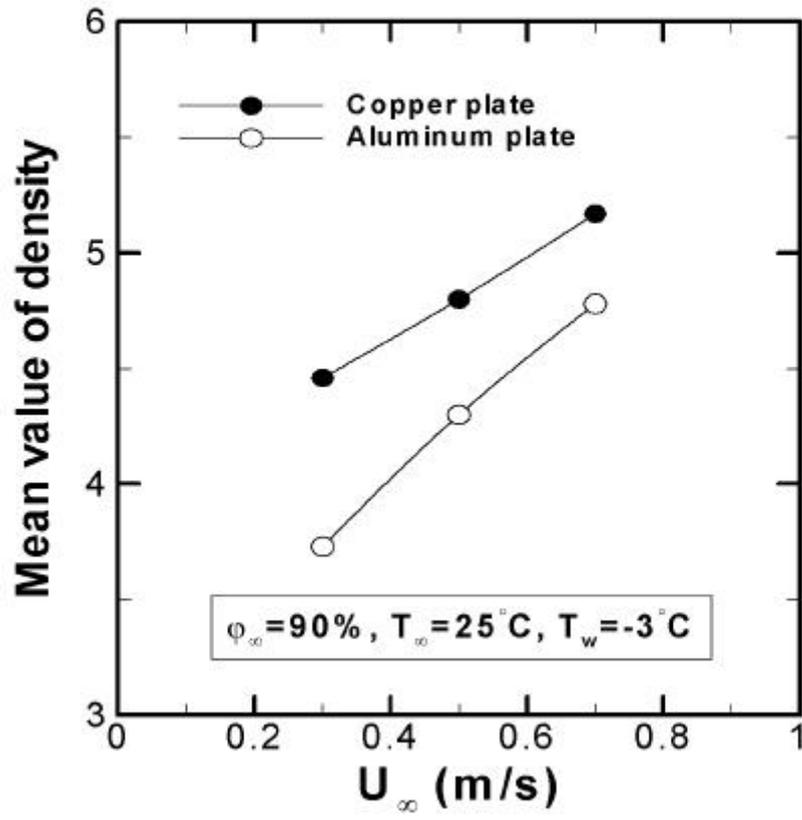


Fig. 3.6 Effect of supply air velocity on mean value of density at steady condition

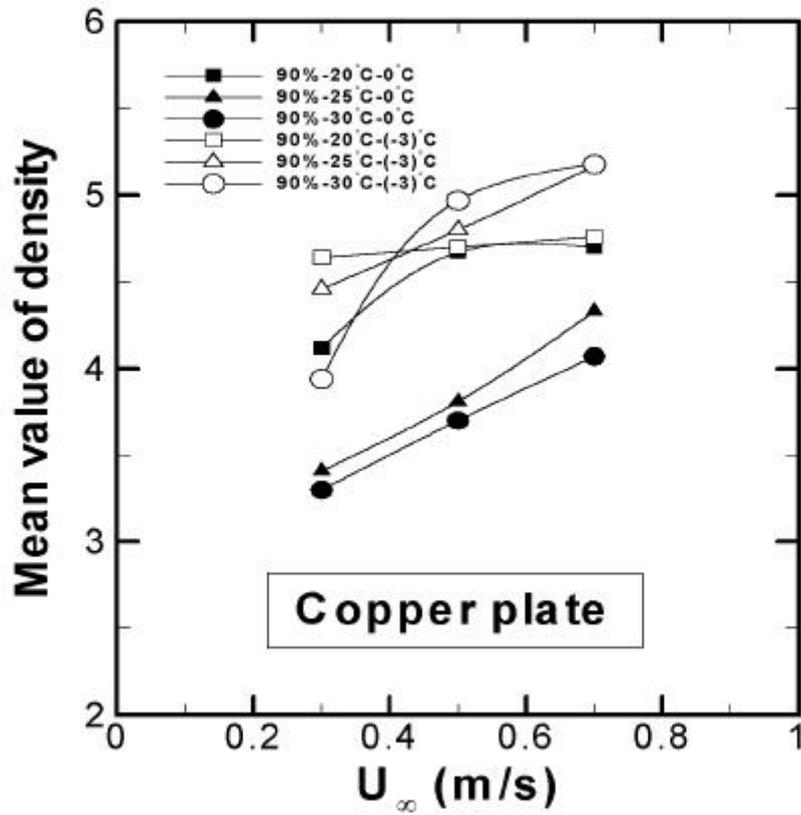


Fig. 3.7 Effect of supply air velocity on mean value of density at steady condition

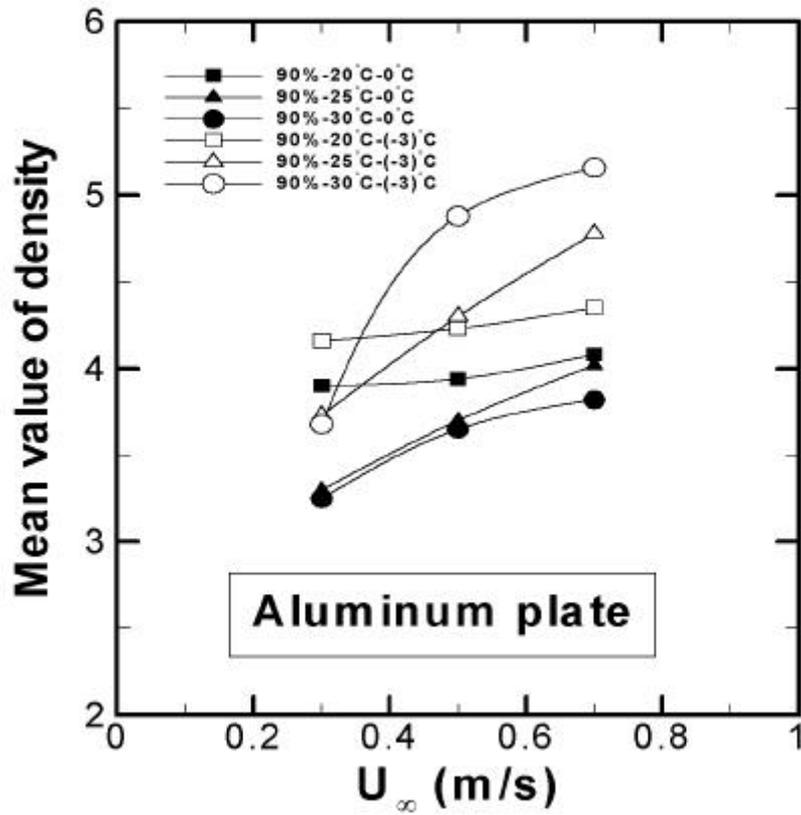


Fig. 3.8 Effect of supply air velocity on mean value of density at steady condition

3.4

Fig. 3.9 3.10 $\alpha=90^\circ$, $U = 0.5\text{m/s}$, $T_w = 0$

가

. Fig. 3.11

가 0

가 가

가

가

가

가

가

가

Fig. 3.12 3.13 $\alpha=90^\circ$, $U = 0.3\text{m/s}$, 0.5m/s , 0.7m/s , $T_w = 0$, -3

가 0

가

가

가 -3

가 가

0.3m/s

가

가 가

가

가

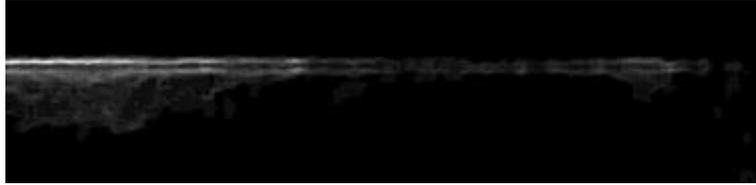
, 가

가

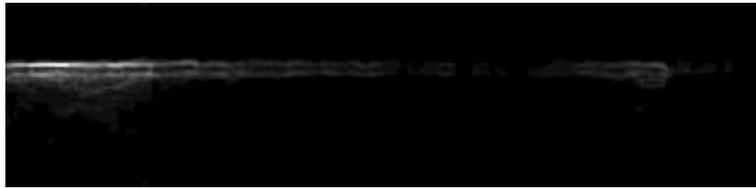
가

0.3m/s

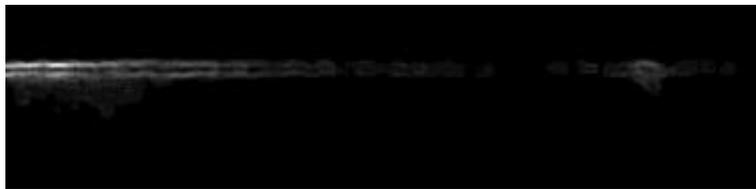
가



(a) $T = 20$



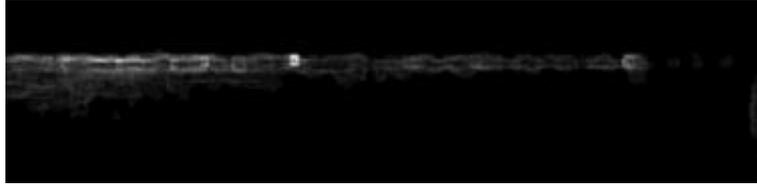
(b) $T = 25$



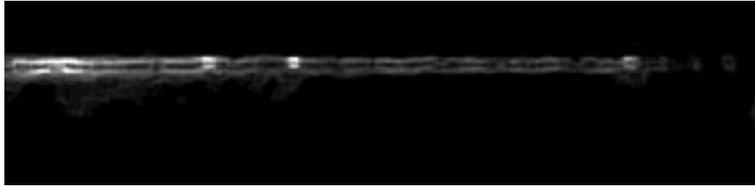
(c) $T = 30$

Fig. 3.9 Effect on supply air temperature (Copper Plate)

; $\phi = 90\%$, $U = 0.5\text{m/s}$, $T_w = 0$



(a) $T = 20$



(b) $T = 25$



(c) $T = 30$

Fig. 3.10 Effect on supply air temperature (Aluminum Plate)

; $\phi = 90\%$, $U = 0.5\text{m/s}$, $T_w = 0$

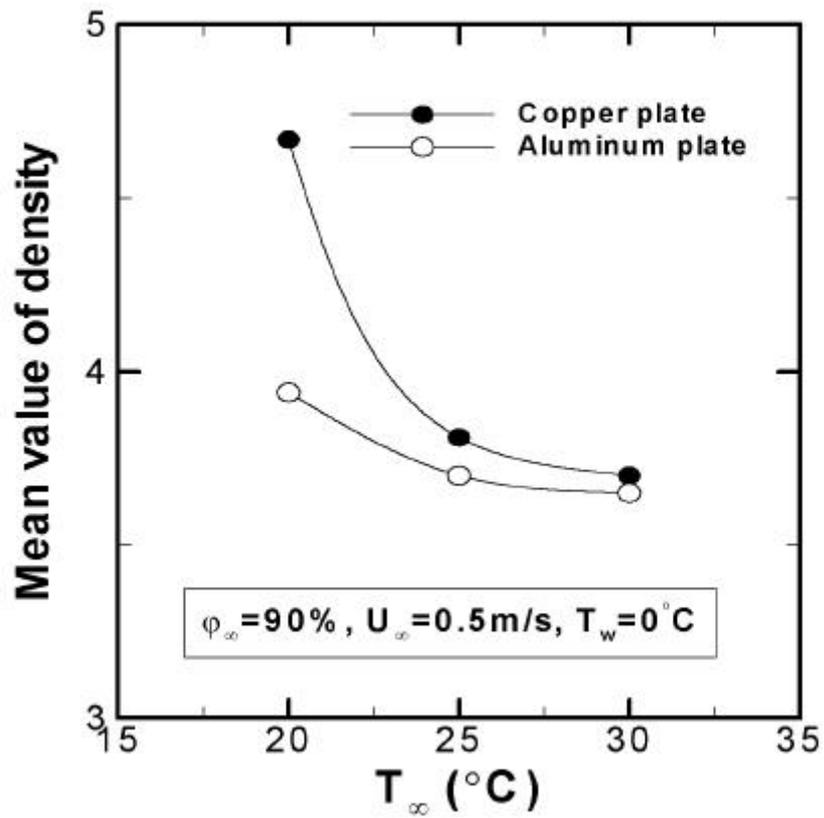


Fig. 3.11 Effect of supply air temperature on mean value of density at steady condition

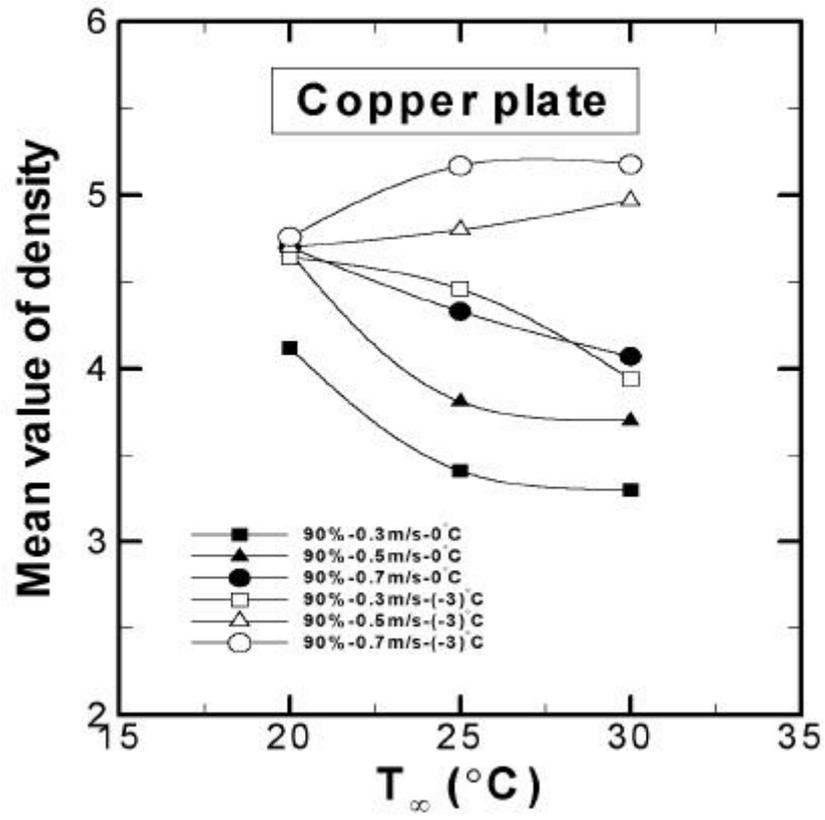


Fig. 3.12 Effect of supply air temperature on mean value of density at steady condition

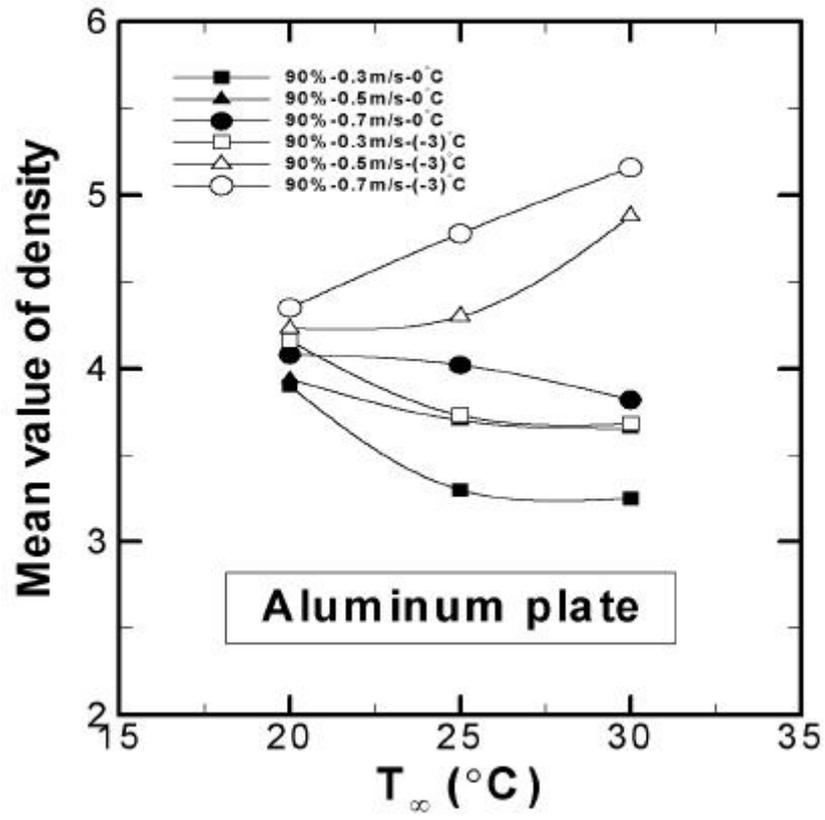


Fig. 3.13 Effect of supply air temperature on mean value of density at steady condition

3.5

Fig. 3.14 3.15 $\theta = 90^\circ$, $U = 0.5\text{m/s}$, $T = 25$

가

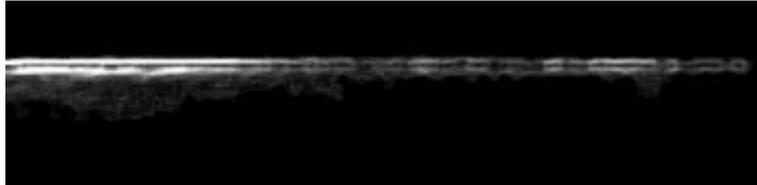
. Fig. 3.16

가 가 ,
가 가 가
가

Fig. 3.17 3.19 $\theta = 90^\circ$, $U = 0.3\text{m/s}$, 0.5m/s
 0.7m/s , 20° , 25° , 30°

Fig. 3.20 3.22

가 가 ,



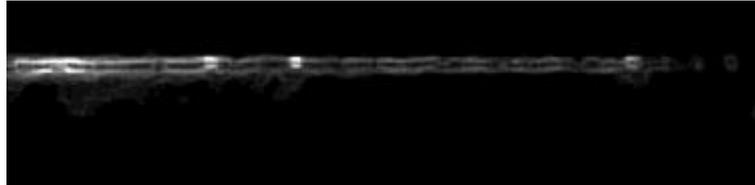
(a) $T_w = -3$



(b) $T_w = 0$

Fig. 3.14 Effect on cooled plate temperature (Copper Plate)

; $\phi = 90\%$, $U = 0.5\text{m/s}$, $T = 25$



(a) $T_w = -3$



(b) $T_w = 0$

Fig. 3.15 Effect on cooled plate temperature (Aluminum Plate)

; $\phi = 90\%$, $U = 0.5\text{m/s}$, $T = 25$

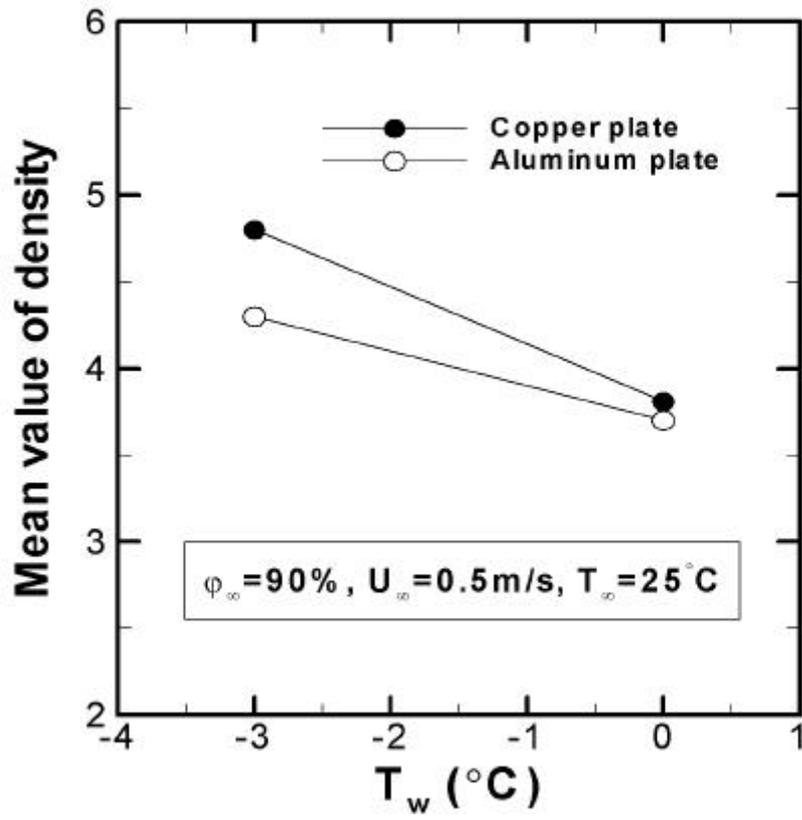


Fig. 3.16 Effect of cooled plates temperature on mean value of density at steady condition

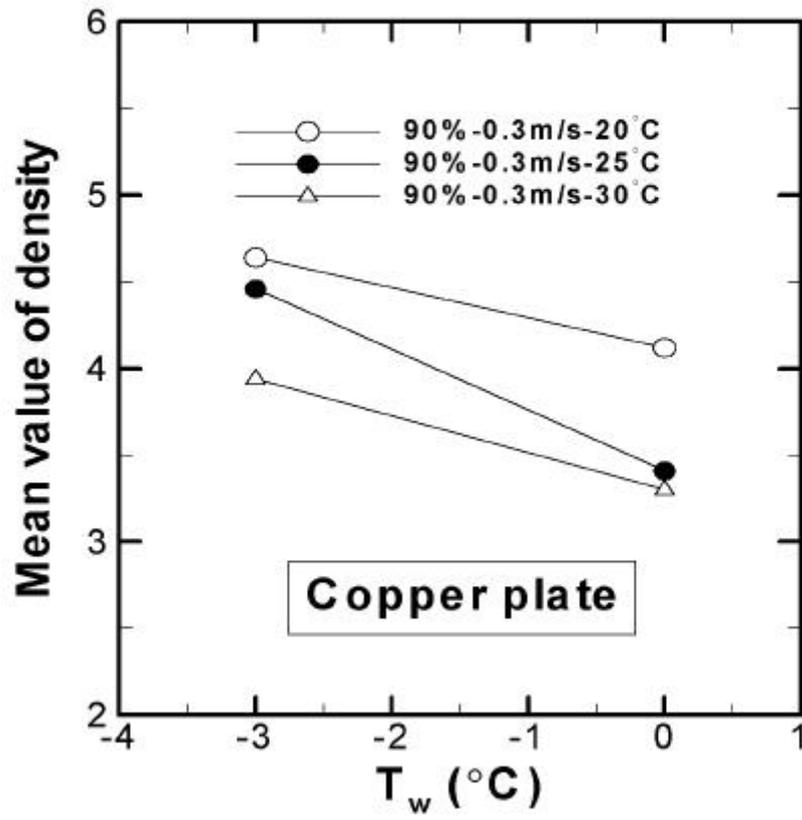


Fig. 3.17 Effect of cooled plates temperature on mean value of density at steady condition

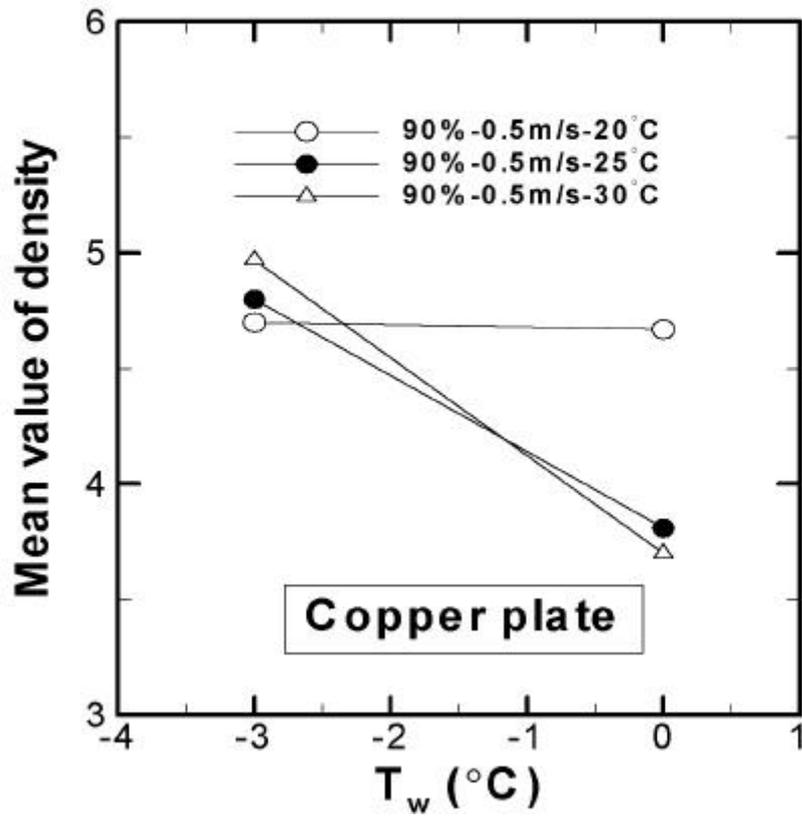


Fig. 3.18 Effect of cooled plates temperature on mean value of density at steady condition

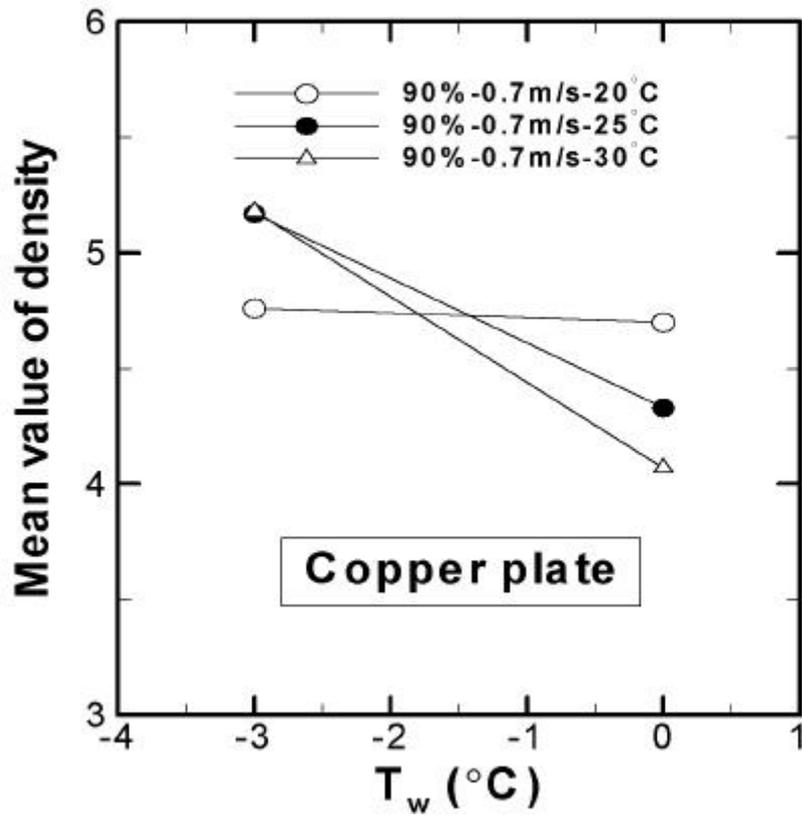


Fig. 3.19 Effect of cooled plates temperature on mean value of density at steady condition

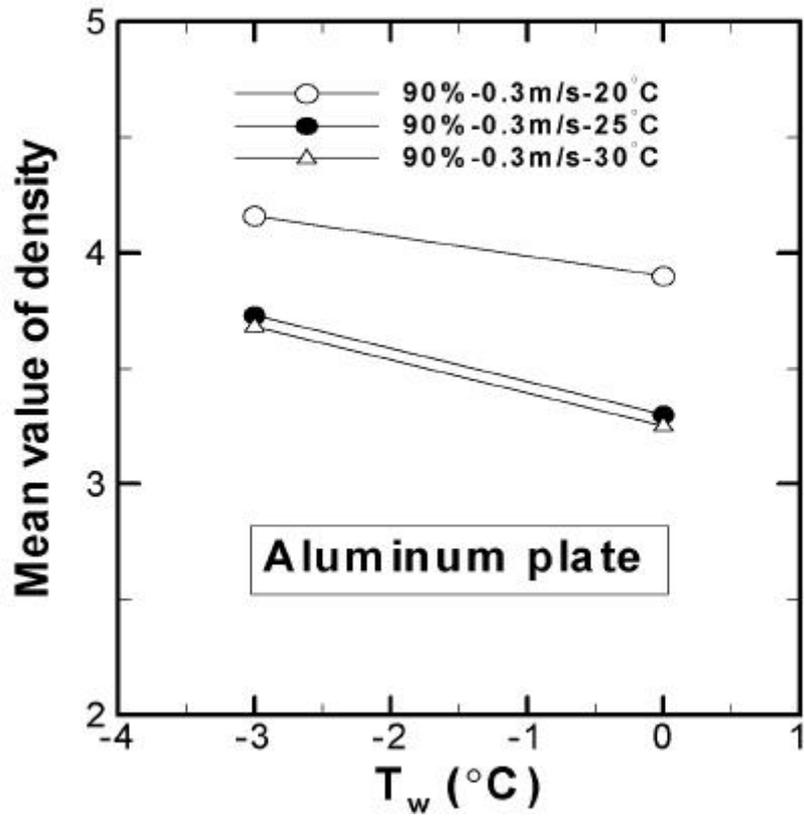


Fig. 3.20 Effect of cooled plates temperature on mean value of density at steady condition

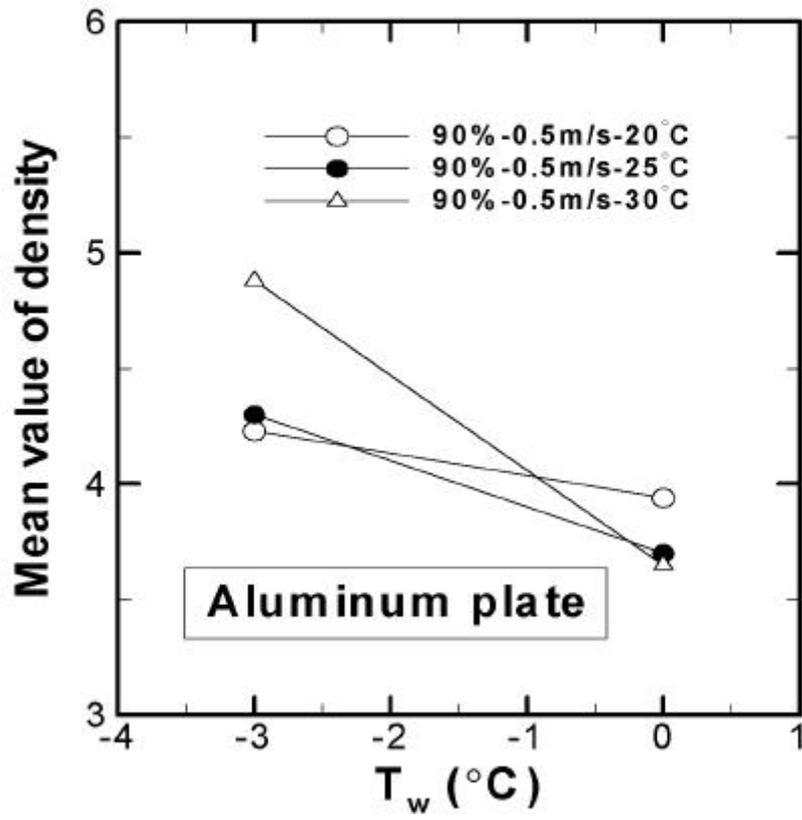


Fig. 3.21 Effect of cooled plates temperature on mean value of density at steady condition

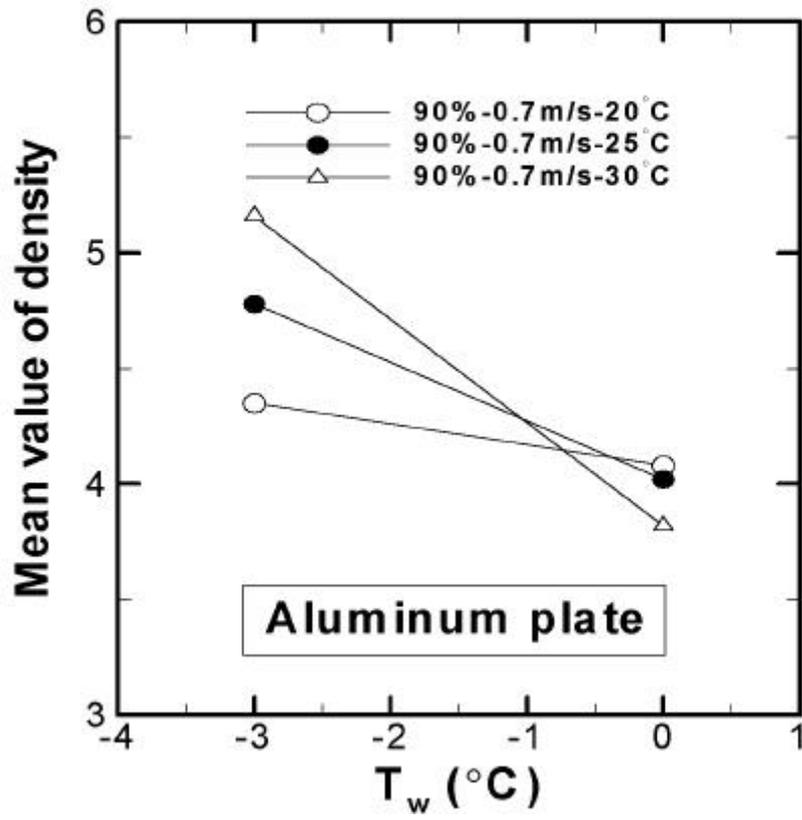


Fig. 3.22 Effect of cooled plates temperature on mean value of density at steady condition

3.6

Fig. 3.23 3.24

$U = 0.5\text{m/s}$, $T = 25$, $T_w = -3$

가

. Fig. 3.25

가

가

가

Fig 3.26 3.27

0.3m/s , 0.5m/s 0.7m/s ,

25 ,

0

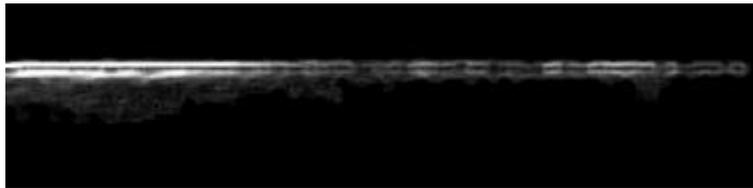
-3

가 가

가



(a) = 80%



(b) = 90%

Fig. 3.23 Effect on relative humidity (Copper Plate)

; $U = 0.5\text{m/s}$, $T = 25$, $T_w = -3$



(a) = 80%



(b) = 90%

Fig. 3.24 Effect on relative humidity (Aluminum Plate)

; $U = 0.5\text{m/s}$, $T = 25$, $T_w = -3$

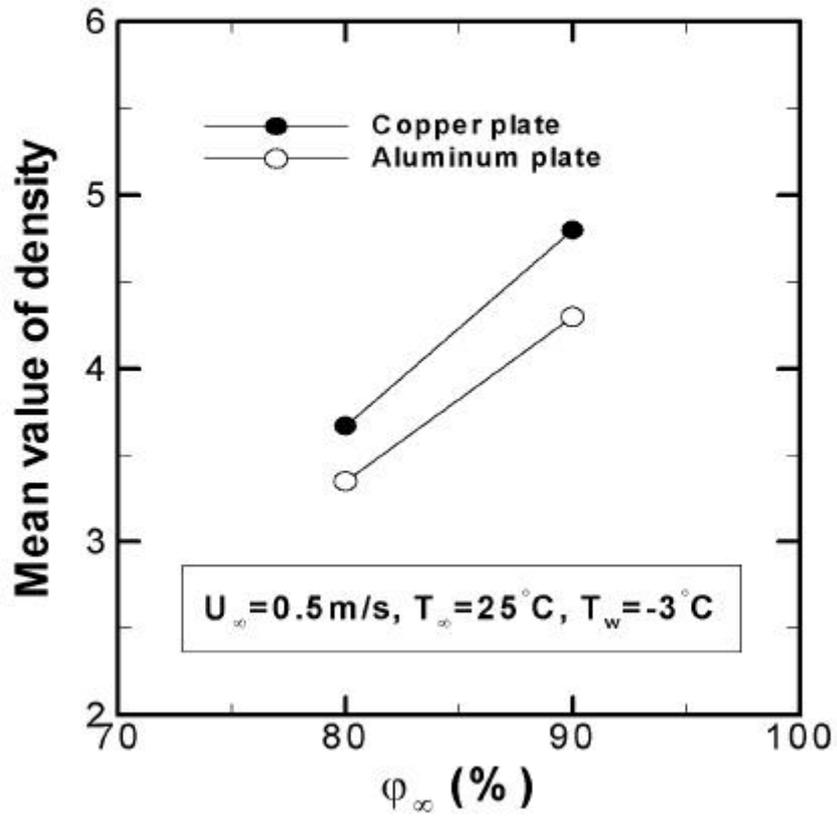


Fig. 3.25 Effect of relative humidity on mean value of density at steady condition

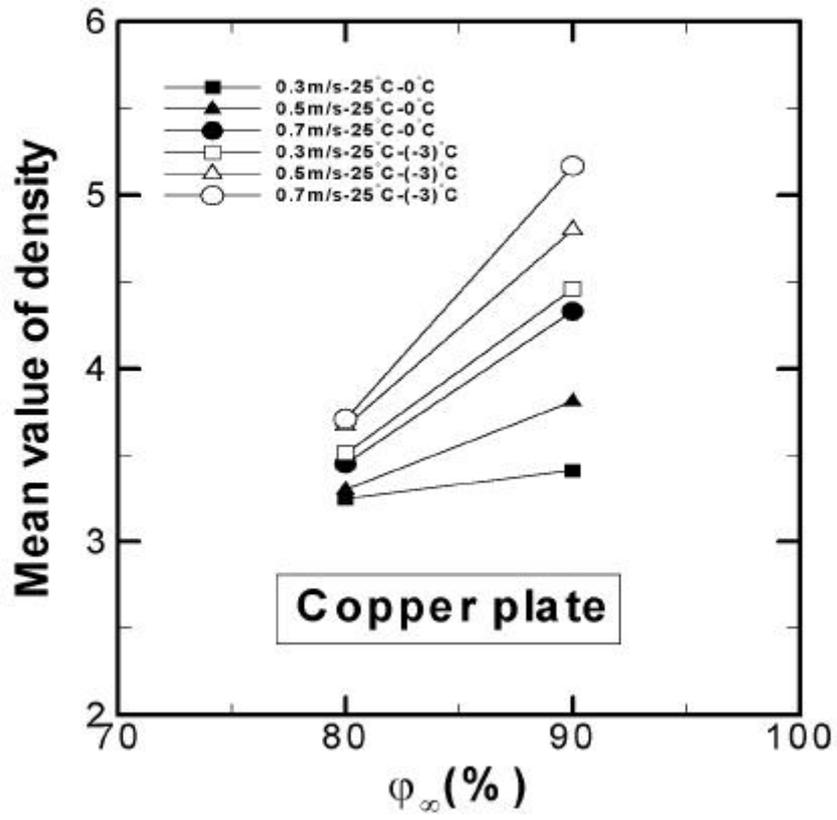


Fig. 3.26 Effect of relative humidity on mean value of density at steady condition

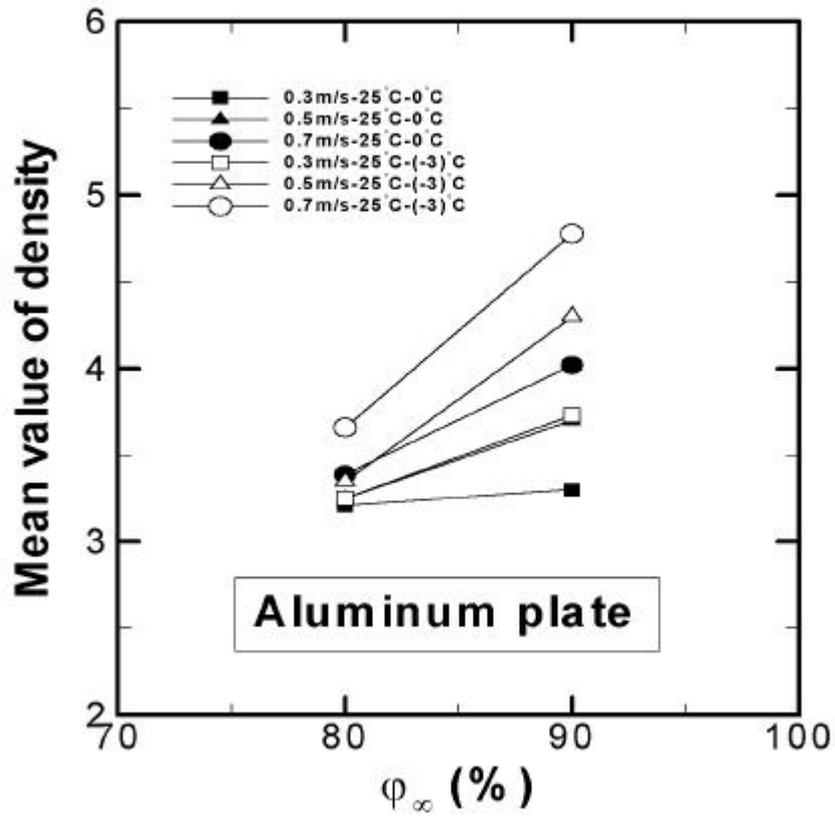


Fig. 3.27 Effect of relative humidity on mean value of density at steady condition

3.7

- 가
- (1) 가
- (2) 가
- (3) 가
- 가
- 가
- (4) 가
- (5) 가

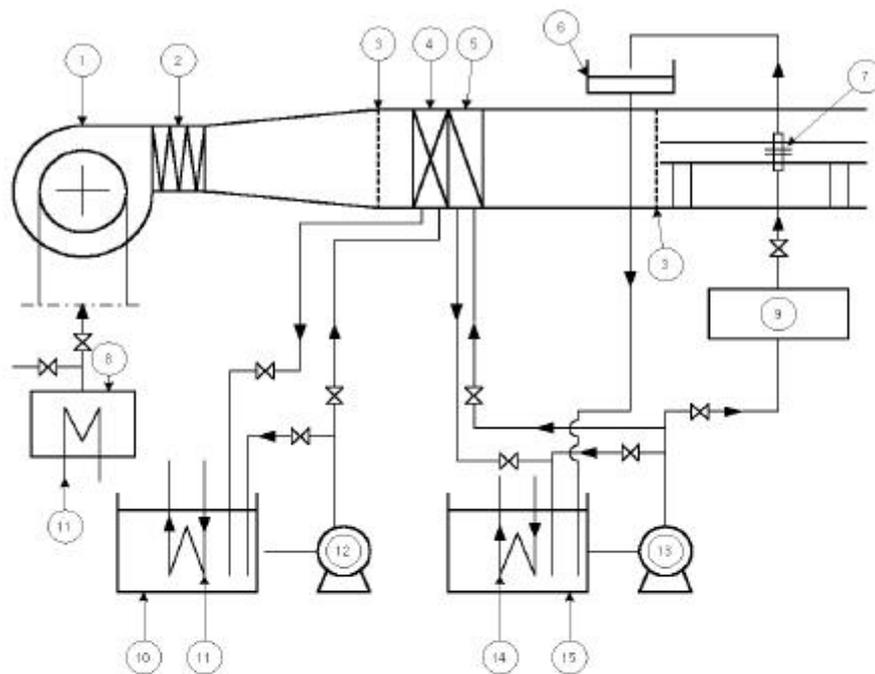
4 -

4.1

Fig. 4.1 -

3

(test section) \varnothing 16mm, 115mm 가 60mm,
30mm, 5mm 10mm
, Fig. 4.2
Fig. 4.3



- | | |
|--------------------------------|--------------------------------|
| ① BLOWER | ② CANVAS |
| ③ SCREEN | ④ HEAT EXCHANGER(HEATING COIL) |
| ⑤ HEAT EXCHANGER(COOLING COIL) | ⑥ DISTRIBUTOR(RETURN) |
| ⑦ TEST SECTION(Fin-Tube) | ⑧ HUMIDIFIER |
| ⑨ DISTRIBUTOR(SUPPLY) | ⑩ WATER TANK |
| ⑪ HEATER | ⑫ WATER PUMP |
| ⑬ BRINE PUMP | ⑭ REFRIGERATOR |
| ⑮ BRINE TANK | |

Fig. 4.1 Schematic diagram of experimental apparatus

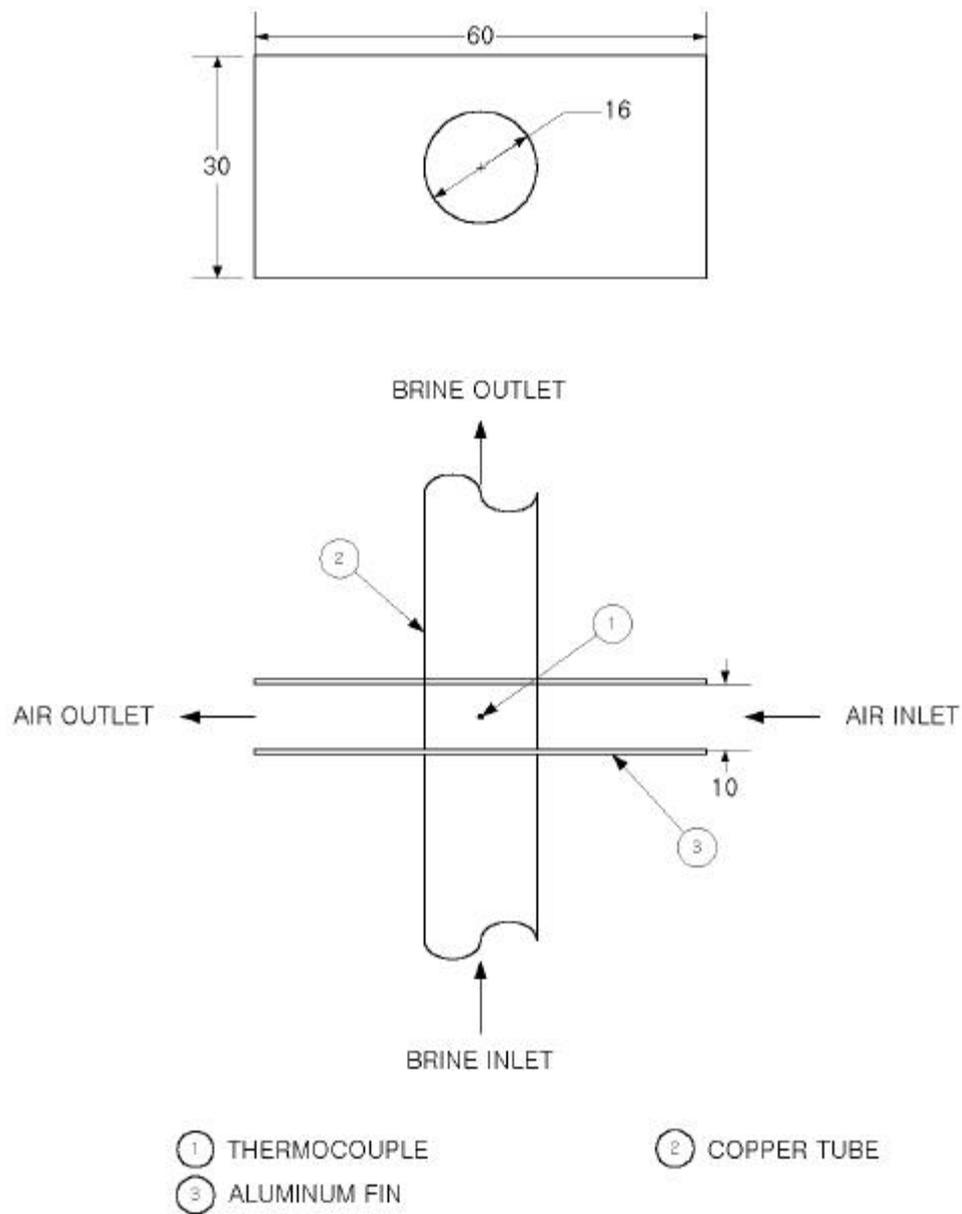


Fig. 4.2 Diagram of test section apparatus(Fin-tube)

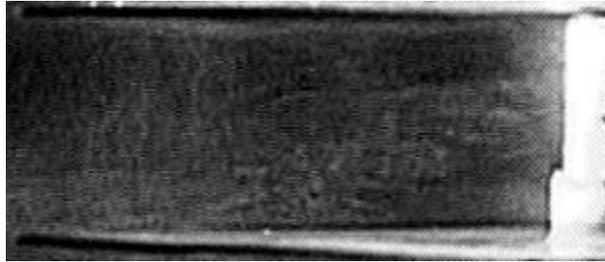


Fig. 4.3 Photo of experimental apparatus

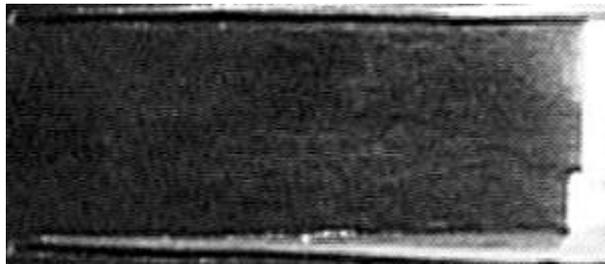
4.2

Fig 4.4 $\epsilon=80\%$, $T = 30$, $T_w = -3$

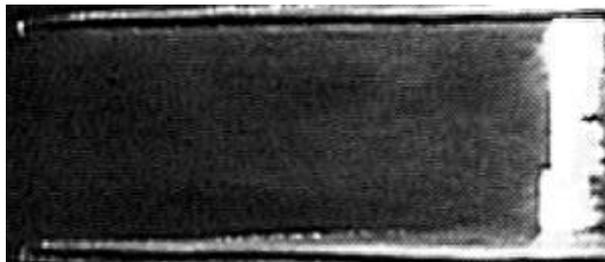
가 .
 , 가 ,
 , 가 . Fig. 4.5
 . 가
 , 가
 가 가 (BF)
 가 .



(a) $U = 0.3\text{m/s}$



(b) $U = 0.5\text{m/s}$



(c) $U = 0.7\text{m/s}$

Fig. 4.4 Effect on supply air velocity (Fin-tube)

; $\phi = 80\%$, $T = 30$, $T_w = -3$

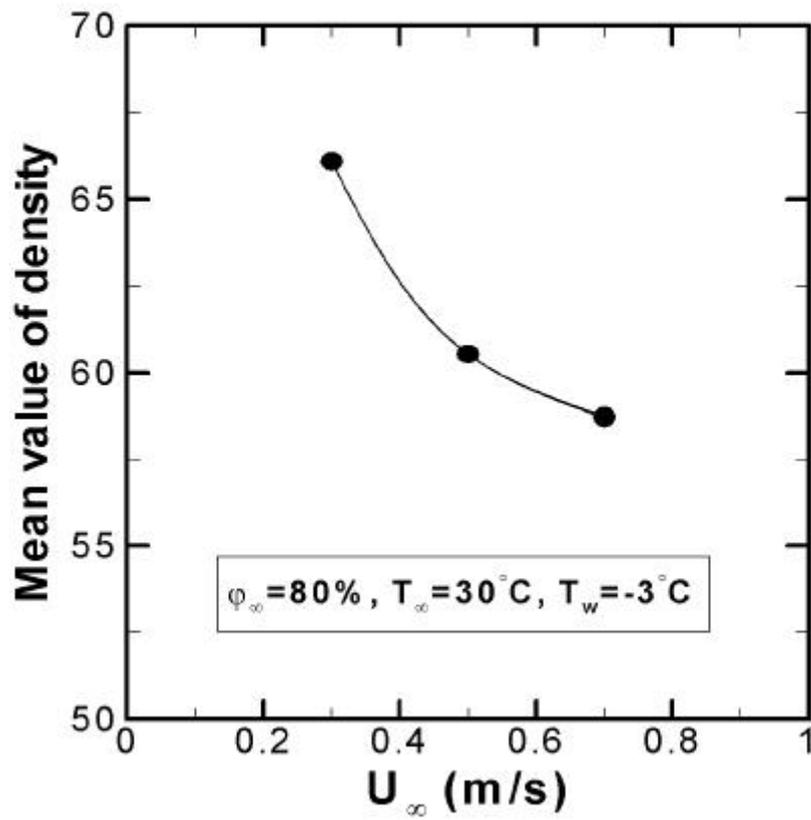


Fig. 4.5 Effect of supply air velocity on mean value of density at steady condition

4.3

Fig. 4.6 $\phi = 80\%$, $U = 0.3\text{m/s}$, $T_w = -3$

가

. Fig. 4.7

가 가

가

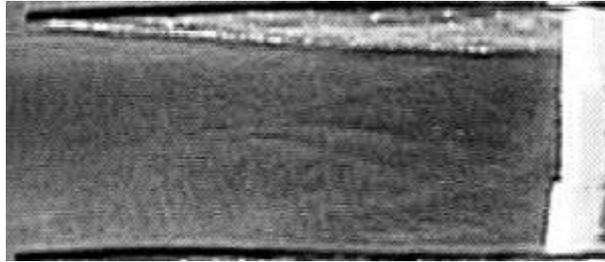
가

가

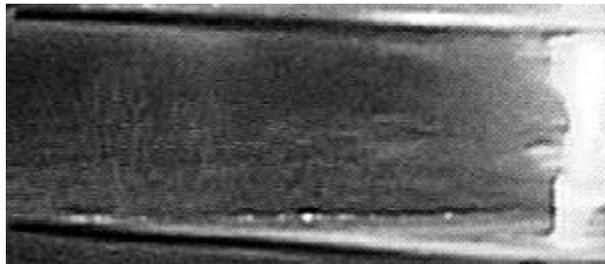
가

가

가



(a) $T = 20$



(b) $T = 25$



(c) $T = 30$

Fig. 4.6 Effect on supply air temperature(Fin-tube)

; $\phi = 80\%$, $U = 0.3\text{m/s}$, $T_w = -3$

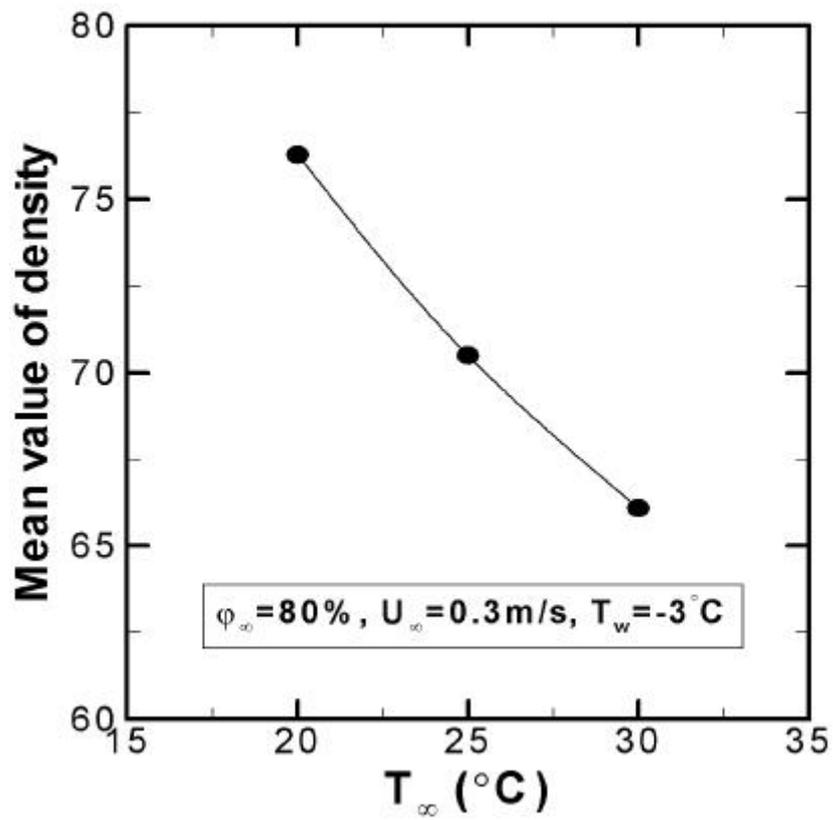


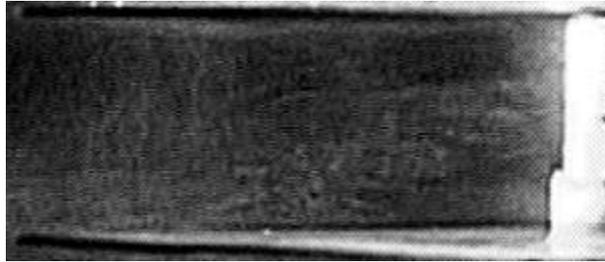
Fig. 4.7 Effect of supply air temperature on mean value of density at steady condition

4.4

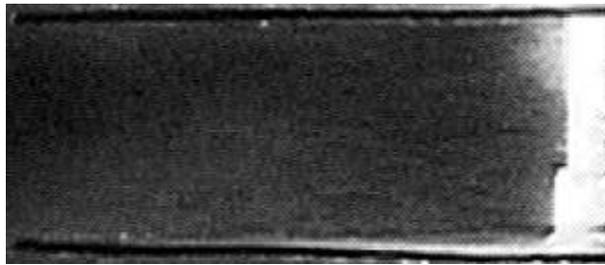
Fig. 4.8 $\epsilon=80\%$, $U = 0.3\text{m/s}$, $T = 30$

가 . Fig. 4.9

가 , 가 가
가 .



(a) $T_w = -3$



(b) $T_w = 0$



(c) $T_w = 3$

Fig. 4.8 Effect on cooled tubes temperature(Fin-tube)

; $\epsilon = 80\%$, $U = 0.3\text{m/s}$, $T = 30$

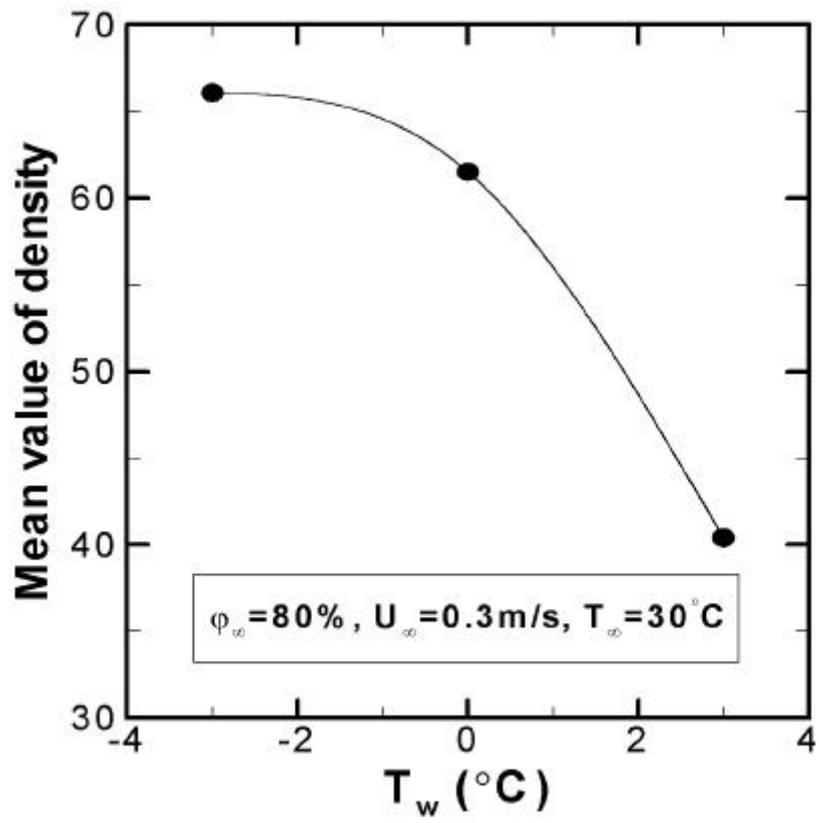


Fig. 4.9 Effect of cooled tubes temperature on mean value of density at steady condition

4.5

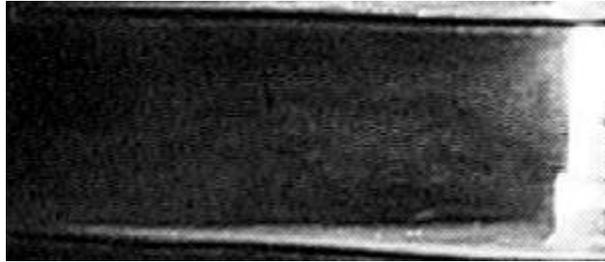
Fig 4.10 $U = 0.3\text{m/s}$, $T = 30$, $T_w = -3$

가

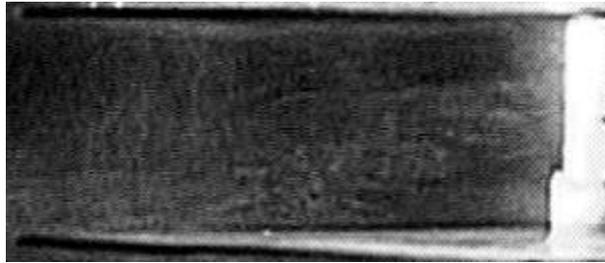
. Fig. 4.11

가

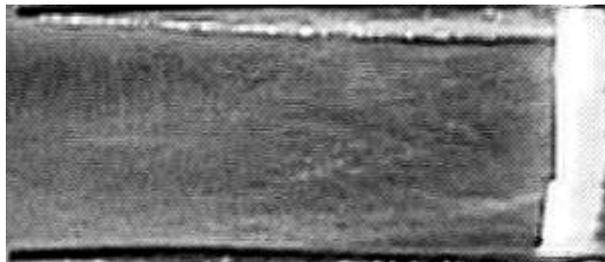
가



(a) = 70%



(b) = 80%



(c) = 90%

Fig. 4.10 Effect on relative humidity (Fin-tube)

; $U = 0.3\text{m/s}$, $T = 30$, $T_w = -3$

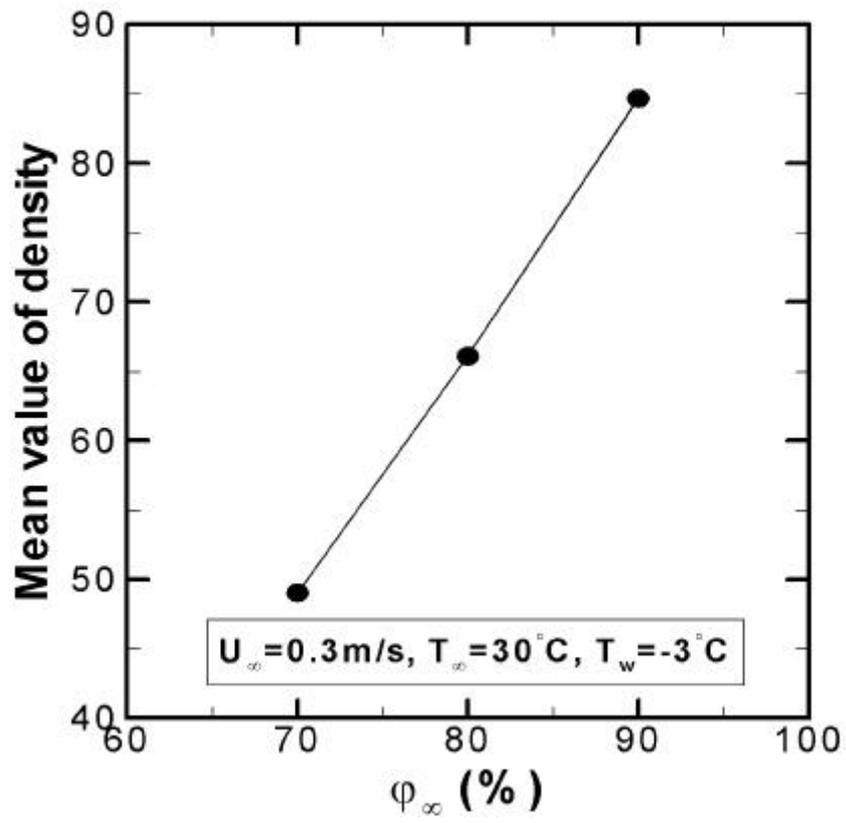


Fig. 4.11 Effect of relative humidity on mean value of density at steady condition

4.6

가

(1)

(2)

(3)

(4)

가

가

가

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, , ,
가

- (1) .
- (2) , -
- (3) 가
- 가 ,
- 가 가 .
- (4) 가 .
- (5) 가 .

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