

1

•

**The study on heat exchanger with in-outlet
fan for livestock building**

“

”

1997 4

:

:

:

:

1

•
 •
 가
 . 가
 . 畜舎 가
 密閉飼育 , 가
 . 4 가
 , 가
 가
 , 流入
 가 外部 가
 .
 가 , 가
 成長率, 産卵率 疾病減少 가
 (生産費)

•
 (out) 畜舎 内(IN)
 (가) (廢
 熱)
 (In)
 “廢熱回收”가 가
 . .
 가 2 가
 , .
 , 가(가 가)
 가 , 가
 , ,
 , ()
 .
 , ,
 , 가
 가 가 가
 가 . .
 가

•
○

< 가 >, <
>, < >

, 가

養豚農家

溫度差異 地域別, 豚舍構造上

17 , 12 , 10
(/) 1,250 , 850 , 833
가

豚舍 内部 有害가

(NH3) 10- 13PPM

, 가 (CO2)

가 가 ,

가 가

養鷄農家 鷄舍形態

가 ,

가 2

18%, 2- 4 35%, 5

가 35%

가

가 5ppm

가가 18%,

5- 20ppm 42%, 20ppm 36%

熱交換裝置 가 , 가

(A1) 0.15t 500mm .

熱交換板 () 9mm, () 12mm, 500mm

9mm , S Flat Top ,

. (< 2>, <

3>)

(FAN) 2 ,

, 가 1,020mm, 930mm, 520mm, 70kg .(<

4>, < 5>)

가

가 , 1 2 (1)

< >

78% . 가

(3)가 10 ,

(16) 10

()
1.46 1.40 .
가 .
가
, 가 2
가
가
.
()
) , 78%
.
○
가
, 가 ,
가 가 .
○
가
, 가
.
가가 ,
가

가

○

가 가

.가

()

가

SUMMARY

1. Subject:

The study on heat exchanger with in-outlet fan for livestock building

2. Object of development

o The temperature and ventilation are important factor to animal breeding farm, because the productivity of breeding is influenced by these factors. Especially in massed animal breeding house these factors are serious. In this point of view, present management of environment of animal house should be improved.

o The object of this development is heat exchanger for animal house to save energy, good ventilation, providing favourable environmental animal house.

o The development and application of heat exchanger will reduce various kinds of animal diseases, and contribute to productivity which results manufacturing cost of animal products.

3. The details of development

o The main object is development of heat exchanger for animal house, that have studied many kinds of animal house and finally decided the type of heat exchanger which withstand against dust, providing high efficiency and low manufacturing cost.

After development of prototype, it applied to animal farm to test efficiency and effect of breeding.

4. The result of development.

o Investigated temperature difference between inside and our side of pig house and cost of heating per one swine which are as follows.

- Average temperature difference between inside and out side of pig house : Kyung-gi area(17), Jeon-nam area(12), Kyung-nam area(10)

- Heat cost per one swine : Kyung-gi area(1,250 Won), Jeon-nam area(850Won), Kyung-nam area(833Won)

- Measured ammonia gas(NH₃) inside of pig house ranged between 10-13PPM, but carbonic acid gas was neglectable.

- Investigated temperature difference between inside and outside of chicken house was: 2 difference 18%, 2-4 difference 35%, Over 5 was 35% which shows small temperature difference of chicken house is more important than pig house. On the contrary, ventilation of chicken house was worse than pig house. consistency of ammonia gas was: below 5ppm 18%, 5-20ppm 42%, over 20ppm 36%.

o As a material of heat plate, used rolled aluminum thickness of 0.15MM and span of 500MM. Rolled aluminum was pressed by wide upper and lower two gears with 9mm heights and 12mm pitch with flat for better heat transfer(ref. Fig 2, Fig 3).

Stacked heat plate and dimension of heat package was 1,020mm(W), 930mm(D), 520mm(H). Mounted two propeller fan at both side of heat package together with dust filter. total weight is 70Kg(ref. Fig4, Fig5)

o Field tested in pig house for one month. The efficiency of prototype heat exchanger unit 78%. Compared feed efficiency of two pig house where one installed heat exchanger, the other without heat exchanger.

Feed efficiency of two house was 1.46 and 1.40 that is almost same. It means that temperature difference between was so small, because there was indirect heating in the house without heat exchanger.

o There is wide range of application with this heat exchanger. Livestock house, green house and other agricultural and industrial purposes.

o To save energy and provide better breeding environment of animal house, this heat exchanger should be supplied more widely to livestock industries. It needs to support a manufacturer by government who can produce this type of heat exchanger.

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for livestock house

- 2) The choice of type of heat exchanger

- 3) The choice of heat exchanger material
- 4) The design of wave of heat exchanger plate
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3	18	
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1	. 24	
1.	24
2.	31	
2	가	35
1.	가	35
2.	가	37
3		41

	1		41
	2		42
1.			42
2.		43	
	3		44
1.			44
2.		45	
3.		45	
4.		(pitch)	47
5.		(Flat Top)	47
6.			47
7.		49	
8.		54	
	4		57
	1		57
	2		59
	3		63

5 **66**

6 **69**

1

1

가 '95 4,684
2% . 55.0KW,
10.0L가 . ('95)
가
가
가 ,
가
가
가 ,
가 , 가
가 , 가
가 , 가,
가 ,
가 . ,
가 ,

가

가 , 가
가 , 가
가 , 가

가

2

가(가) ,
가 「 가
가
가 '96
1 29 3 7 (2 10) , (, ,
) , () , () , () ,
() 가 32 (< 1>).
가

96 12 11 12 27 (15) (, ,
 ,), () 34 가
 . < (16), (2),
 (4), (6)> , < (6)> .

가 가 가

() 熱效率 小型 輕量化 ,
 가 가 .

가
 1997. 1. 6 2 5 (1
) .

가 ,

豚舎内

()
 (, 32 = 4 x 8 /)
 (, 32 = 4 x 8 /) .

○ , ○
, ○ : ,
(< 2 >) .

가 .
가 ,
가 .
()
가 가 . .

3

가 (= ,)
. (= ,)
. .
< 1 ,
, 1995 10 > , < ,
, 1995 12 > , () ()
< 3 , , 1995 12 > , -
< 4 , , 1991,12 > .
가 가 (,)
. , () .
2가 가

,
가 .

가

62- 42294 .(<

1>)

가

가 가

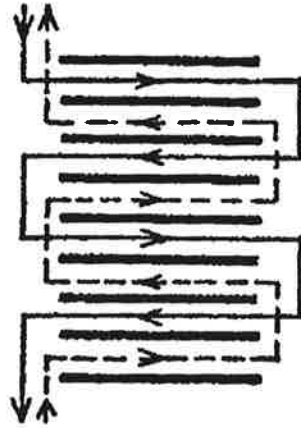
(81- 617) .(< 2>)
가 가 가 , 가가

(重)

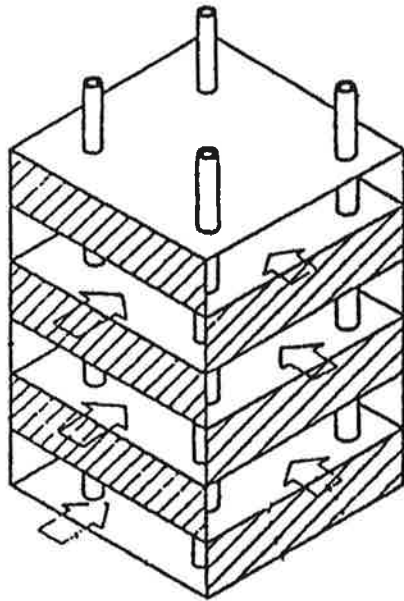
가

가

가 가 . (< 3>)

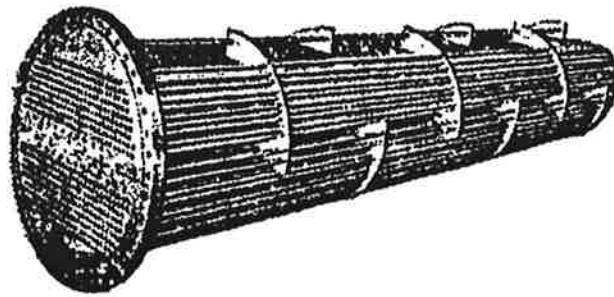


〈플레이트 열교환기 원리〉

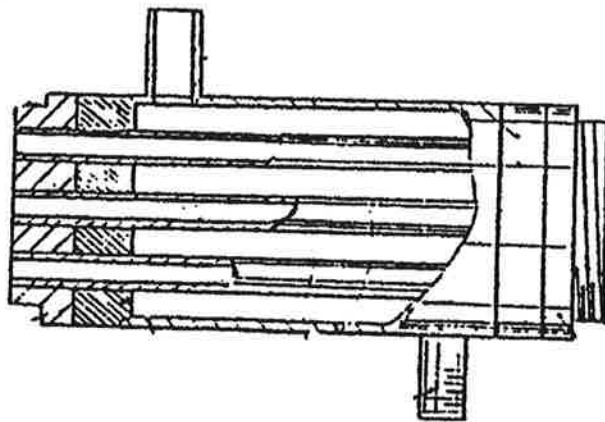


〈개발품:일본실용신안공보소 62-42294〉

〈그림1〉 플레이트식 열교환기 원리와 개발품

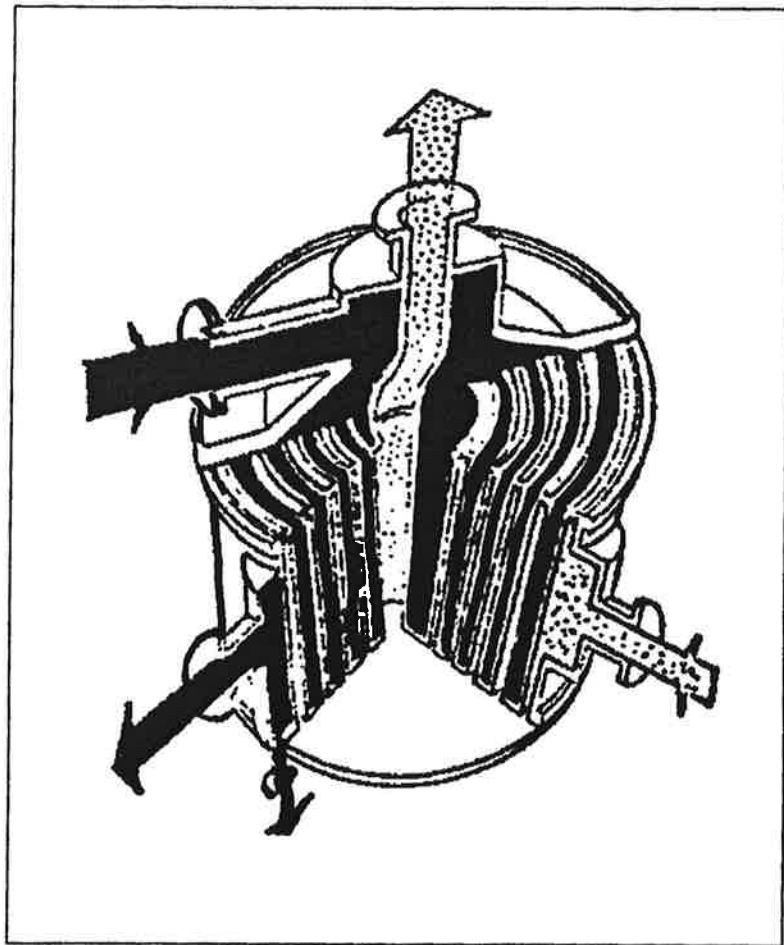


〈다관원통식 열교환기 원리〉



〈개발품:한국특허 공보(공고 81-617)〉

〈그림2〉 다관원통식 열교환기 원리와 개발품



〈그림3〉 와류판식 열교환기 원리

가

, 가 2가 ()

가

가 ,

30Kg 92Kg

(1 19m³/h)

(1 52m³/h)

2.70 2.74,

55.5% 32.4%,

34.8%

35.4%

2 가

1 .

1. 豚舍 適正溫度 換氣

1) 豚舍 適正溫度

, (Heat), (CO₂), (H₂O)

()

(Sensible heat)

(Latent heat)

가

< 4>

(The thermoneutral zone)

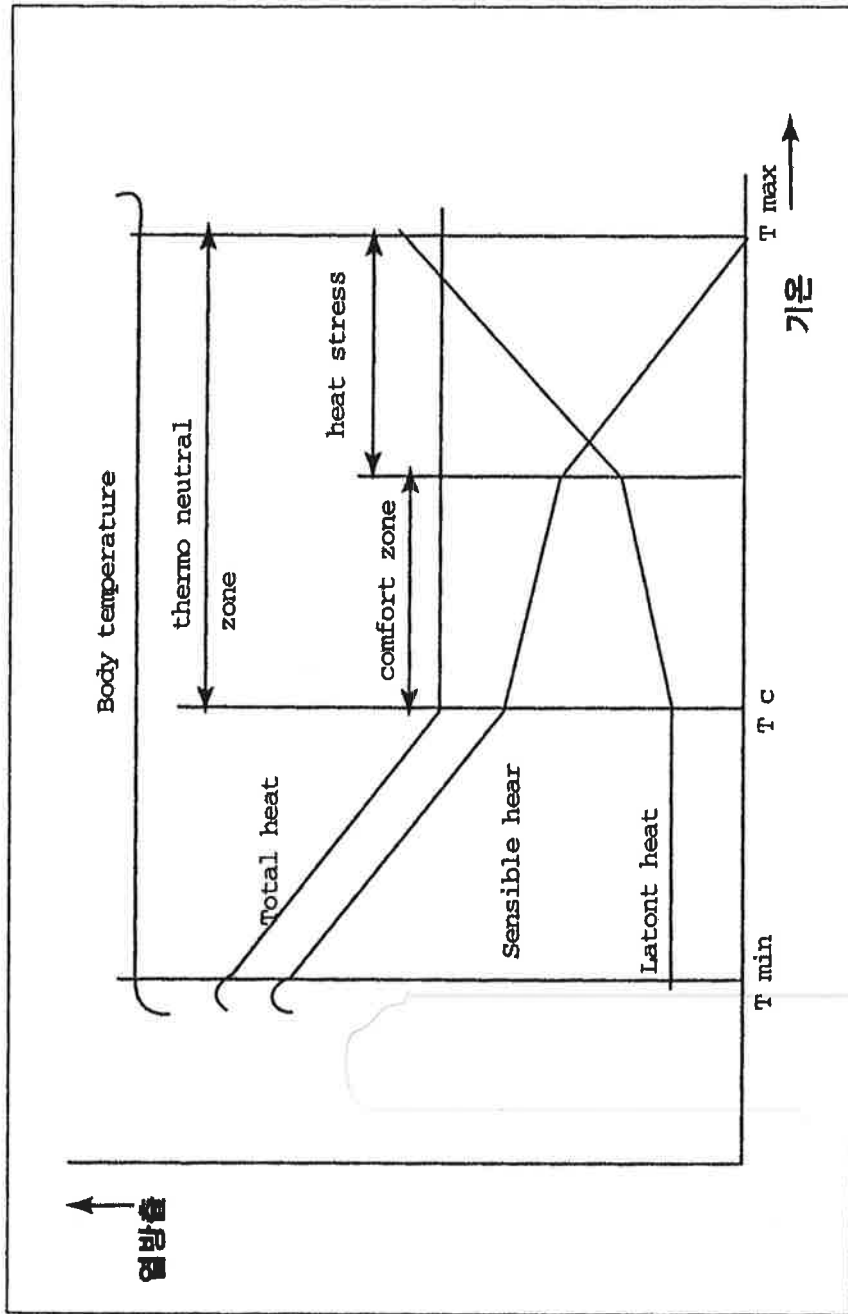
, The

comfort zone

(The critical temperature)

가 . <

1Kg ±1 0.5g 가 가)



(그림 4) 기온과 열방출과의 관계

가 . <

1>

16 , 10 21 , (2)
 35 , 32 38
 가 .
 適正溫度 , 가

< 1>

	()	()
	16	10 21
	16	10 21
	16	10 21
(2)	35	32 38
" (3)	27	24 30
" (5 14Kg)	27	24 30
(14 23Kg)	24	21 27
" (23 34Kg)	18	16 23
(34Kg)	16	10 21

< > , “ ” , 96.12, 154

2) 豚舍 適正換氣

가 , 가
(NH₄), (H₂S), 가 (CH₄),
가 가 .
가 가 (NH₄) 가
가 .

가 3ppm
가 15ppm
(< 2 >)
(H₂S) 가
. 100ppm , ,
10ppm
(< 2 >)
가 (CH₄) 가 가

가 (, ,)
) 換氣 .

< 2>

(H ₂ S)		10 ppm	
		20 ppm	, ,
		50 100 ppm	,
		200 ppm/ 1	, ,
		500 ppm/ 30	, ,
		600 ppm	
		100 ppm	,
		200 ppm	, , ,
(NH ₃)		1 20 ppm	, .
		100 ppm/1	
		400 ppm/1	, ,
		700 ppm	, ,
		5,000 ppm	
		10,000 ppm	
		50 ppm	, ,
		100 ppm	, , ,
		300 ppm	, ,

,

가 , 가

가 가 < 3>

(180kg) 14cfm, (1 2) 2cfm,

(70 100kg) 10cfm .

< 3>

()	(Kg)	(cfm/1)
	180	14
	180	20
	150	12
(2)	5 15	2
.. (3)	15 35	3
	35 70	7
	70 100	10

가

가 가 (入氣)가

(入氣口: Imlet) (Outlet)

自然換氣方式(Natural Ventilation)

(Mechanical Ventilation)

가

가

가

<

>

,

(Exhaust, negative

pressure ventilating system),

(Positive pressure ventilating

system), (,)

陰壓換氣方式(ENPVS)

陽壓換氣方式(PPVS)

가

折衝形換氣方式

가

2. 鷄舍 適正溫度 換氣

1) 鷄舍 適正溫度

가

, 가 가

< 4> . 1 2
(76 137g) 32 33 , 3 26 27 , 5 18 20

가

가

가

< 4 >

()	()	(m ³ /h/kg)	
1 2 (76 137g)	32 33	1.00	-
3 4 (137 273)	31		-
5 7 (273 390)	30		-
2 (941 1040)	28 29	0.85	-
3 (1392 1538)	26 27	0.70	-
4 (1606 1775)	22 24	0.60	-
5 (1663 1836)	18 20	-	9
(2kg)	..	-	10
(3Kg)	..	-	20

() 1. 2 “가 ” 1988 ,

2. , 1995 11

3. “ , ” 1997.1

2) 鷄舍 換氣

가 가 , , , , 가 ,
 가 가 ,
 . < 5> 가 19 20
 0ppm, 50ppm 75ppm 17.7%, 11.4%, 8.2%
 가 75ppm가 0ppm 200% .

가 (O2)16% , (CO2)
 0.3% , (CO) 40ppm , (NH3) 20ppm ,
 (H2S) 5ppm , 가 5% < : “ ” 1995 10 ,
 > .

< 5>

()	(ppm)		
	0	50	75
19 21	17.7	11.5	8.2
22 26	70.2	51.5	42.2
27 30	90.7	85.7	73.9
31 34	90.2	88.7	83.2
35 38	90.9	88.5	83.8
39 40	87.2	82.1	83.6

() , “ , ” , 1996. 10

< 5> 1 7 (76 390g)

1.00 m³/h/kg, 2 (941 1,040g) 0.85 m³/h/kg, 3 (1,392 1,538g)
 0.70m³/h/kg, 4 (1,606 1,775g) 0.60m³/h/kg .

< 6>

0 0.23Kg 0.0032m³/M/h, 0.64Kg 0.015m³/M/h,
 1.18kg 0.021m³/M/h, 1.77kg 0.026m³/M/h, 2.4Kg
 0.032m³/M/h가 .

< 6>

(: m³ /)

()	(Kg)				
	0.23	0.64	1.18	1.77	2.40
0	0.0032	0.015	0.021	0.026	0.032
4.4	0.0068	0.020	0.034	0.054	0.071
10.0	0.0085	0.023	0.045	0.065	0.091
15.6	0.0102	0.028	0.054	0.079	0.108
21.1	0.0119	0.034	0.062	0.093	0.128
26.7	0.0136	0.037	0.071	0.105	0.141
32.2	0.0156	0.042	0.079	0.119	0.161
37.8	0.0170	0.048	0.088	0.133	1,181

() , “ , ” 1995 2

2 가

1. 가

1) 養豚農家 煖房實態

32 가

< 7 >

17 , 10 , 12

가

母豚頭當 月 煖房費用

1,250 ,

833 , 850

, (), ()

, 750 1,200 .

가

가 , 가

< 7 > 가

()	(A)	22	20	20
	(B)	5	10	8
	(A - B)	17	10	12
(/)		1,250	833	850

()

2) 養豚農場 換氣實態

가
가
가
가
가 < 8>
가 (ppm) 10 13ppm ,
()
가
가 가 , 가
가
< 8> 가

(NH3)	10 ppm	13 ppm	10 ppm
가 (CO2)		-	-
		-	

() .

2. 가

1) 養鷄農家 媛房實態

가 가

가 無窓鷄舍 20 (59%),
 14 (41%) .<(9) >

2 가 6 (18%), 2 4
 가 12 (35%), 5 가 12 (35%) .

가가
 , 가
 . 가
 가 가 4 가(12%) .
 가

< 9 > 가

			2	2 4	5	
가 ()	20	14	6	12	12	4
(%)	59	41	18	35	35	12

가

1 (85 /), 2 (75 /), 3 (50 /), 4 (35 /), 5 (30 /), 6 (20 /), 7 8 (15 /), 9 (20 /), 10 (35 /), 11 (50 /), 12 (75 /)
 / 1 10,000首
 850,000 , 50,000 4,250,000

90

(11 3) 50±5 /首, (4 10) 20±5 . ,
 가

2) 養鷄農家 換氣實態

가 < 10>
 가 (NH3) 5ppm 6 가(18%), 6 10ppm 8
 가(24%), 15 20ppm 6 가(18%), 20ppm 12 가(36%)가
 .
 가 36% 가 20ppm
 ,
 .
 가 34 가 24 ,
 가 30 가 6 가(18%), 30 가
 18 가(53%) .
 가 ,
 가

< 10> 가

	(NH3)				Fan . ()	
	5ppm	6 10ppm	15 20ppm	20ppm	30	30
가 ()	6	8	6	12	6	18
(%)	18	24	18	36	18	53

가

, .
 , 21,000首 (100m, 13m)
 48 Fan 10 , Recirculation Fan & Chimney 4 ,
 48 6
 2,500 .
 , 33,280 (90m, 12m)
 48 Fan 12 , 48 Fan 6 ,
 1,000 .
 57,600 (90m. 12m)
 48 Fan 16 , 48 10 가
 4,000 .

3

1

가 .

(steam turbine)

1

(burner)

가

“ ”

가 ,

가

가 , 가

가

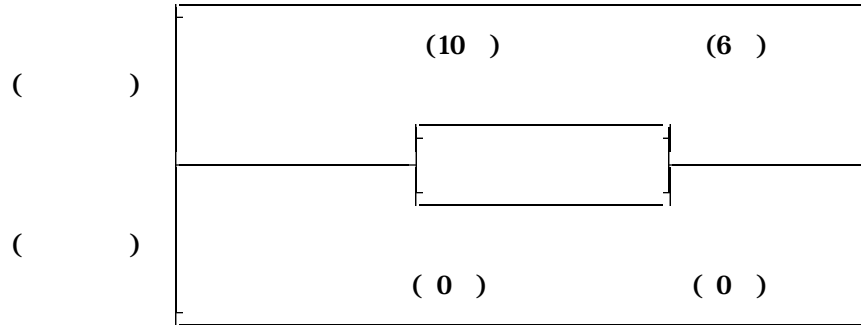
가

2 가

()

가

< 5 >



< > 10 0
 < > 0 6

2 . .

1. 一般 工業用 熱交換機 種類

(Direct-Contact Heat Exchanger), (Surface Heat Exchanger),
 (Liquid-Coupled Indirect Type Exchanger),

表面式 熱交換機(Surface Heat Exchanger)

가 가 ,

間接式 熱交換機(Liquid-Coupled Indirect Type Exchanger) 2

直接 接觸式 熱交換機(Direct-Contact Heat Exchanger)

2

(Pre-Heater), (Super Heater), (Evaporator), 가
(Re-Boiler), (Cooler), (Chiller), (Condensor)

- • 가 (Air to Air)
-
- 가
-
- 가가
-
-

2. 畜舍用 熱交換機 種類

가

(多管圓筒式熱交換機, Shell and Tube Heat

Exchanger)

가 가 가 .
(Plate Fin Type Heat Exchanger)

가
가가 , , ,

(Surface Heat

Exchanger)

(Plate Fin Type Heat Exchanger) .

3 .

1. 畜舍用 廢熱回收 裝置 開發 製作 順序

()

2. 熱交換機 種類 選定

(Plate Fin Type Heat Exchanger)”

3. 熱交換機 材料 選定

가 가

가 (Al)

(Cu), (Fe), (Cu) 가 가

가 .

, (Fe)

, 가

가

(Ag) 가

가 가 .

(Al)

(Roll) ,

, 가 . 20

175kcal/mh (Ag) (20 350kcal/mh) 1/2

(Fe)

(51kcal/mh) 3 (Al)

. (< 11>)

0.15t 500mm

< 11 >

	()	$\left\{ \frac{\text{kg}}{\text{m}^3} \right\}$	$\left\{ \frac{\text{kcal}}{\text{mh}} \right\}$	$\left\{ \frac{\text{m}^2}{\text{h}} \right\}$
	20	7130	97	0.149
	20	2700	175	0.301
"	100		177	0.291
"	300		198	0.296
	20	19320	254	0.424
(純)	20	10490	360	0.613
"	100		357	0.597
(99.9%)	20	10490	350	0.595
	20	7290	55	0.140
(純)	20	7870	58	0.067
(純)	20	8960	332	0.435
"	100		324	0.381
"	300		315	0.355
()	20	8900	320	0.360
	20	8620	25	0.031
(99.9%)	20	8900	77	0.082
(99.2%)	20		51	0.054

4. 熱交換機 波高値 (pitch) 選定

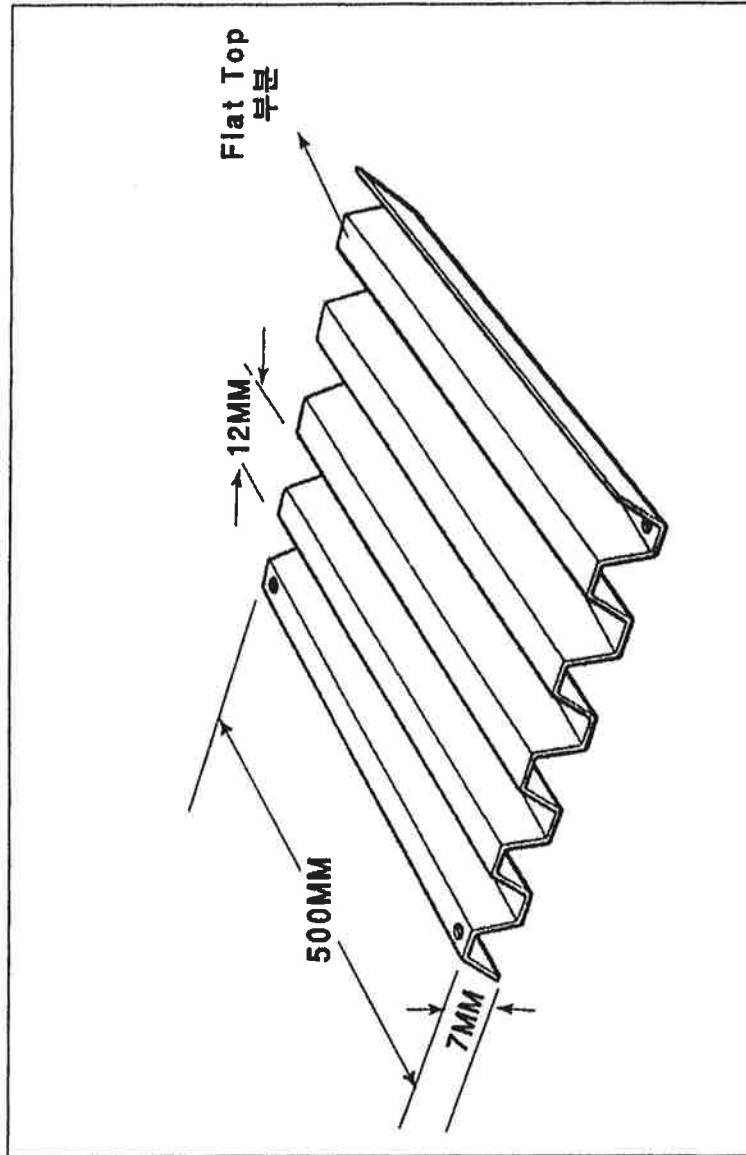
가
 0.15t 500mm < 6>
 , < >(9mm) < > 12mm, 500mm ,
 9mm가
 ,
 가
 , (9mm), (12mm)가
 가

5. 熱交換機 波高 平面(Flat Top)

(6)
 S
 (Flat Top)
 S (Flat
 Top)

6. 熱板 機械 製作

(7 ,) S



(그림 6) 열교환판

< 7 >

(ROLL)

,

가

(DC Geared Motor)

가

2

(Roll)

2

120g/mm²

가

가

가

7. 熱交換

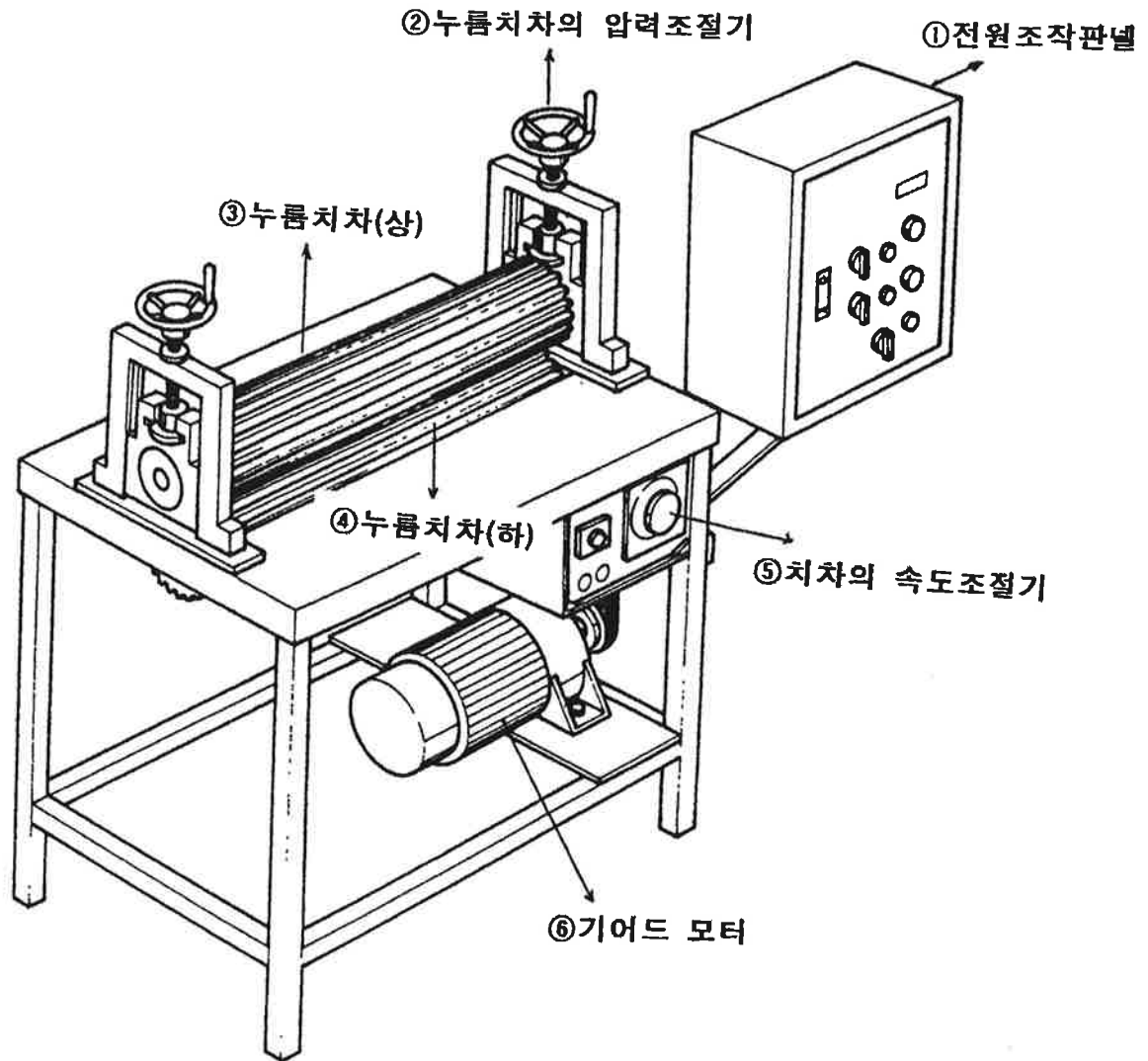
製作

< 8 >

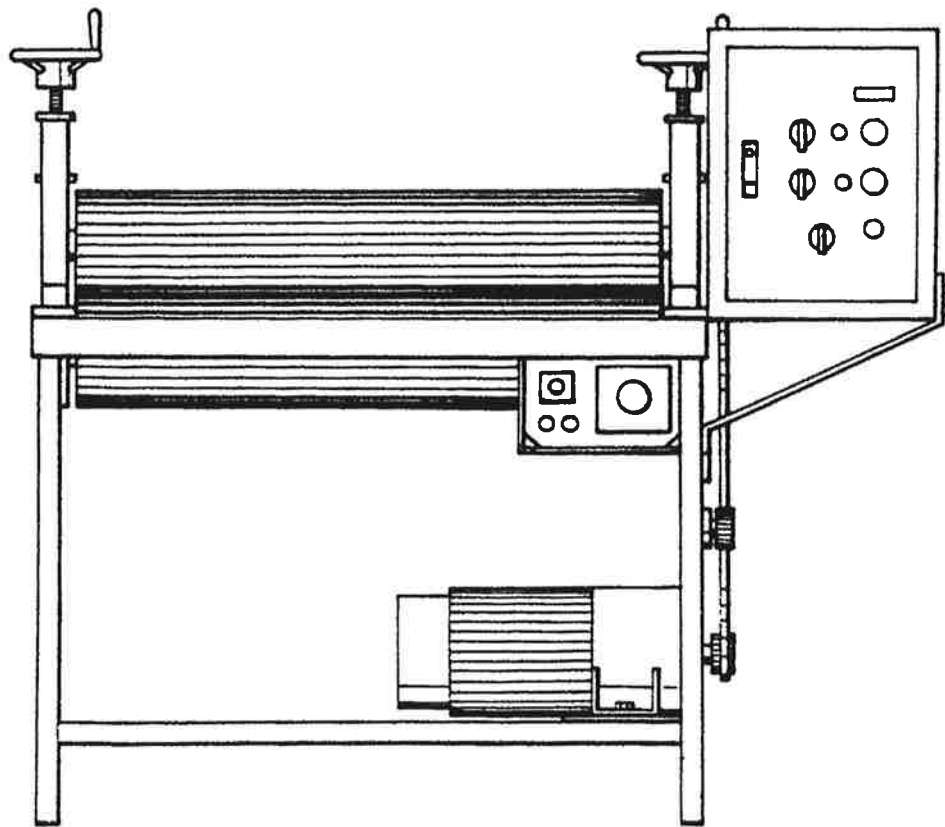
A

B

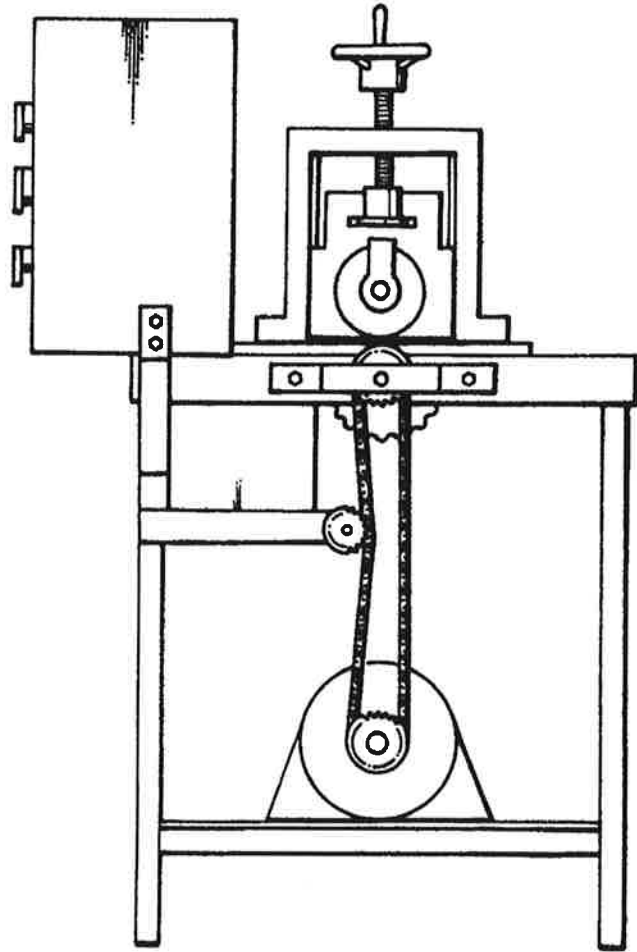
結露現象



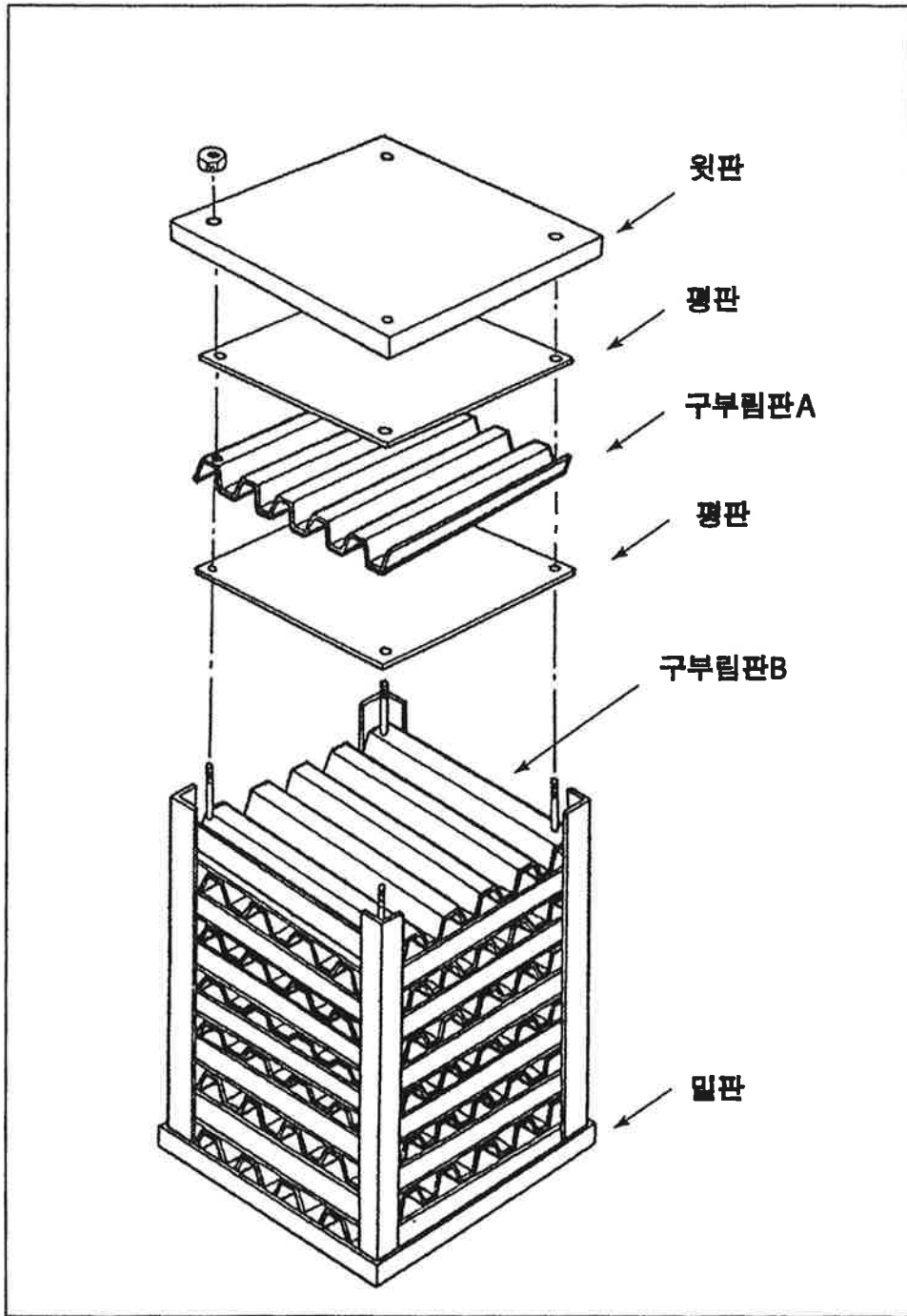
<그림 7> 열판을 누르는 기계



열판을 누르는 기계(정면도)



열판을 누르는 기계(측면도)



(그림8) 열교환 팩케지

(Nipple)

8. 熱交換機 組立完成

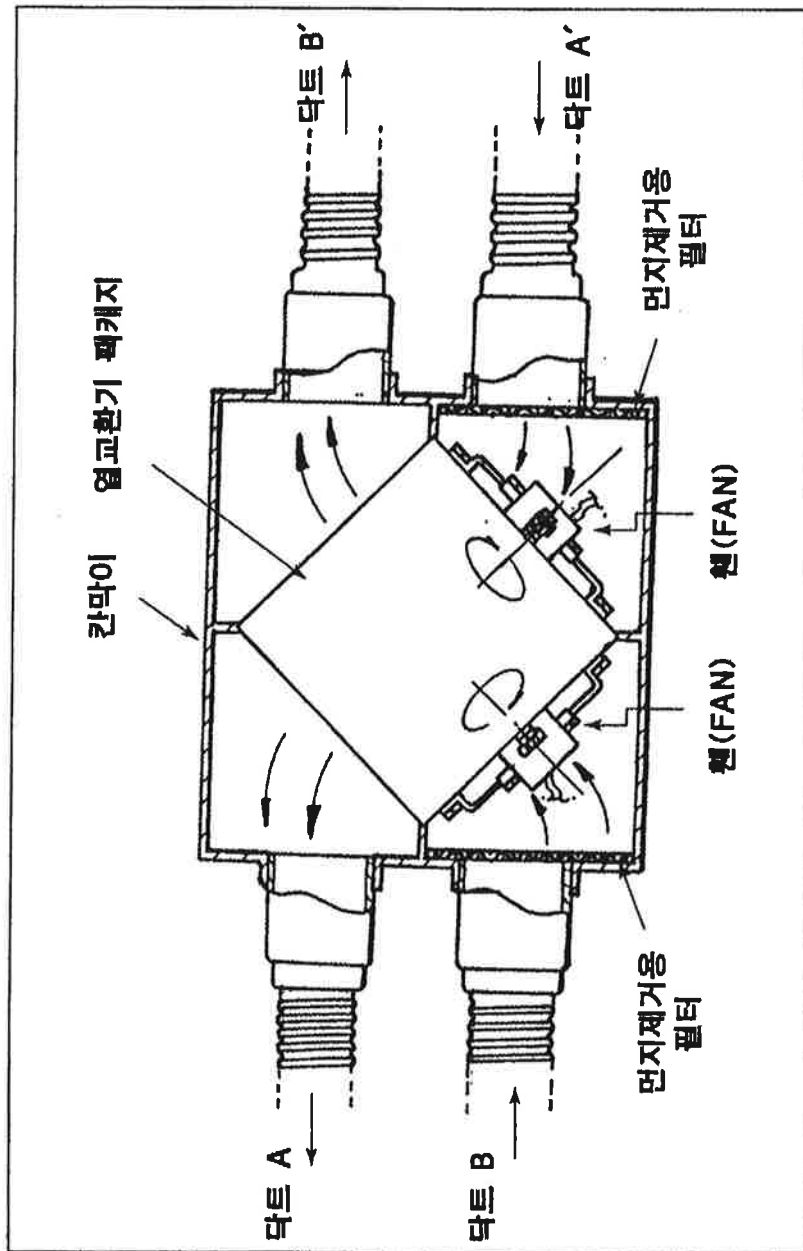
(Fan) 2 ,
2,500m³/hr , 가 600 2,500m³/hr

(Fan)

(Filter)

(Flexible Duct) A, B, C, D 4

< 9, 10> 가 1,020mm,
930mm, 520mm 70kg (Flexible
Duct) 350mm ϕ (Fan) A B 400mm ϕ
2,500m³/hr 1 , 1 2 ,
가 600m³ 2,500m³/hr 가



(그림9) 열교환기 단면도

4

1 .

가 가

. 1997 1 6 2 5 1

()

.

.

,

< 11 >

A, B, C, D 4

,

3

(9 , 14 , 16 30)

(Fan)

1,300m³/hr- 1,800m³/hr(5)가

가

,

1,300 -

1,500m³/hr

.

55- 65

(32

)

(32)

,

(18

)

[4.6m x

15.5m x

2.7m] 8

.

(4 =32)

(4 =32)

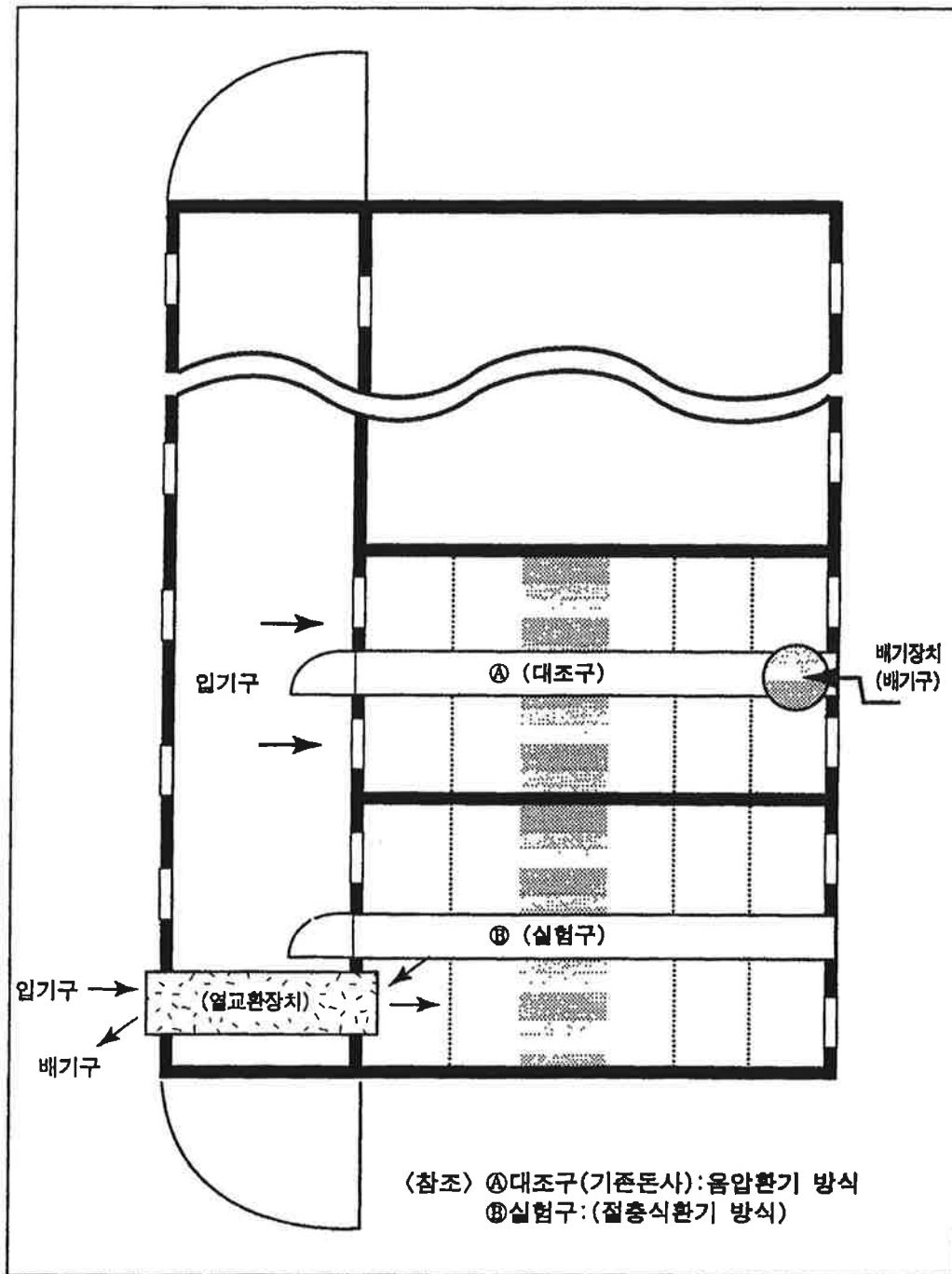
,

. <(2) >

>

가

가



〈그림11실험구와 대조구의 돈방위치와 환기구(방법)〉

2 .

< 11>

< 12>

0.78

78%

가

1,300m³/hr- 1,500m³/hr

()

()

<

13>

32

1.46,

가 1.40

< 14>

<

11>

가

4-5

(

)가

(2)

15-25

1

가

가

가

가

가

< 12 >

		(A)	(B)	(C)	(D)	
1/ 6	1.3	15	6	- 3	4	0.78
7	1.3	17	8	- 4	3	0.78
8	1.3	17	10	1	7	0.86
9	1.3	14	5	- 2	5	0.78
10	1.3	18	9	3	11	0.88
11	1.3	17	8	3	10	0.78
12	1.3	16	7	2	9	0.88
13	1.3	15	6	2	8	0.75
14	1.3	16	8	- 1	4	0.63
15	1.3	17	8	2	7	0.56
16	1.3	15	7	- 1	6	0.88
17	1.3	16	9	3	8	0.71
18	1.3	16	8	3	10	0.88
19	1.3	15	7	2	6	0.50
20	1.3	17	10	4	8	0.57
21	1.3	19	12	5	10	0.71
22	1.3	14	6	- 1	5	0.75
23	1.3	19	13	7	12	0.83
24	1.3	20	14	6	11	0.83
25	1.3	17	8	- 2	6	0.89
26	1.3	17	9	0	7	0.88
27	1.3	17	8	1	6	0.56
28	1.3	13	3	- 8	1	0.9
29	1.3	17	9	- 6	1	0.83
30	1.3	15	8	0	6	0.86
31	1.3	11	1	- 8	- 2	0.60
2/ 1	1.3	15	8	1	7	0.86
2	1.3	16	9	1	7	0.86
3	1.5	14	6	- 3	4	0.88
4	1.5	15	8	2	8	0.86

)○ 가 .
○ = (D- C)/(A- B)

○ ()

					()
	1	2	3	4	
()	8	8	8	8	32
(Kg)	146 (18)	148 (18.5)	170 (21)	172 (22)	636
(Kg)	181	188	206	210	785
(Kg)	35	40	36	39	150
(Kg)	45	50	59	65	219
	1.29	1.25	1.64	1.69	1.46

: () .

○ ()

					()
	1	2	3	4	
()	8	8	8	8	32
(Kg)	196 (18)	186 (18.5)	182 (21)	1 8 9 (22)	753
(Kg)	236	225	218	227	906
(Kg)	40	40	36	38	153
(Kg)	53	49	55	58	215
	1.33	1.24	1.53	1.54	1.40

: () .

< 14> . ()

	豚舎 外部温度	豚舎 内部温度	
1/ 6	1	19	22
7	1	19	23
8	2	17	20
9	0	18	21
10	4	20	24
11	1	19	23
12	- 3	18	21
13	- 1	19	22
14	2	17	20
15	1	20	22
16	1	17	23
17	4	18	22
18	2	20	21
19	- 1	16	20
20	1	19	23
21	1	22	22
22	- 5	15	18
23	8	21	23
24	6	22	24
25	- 1	20	24
26	1	20	24
27	0	20	22
28	- 8	17	20
29	1	20	24
30	1	20	24
31	- 8	15	24
2/ 1	2	18	23
2	1	20	22
3	- 2	17	21
4	3	18	22

3

70 90%

(78%)

70 90%

< 15 >

가 850 100

850,000 , 306,000 544,000

(64%)

가

< 15 >

(:)

	(850)			(1,250)		
	(A)	(B)	(A - B)	(A)	(B)	(A - B)
100	850,000	306,000	544,000	1,250,000	450,000	800,000
200	1,700,000	612,000	1,088,000	2,500,000	900,000	1,600,000
300	2,550,000	918,000	1,632,000	3,750,000	1,300,000	2,450,000
400	3,400,000	1,224,000	2,176,000	5,000,000	1,800,000	3,200,000
500	4,250,000	1,530,000	2,720,000	6,250,000	2,200,000	4,050,000

() 80% 64% (80% x 가) 가 .

가 1,250 800,000
가 .

Kg < (14- 23kg)
<21- 27 > 1 가
0.5Kg 가 < 16>
100 1 가 1 50Kg(1.5 /
) 가 , 2 100Kg(3 /), 3
150Kg(4.5 /), 4 200Kg(6 /) 가

가 , ,
가 < 110kg 1,540
“ ”>

< 16>

(: Kg/)

	100	200	300
1	50Kg	100Kg	150Kg
2	100	200	300
3	150	300	450
4	200	400	600
5	250	500	750

가

, , 가 가

가

.

5

, , , , ,
 ,
 가
 .
 4 , 9 4 8
 가
 가 가 20
 , , 가
 가 2 , 3 ,
 .
 가 가
 , , ,
 .
 가
 .
 가 , ,
 가 .

가 “ ” 78%
가 가

(4 ,)

(NH₃), (H₂S)

가
가 ,
() ,
가
가
- 67 -

6

1. , “ ” () , 1995
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< 1 >

가

(:)

가				
				() -

()				
	()			
가 (NH3) 가 (CO2)				

(•)

가



(:)

가				() -
---	--	--	--	-------

()				
	()			
	(NH ₃)			
	가 (CO ₂)			

(•)

< 2 >

/							
			A	B	C	D	

< . >