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Development of Solar Air Heating System in Mongolian Winter Season

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***Abstract*—It's very cold in Mongolian winter season and especially January has the best cold temperature as -40℃ over. Then it is important to use the heat collector has two advantages. The one is economical benefit than fossil energy and the other is environmentally-friendly. A solar air heating system is one of the popular renewable energy collection supplying hot air for everyday life. Here, we designed heat collector of tin pail type. The size of the heat collector is 105cm in height, 85cm in width and the heat flux collected at the heat collector from sunlight was assumed 1.2kW/㎡. The air velocity at the exit of the pipe operated in the heat collector was varied from 0m/sec to 6m/sec to see the change of the air temperature with the velocity. Finally we found that the maximum temperature of the exit on the heat collector shows 80℃ as the forced air velocity at the exit is 6m/sec.**

Keywords—heat collector; economical benefit; environmentally-friendly fossil energy; solar air heating system; popular renewable energy; heat flux; sunlight; air velocity; air temperature;

I. INTRODUCTION

As a heating device that produces and supplies hot water by using solar energy, plate type or vacuum tube type collectors have already been introduced into our lives. However a simple type of air pipe type collector is more simple than conventional solar hot water collection system and it can heat air at room temperature above 75℃ and can be used as heating energy for living space. Therefore, it has economic advantages and more convenience of device system than solar hot water collection system. The energy conversion efficiency of the air-heated solar collectors is expected to be over 70% and the efficiency of the collector is lower than that of the conventional flat or vacuum tube type apparatus, which is 85%. But in terms of production cost of the heat collecting device, it can be lowered by 40%, which is about four times the economic effect.

In addtion, the temperature of air that can be produced through this device is more than 75℃ and the temperature that can be used for indoor heating in everyday life is more than 40℃. Therefore it has value of use in life. A solar air heating system is one of the wonderful renewable energy collection systems supplying hot air in our daily life. In this study, a simple flat plate type heat collector was designed and the heating performance of the system was analyzed numerically to understand the availability of the system for the practical application in industry.

II. HEAT COLLECTOR MODELING

When solar radiation is applied to an air heat flat solar collector, the surface of the tubes installed inside the collector's inner diameter increases and the internal air temperature rises. Due to this cause, the atmospheric pressure inside the tube is formed due to increased pressure inside the tubes, and the natural convection currents of air are formed. The program was used by the British CHAM to interpret the natural convection phenomenon of air inside the collector in a finite volume method.

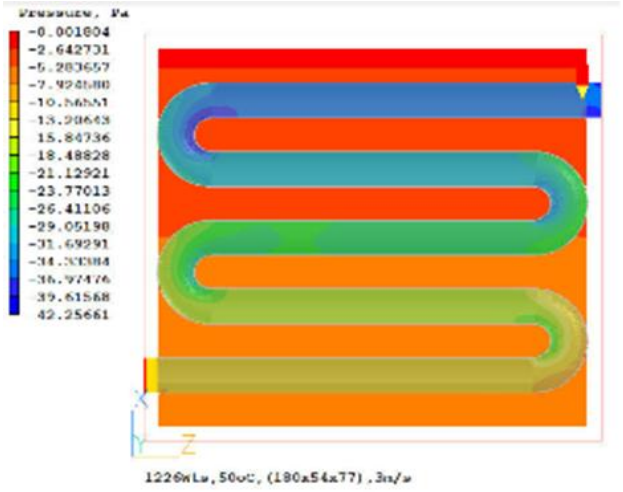

Fig. 1. *Variation of volume flow rate of air due to exit air velocity.*

Fig.1 shows changes in air flow rates according to the variation in the rate of forced air discharge at the output pipe.

Production of warm air produced through this device can be found to produce warm air of up to a maximum of 161 ㎥/h with a maximum discharge rate of 6 m/s.

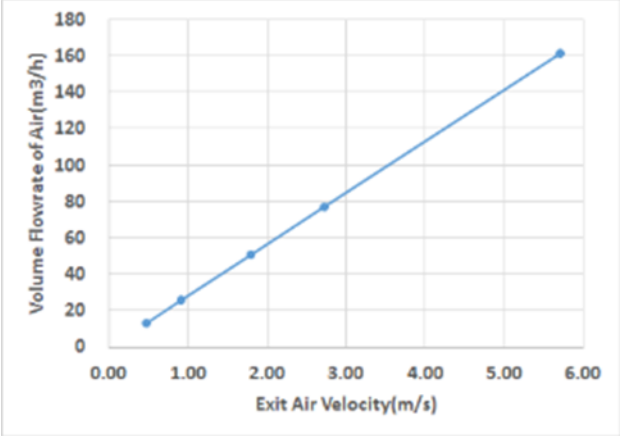

Fig. 2. *Changes on ait temperature against output velocity of heat collector.*

Fig.2 shows changes in air temperature due to changes in output velocity of heat collector. When the output velocity of heat collector exceeds 6m/sec, the temperature of output air is increased to 40.5℃.

III. Procedure and Result

Fig.3 shows schematic diagram of heat collector. In heat collector, heat collector consist of aluminum pipes (10cmΦ×60cm) and U-type pipes.

The size of collector trunk is 105cm in length, 85cm in width and 20cm in depth. And the solar flux of heat collector was applied average 1.2kW/m2. The air velocity at the exit of the heat pipe installed in the heat collector was varied from 0m/sec to 6m/sec to see the change of the air temperature with the velocity.

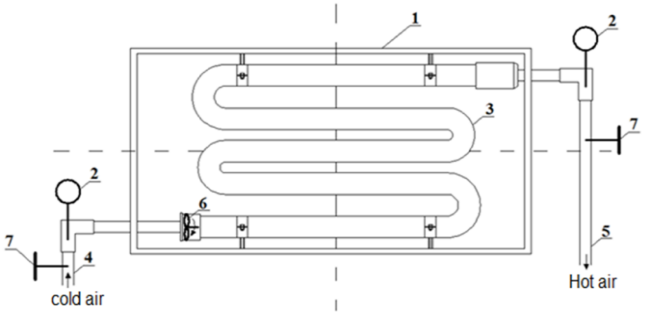

Fig. 3. *Schematic diagram of heat collector.(1.collector trunk 2. temperature sensor 3. collector pipe 4. cold air input 5. hot air output 6. circulated fan 7. control valve)*

From the study, it was found that the maximum temperature of the hot air at the exit of the model solar heat collector is 80oC as the forced air velocity at the exit is 6m/sec and the volume flow rate of the air is 161.3m3/h. This information would be incorporated to decide the reasonable size of the solar. The tilt angle of heat collector is adjusted 45~60° on the horizontal surface.

Fig. 4. *1.actual air heating system 2.checking collector output temperature*

Table 3 shows number of colony using syringe electrode's inside diameter of 0.25mm and table 4 appears that of syringe electrode's inside diameter of 0.45mm.

TABLE I. Various Data of Air Heating System

No	time	solar flux(w/㎡)	collector output temp(c)	indoor temp(c)	ambient temp(c)
1	14:30	1040	50	20	-14
2	14:50	1040	53	24	-14.3
3	15:10	1045	60	25	-14.5
4	15:30	1043	56	23	-15.6
5	15:50	1033	48	22	-18.6
6	16:10	1015	34	20	-22

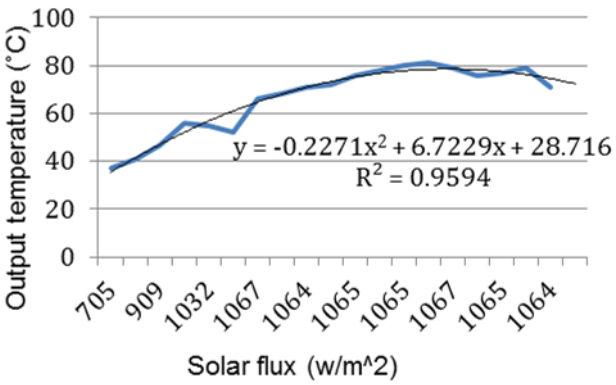

Fig. 5. *Collector output temperature against solar flux*

In table 1, On the over time, the lower the temperature of the solar flux, the lower the temperature of heat collector. And indoor temperature appears the heat loss considerably according to ambient temperature.

In fig.5 the heat collector efficiency is showen as function of collector output temperature against solar flux. In especially, the Mongolia has a natural condition of solar power plant that products solar energy because of its average solar flux, which has an average solar flux of 1.2kW/㎡ per year, compared with other countries. Thus, the temperature difference between sunrise and sunset shows a temperature difference of 10~20 degrees.

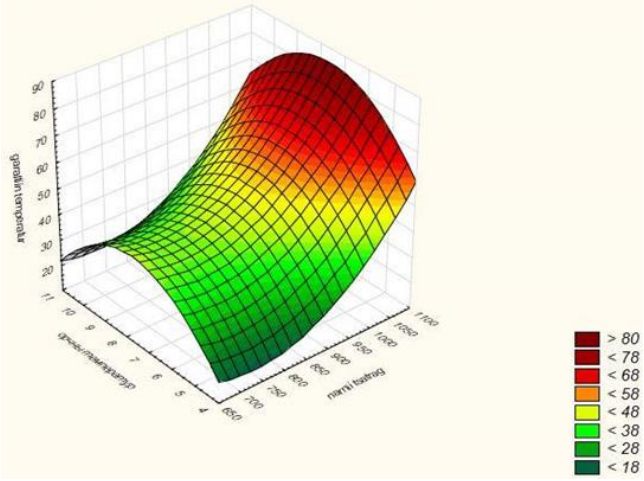

Fig. 6. *Collector output temperature against solar fluxsolar flux(X) and relation of ambient temperature (Y) and collector output temperature(Z)*

In Fig.6, the larger the solar fluxes, the higher the ambient temperature, the more increase the output value of the collector, The performance of the heat collector indicates a high value in red color. Also the correlation coefficient related to solar flux and collector output temperature is 0.82 which indicates that all arguments of this model are relatively correlated.

The regression equation is

$$y = -0.2271x^2 + 6.7229x + 28.716$$

Under Fisher's indicators$F_{real} = 38.78$ but in theory $F_{theory} = 4.6$. If it is $F_{real} > F_{theory}$ regression equation is accurately 95%.

If we calculate useful energy of collector.

$$Q_A = 1086.87$$

Experimental work outcome shown efficient of collector

$$\eta = \frac{Q_A}{A * I_T} = 0.64$$

Where:

A –Collector squire m2

I_T–Solar radiation density w/m2 striking Collector squire per share

IV. CONCLUSION

Based on the purpose of using the solar energy heating system, the purpose of developing a simple type of solar powered air heating collector, the amount of usable energy was theoretically calculated, and the development model was actually produced.

The air temperature produced by the size of the solar collector (105cmX85cmX20cm) was 40.5℃, and the output of the air produced at this time was estimated at approximately 161m3/h.

Solar thermal energy could be utilized to maintain the environment in which the climate was suitable for human activity.

In particular, it can be used as a good heating mechanism that can be used economically for the Mongolia as northern region, and preferably for future heating and development.

REFERENCES

[1] Weiss, Werner, Irene Bergmann, and R. Stelzer, "Solar heat worldwide"2010.

[2] PHOENICS Technical Report (TR/326), “Concentration Heat And Momentum Limited”CHAM, 2011.

[3] Yakhot. V. and Smith. L.M., “The Renormalization Group, Three-Expansion and Derivation of Turbulence Models,” J. of SCI. Computer, Vol.1, No.3, 1986.

[4] K.Asano, J. Electrostat. Japan 8 ,182,1984

[5] Douglas, J.F., “Fluid Mechanics”, pp.406~447, Pretice Hall, 2001.