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The Research of Water Evaporating-cooling Humidifier's Application In Air conditioner

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ABSTRACT

The paper designed a new air conditioner with water evaporating-cooling humidifier, based on the demand of home air conditioner. The operation mechanism, structure and design procedure is introduced in this paper, and after a series of measurement, concluded that the air conditioner with water evaporating-cooling humidifier can improve the humidification and maintain the original performance of air conditioner.

1. INTRODUCTION

From survey and customer feedback, consumers expect air conditioner to include humidification function. In an environment after long time operation of air conditioning (especially during winter when heating is used), if the air conditioner does not provide humidification, consumer need to purchase additional humidifier to improve in-room humidity. It is extra cost and takes more space.

In addition, low relative humidity will cause people to feel uncomfortable. Other long term effects include: cold, aging of skin, fatigue, headache; reduced life of clothing, furniture and equipments. Low humidity also increases hazardous material such as statics and dust.

Therefore, an air conditioner with humidification function is needed, and it should not affect the performance, installation and physical appearance of the air conditioner.

2.CONVENTIONAL METHODS OF HUMIDIFICATION

2.1 Water humidification

Uses various mechanism (such as electrode, Ultrasonic, Wet film) to convert vaporize water and feed into the room, and effectively increase the relative humidity in the room. The advantage is effectiveness, fast, and disadvantage is water needs to be compensated constantly.

2.1.1 Humidification with ultrasonic

Ultrasonic humidifier uses high frequency oscillation generated by ultrasonic wave and atomizes water into ultra fine particles about 1 to 5 micron. The water particles are spread into the air with a fan, therefore increase the humidity. The advantage of ultrasonic humidifier is low consumption of water and electricity, high capacity, fine particle size, fast, simple and small device structure. Disadvantage is that it requires certain water quality. Long term use will cause rapid growth of germs, effect of white powder , and the atomization device has short life.

2.1.2 Electrode humidification

Tap water has certain conductivity. By inserting electrodes into water and connect to AC power supply, current is induced through the water between the electrodes. The electrical power is completely converted into heat and produces vapor from the water. Advantages of electrode humidifier include low vapor pressure, no mineral material

in the vapor, no germ and white powder; disadvantages are water condensation, high cost and high power consumption.

2.1.3 (Evaporation) Wet film humidification

(Evaporation) Wet film humidification is an isoenthalpy method. Evaporation of water is induced by absorption of energy from the ambient. The dry-ball (???) temperature in the air drops while the absolute humidity increases, but the total enthalpy in the air is held constant; Wet film humidifier has low cost, clean, and will not cause condensation, Its drawback is bigger size than ultrasonic.

2.2 Waterless humidification

Waterless humidification uses rotating wheel to absorb water, as the reverse of dehumidification through absorption. It uses high absorption material to absorb water vapor in the air, and blow the humid air into the room after heating with a blower. In the meantime it provides fresh air and oxygen; its disadvantages are complex design, high cost, and humidification is only possible during heating.

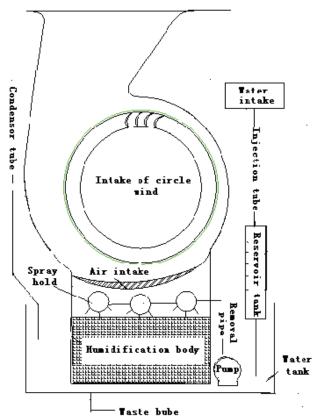
Each of the above mentioned humidification methods has pros and cons. The trend of air conditioning is miniaturization and distributed system. This also dictates the miniaturization of the embedded humidification system. Wet film and ultrasonic humidifier address such demand.

In meantime, humidification in air conditioning should address these issues: ①power saving; ②white power; ③reduce water scale; ④maintain the performance of air conditioner。

3. INSTALLATION AND EXPERIMENT METHODS

3.1 Installation

Based on the internal structure of air conditioner, assemble of wet film and size, we selected two installation methods: on top and on the bottom. We analyzed the feasibility of the two choices through experiments. The schematics is plotted in plot 1 and 2.



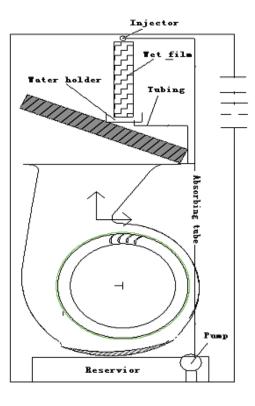


Figure 1: Humidifier is installed on the bottom

Figure 2: Humidifier is installded on the top

3.2 Experiment method

There are three sections in the experiment: first is functional test of the wet film material; second part is the affect of location of the humidifier in the air conditioner; the third part is the effects of the humidifier on the air conditioner performance. The scheme is listed on table 1.

Table 1: The scheme of the test

TWOIR I. THE BENEFIT OF MIC VECT				
Objective	Requirement	Testing parameters		
Selection of web film material	compare performance of materials	1 temperature		
Selection of web inin material	under the same condition	2.relative humidity		
	compare the effect on humidification,	1.temperature		
Selection of humidifier	air flow and noise when humidifier is	2. relative humidity		
location	installed on top and bottom of air	3.volume		
	conditioner	4.nonise		
		1.volume		
	humidification, cooling, and heating	2.noise		
overall performance	performance, humidification	3.cooing performance		
	comparison with standalone humidifier	4.heating performance		
	-	5.relative humidity		

4.RESULTS

4.1 Characterization of wet film material

Experiment method: in a 1m3 sealed container, blower blows air to the wet film from normal direction to compare different film materials. Record the absolute and relative humidity in the container after 0.5 hour, 1 hour and 2 hours. The results are listed in table 2 and 3.

T 1 1 0 T CC .	0.1				
Table2:Effect	of hii	midify	ın	materal	A

ruorez.Erreet or nammarty in matterial ri					
Material(A)paper (1)					
т:	T (°C)	DII (0/)	Humidity		
Time	Temperature ($^{\circ}$ C) RH ($^{\circ}$)		content (g/kg)		
0h	30.7	73	d1=20.4		
0.5h	31.5	93.2	d2=27.6		
1h	32	94.2			
2h	32.7	94.7			
Dif	Difference humidity in half hour: d2-d1=7g/kg				
	Used water volume:100ml/h				
	Material(A)paper (2)				
Time	Tammaratura (°C)) RH (%)	Humidity		
1 IIIIe	Temperature ($^{\circ}$ C)		content (g/kg)		
0h	29	72.5	d1=18.3g/kg		
0.5h	30	93.1	d2=25.2		
1h	30	94.2			
2h	30.9	94.8			
Difference humidity in half hour:d2-d1=7g/kg					

Used water volume for humidity:75ml/h

Table3:Effect of humidity in materal C

Material(C)aluminium (1)				
Time	Temperature (°C)	RH (%)	Humidity content (g/kg)	
0h	31	71	d1=20.2	
0.5h	31.4	90.7	d2=26.7	
1h	31.5	92.8		
2h	31.6	94		
Diffe	Difference humidity in half hour: d2-d1=6.5g/kg Used water volume:85 ml/h			
	Material(C)aluminium (1)			
Time	Temperature (°C)	RH (%)	Humidity content (g/kg)	
0h	32.4	74.5	d1=23.1	
0.5h	32.9	87.6	d2=28.1	
1h	32.9	90.9		
2h	32.4	93.9		
Difference humidity in half hour:d2-d1=5g/kg				
Used water volume for humidity:60 ml/h				

From the testing results in table 2 and 3, paper film performs better than aluminum; humidification is improved with higher wave density, however the air flow resistance is also increased. Considering the overall performance, paper web film with 7mm wave length is selected for the following study.

4.2 Installation location study

4.2.1 Comparison of humidification with different location

Experiment method: in a concealed room of 15m², select low speed mode and turn on the humidifier, Measure the room humidity at different time, and compare the result when the humidifier is located on the top vs. on the bottom of the air conditioner.

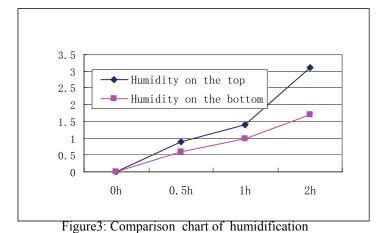


Figure 3 shows that humidifier located on the top performance better than bottom.

4.2.2 Effect of location on air flow rate

Experiment method: in the wind tunnel, measure the flow rate of the original air conditioner, with humidifier on the top, and with humidifier on the bottom. We measured flow rate and rotation speed at high, medium and low speed mode.

Table4:Flow rate parameters of difference condition

Scheme		Flow rate (m3/h)	Powe(w)	Revolution (n/h)
Humidifier on the bottom	Super high speed	968.5	163.4	422
	High speed	839.5	147.3	372
	Medium speed	777.9	139.0	343
	Low speed	714.1	130.8	321
Original	Super high speed	1032.0	164.2	434
	High speed	897.4	147.9	384
	Medium speed	830.5	139.6	354
	Low speed	760.0	131.5	330
Humidifier on the top	Super high speed	1027.2	165.6	434
	High speed	893.8	147.9	386
	Medium speed	830.9	139.4	360
	Low speed	761.6	131.3	335

From table 4, it is shown that humidifier located on the top has little effect on the flow rate; as comparison, when the humidifier is on the bottom, some air leaks from the web film, and reduces the flow rate through the evaporator.

4.2.3 Noise comparison with different locations

Experiment method: in the noise laboratory, measure the noise of the original air conditioner, with humidifier on the top, and with humidifier on the bottom at high and low speed mode. Result is listed in table 5.

Table5:Noise parameters

Scheme	Noise (dB)		
Original	High speed		
	Low speed	38	
Humidifieron the top	High speed		
	Low speed	38	
Humidifieron the bottom	High speed	42.3	
	Low speed	38.1	

Table 5 shows that neither location has effects on noise.

Combining all the above experiment results, we concluded that humidifier installed on top of the air conditioner perform slightly better than on the bottom. In the next step, a prototype is built with wet film installed on the top, and overall performance is measured.

4.3 Performance measurement of humidifier prototype

4.3.1 Humidification performance

Experiment method: in the comfort laboratory, turn on and off the humidification function during heating, and record the increase of humidity at different time.

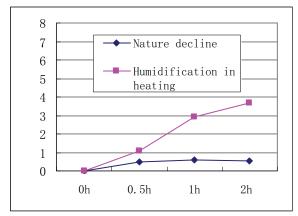


Figure 4: Humidity content during heating

From figure 4, we can conclude that without the humidification function (natural decay), the humidity level in the room is almost constant. When the humidification is turned on, the humidity level is significantly increased. Therefore, the performance of the prototype is satisfactory.

4.3.2 Heating performance

Experiment method: In the enthalpy lab, compare the COP during constant heating between the original air conditioner and AC with humidifier.

The testing results show that at the same heating level, COP is 2.9 without the humidifier; with humidifier it reduced to 2.7. Therefore humidification will effect heating performance of the air condition.

4.3.3 Cooling Performance

the same humidity as stand alone humidifier. The performance is equivalent

5. CONCLUSION

The following conclusion is made from many series of experiment results.

5.1 Material performance

Performance of the humidifier material is dependent on many factors such as material property and wave length. Humidification is improved with higher wave density, but it also increases flow resistance, paper material performs better than aluminum. However, paper material is worse in bacteria and fire resistance performance.

5.2 Location of humidifier

From experiment, humidifier on the top is preferable than on the bottom, it has no effect on the flow rate and noise, plus significant humidification.

5.3 Performance of humidifier-AC prototype

- (1) Performance of the prototype is favorable, humidity level in the room is significantly increased under heating condition.
- (2) under constant cooling, the prototype has no effect on the cooling performance (energy effect ratio is 2.5 with and without the humidifier.
- (3) under constant heating, the prototype has little effect on the heating performance (energy effect ratio is 2.7 with humidifier and 2.9 without the humidifier).
- (4) From comparison, the prototype has equivalent performance with commercial humidifier.

REFERENCES

Yuan Jianxin, 2000, The application of ultrasonic humidifier in winter in cold and dry area. Refrigeration Transaction, Vol 19, no. 4: p73-74.

- Zhang Yongquan, Ju yongping, 1997, Performance study of film humidifier. Equipment Development. Vol. 27, no 4:P42-44.
- Li Rongnian and Yesheng, 2004. The development of waterless humidification in comfortable air conditioner. Vol. 25(1):p46-48.