DEVELOPMENT OF A FLAT PLATE SOLAR AIR COLLECTOR

D.Baatarkhuu[1, a*], J.Amgalanzul [2,b], D.Myagmarsuren[3,c], Ch.Turbadrakh[4,d]

[1,2,3] Department of electrical engineering and electronics, School of engineering and technology, MULS

[4] Vice-President of Academic affairs, Mandakh University Mongolia

[a]elec_eng@muls.edu.mn , [b]amgalanzul@muls.edu.mn, [d]turbadrakh@mandakh.mn

Abstract

Mongolian environmental pollution steady increased by usage of traditional energy resources for growth of energy consumption. 36.9% of air pollution in Ulaanbaatar is caused by utilization of raw coal for heating of ger district and Ulaanbaatar has second most polluted air in the world. Replacement of energy resources by the renewable energy is the one option to reducing of air pollution. Mongolia has lot of sunny days, therefore heating supply of buildings by solar energy is one of the most effective choice for both environmentally and economically. Results of experiment of air heating solar collector with heating spiral for buildings are shown in this research paper. Correlations of solar intensity, collector outlet temperature and ambient temperatures are studied for this research paper. The solar collector had 1064.65W power and 0.64 coefficients of efficiency and these values were almost same to other collector values, which are used in practice.

Keywords energy, heat, solar flux, air temperature

INTRODUCTION

Mongolian environmental pollution steady increased by usage of traditional energy resources for growth of energy consumption. 36.9% of air pollution in Ulaanbaatar is caused by utilization of raw coal for heating of ger district and Ulaanbaatar has second most polluted air in the world. Replacement of energy resources by the renewable energy is the one option to reducing of air pollution (Baatarkhuu, 2017).

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 addition, 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 (Venu Arun, 2013).

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.

1. 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. 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.

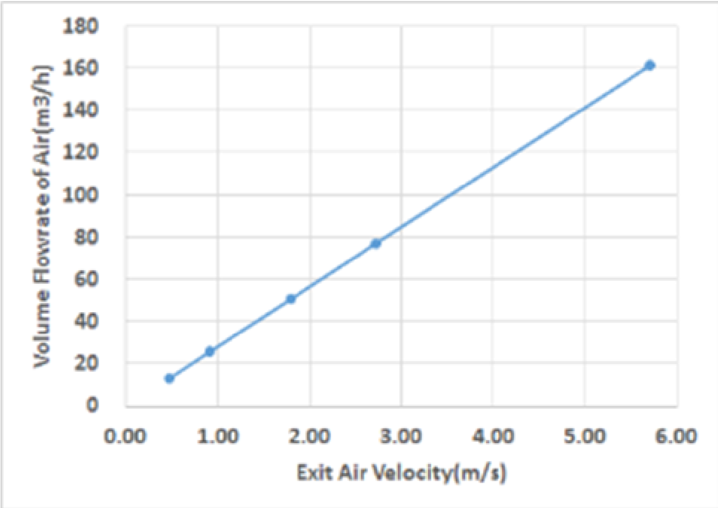

Figure 1. Changes on ait temperature against output velocity of heat collector

Fiigure 1 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℃.

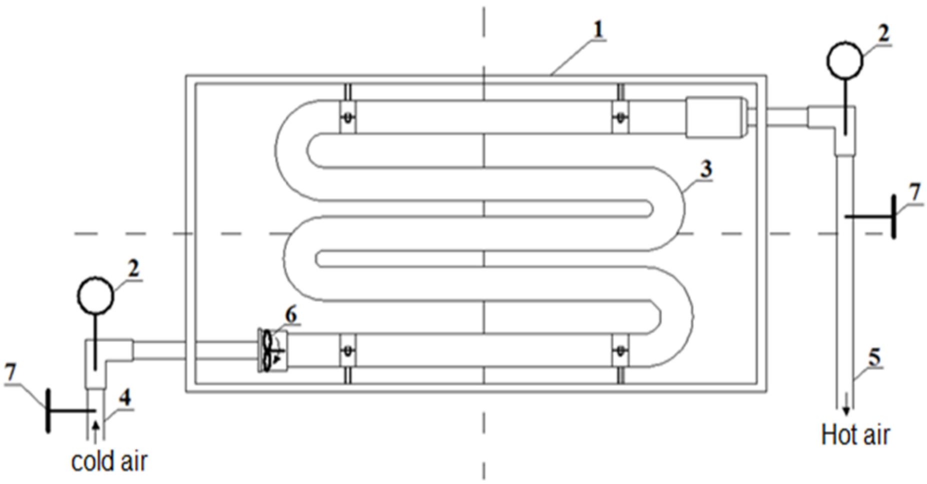

Figure 2. Schematic diagram of heat collector (1-collector trunk, 2-temperature sensor, 3-collector pipe, 4-cold air input, 5-hot air output, 6-circulated fan, 7-control valve)

Figure 2 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.

Figure 3. Actual air heating collector

2. RESULTS

Experimental work was conducted in Renewable Energy Polygon of Engineering and Technology School. After the installation instruments we recorded parameters of thermal collector repeated every 20 minutes. It has shown in table 1.

Table 1. Measurement value

№	Time, (Min)	Solar radiation w/m^2	Output temperature	Ambient air temperature	Input temperature	Output speed m/s	Input speed m/s
1	10:37	1058	70	6	9.5	1.9	1.8
2	10:57	1061	81	7.5	9.5	2.6	2.6
3	11:17	1068	81	8.3	9.5	2.3	2.1
4	11:37	1068	82	10.2	9.5	2.3	2.3
5	11:57	1073	86	10.7	9.5	2.6	2
6	12:17	1073	87	10.8	10	2.6	1.9
7	12:37	1073	92	11	10.5	2.6	2.3
8	12:57	1074	92	11.8	10.5	2.5	1.8
9	13:17	1071	91	13	10.5	2.1	1.2
10	13:37	1073	89	12.8	10.5	2.1	0.7
11	13:57	1073	90	13.5	10.5	2.9	1.9
12	14:17	1076	88	13.7	10.7	2.5	2
13	14:37	1073	86	13.5	10.7	2.4	2.3
14	14:57	1073	82	13.3	10.5	1.9	1.9
15	15:17	1064	78	13	10	2	1.6
16	15:37	1055	74	13.2	10	2.1	1.7
17	15:57	919	63	12.8	10	1.3	1.3
18	16:17	902	61	11.4	10	1.5	1.1
19	16:37	754	53	11	10	0.7	0.7
20	16:57	734	46	10	10	0	0

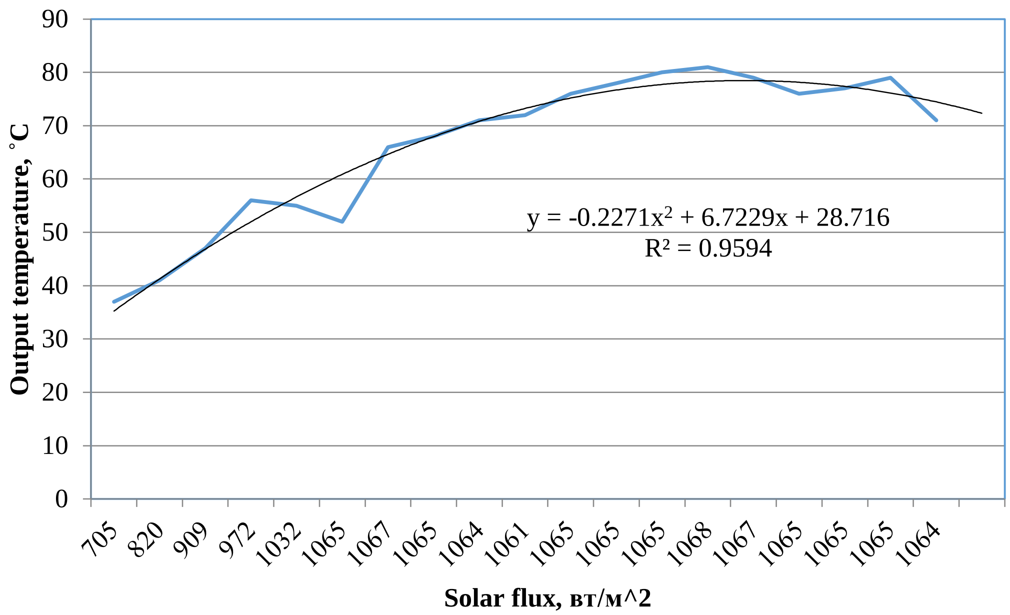

Figure 3. Collector output temperature against solar flux

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 figure5 the heat collector efficiency is shown 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. Also the correlation coefficient related to solar flux and collector output temperature is 0.92 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

$$Q_A = 1086.87 \text{ W}$$

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

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 (105cm,85cm, 20cm) was 40.5℃, and the output of the air produced at this time was estimated at approximately 161m^3/h. The solar collector had 1064.65W power and 0.64 coefficients of efficiency and these values were almost same to other collector values, which are used in practice. 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. Baatarkhuu, D., Amgalanzul, J. and Buuveibaatar, R. (2017). “Results of Experiment of Solar Collector with Spiral Tube” The 8th National Renewable Energy Forum. May. Ulaanbaatar. Mongolia
2. Venu Arun and P Arun.,(2013)“ Simulation Studies on Porous Medium Integrated Dual Purpose Solar Collector”. International Journal of Renewable Energy Research, Vol.3 No.1, pp 114-120.
3. Esen Hikmet., (2008) “Experimental Energy and Exergy Analysis of a Double-Flow Solar Air Heater Having Different Obstacles on Absorber Plates”. Building and Environment., Vol.43 pp 1046–1054.