A Thermoelectrical Approach To The Waste Energy Thrown By Chimneys

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ABSTRACT

Gases occurred at the end of combustion based on fossil fuels are thrown by means of chimney through the atmosphere because of negative pressure. The height of chimneys and temperature of the combusting gases seem as significant parameters in the case of thrown gases. Recovery heat energy thrown from the chimneys is aimed using the Method of Thermoelectric Converter (TEC) in terms of electrical energy in this work. For this purpose, a model based on a thermoelectric converting system was thought and a related prototype was developed. In the model, the energy converting system was mounted just on the chimney in order not to affect flow of the gases. It was concerned that the energy thrown from the chimney as a lost energy would be recovered by a converting system in terms of electrical energy in some quantity. The experimental data based on the prototype was obtained related to the waste energy recovery.

Key Words: Waste Energy, Energy Recovery, Thermoelectric Converters, Chimneys

I. INTRODUCTION

As the fossil fuels have been runing out day by day, the concept of efficient energy consumption is getting important all over the world. Particularly, concepts of the waste energy recovery and efficient energy consumption have been one of the most significant research topics [1,2]. Some typical studies about the waste energy recovery have been seen in the literature searching. The research about electricity generation produced by means of thermoelectric conversion extends to the earlier years [3, 4]. Not only have thermoelectric converters used for conversion from heat to electrical energy, but also they are utilized for the purpose of cooling and heating.

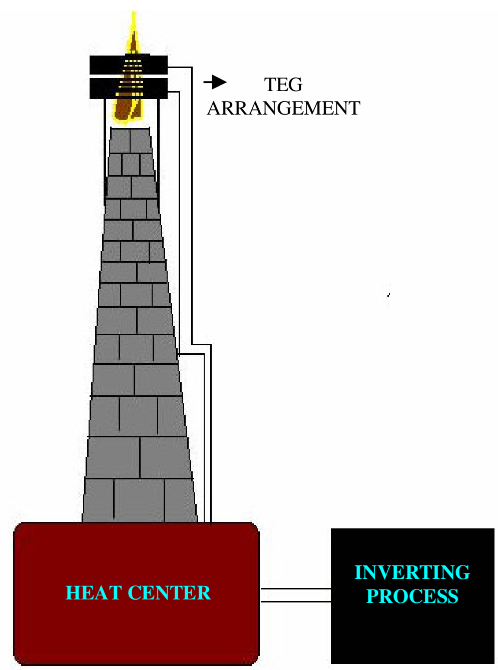

Figure-1. A TEG model concerned in the study.

The effects of Thomson, Peltier and Seebeck are also related to this subject. The performance of the thermoelectric material is characterized by a term [5] as follows;

$$Z=S^2 /Kr \qquad (1)$$

where S is the Seebeck coefficient, r is the electrical resistance and K is the thermal conductivity. A good Figure-1. Thermoelectric conversion model concerned for a heat center with a chimney system.

thermoelectric material must have a large Seebeck coefficient, high electrical conductivity and low thermal conductivity [5,6]. In order to produce the thermoelectric converter working in different temperature ranges, different materials must be utilized. The TEC which is made of the compound lead-telluride, is convenient in the temperature range 230-530°C. The TECs made of bismuth-telluride compounds are used for the temperature range from 25 to 130°C. For temperatures above 530°C, the alloys of germanium-silicon are the best materials for the production of thermoelectric converters. Especially, both lead-telluride and germanium silicon thermoelements are used for power generation [5-11]. Concerning the properties of the thermoelectric converters (TEC), new applications have been appeared such as a thermoelectric battery-charger with microcontroller-based technique [12]. The heat energy thrown from chimney as a lost energy was thought and conducting an experimental study the data was obtained based on the experimental arrangement.

II. Experimental Procedure

A chimney was concerned as a heat source giving out energy and the heat energy recovery was considered in this work. It was aimed to absorb the lost energy in maximum level by means of a heat exchanger made of copper. In the developed model, the best position for the heat exchanger was assumed to be the top of the chimney as seen in Figure 1. A prototype based on this model was produced and applying some temperature differences (ΔT) to the TEC system potential differences (Vdc) were obtained. However, it is important to keep the ambient temperature of the TEC units in the range of working temperature. A chimney with the TEC system is shown in Figure-1. It is aimed to recover the waste energy thrown from the chimney in the form of electrical energy. As a thermoelectric converter unit, the model of TEC1-12708 was utilized in the study. A part of the thermoelectric generator used in the experiment is seen in Figure-2. Utilizing an inverter in the experiment ac electric current was converted to dc electric current (220 Vac, 50 Hz).

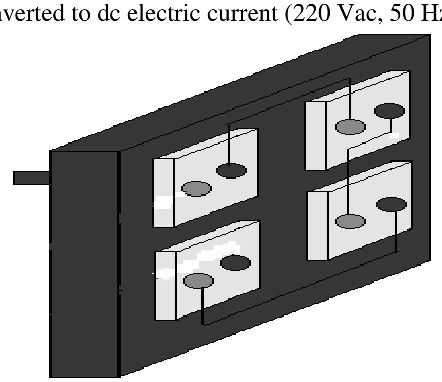

Figure-2. A part of the thermoelectric generator utilized in the experiment.

It is necessary that the system must be supplied by a heat source giving continuous heat energy in order to get continuous electric current from the thermoelectric generator. The heat transfer by means of conduction method takes place for the power generation in the arrangement.

III. Experimental Results

To recover the waste heat energy in some quantity thrown from a heat source was contemplated in this work. The results were obtained using the experimental setup. The applied temperatures T1 and T2, and the obtained potential differences Vdc are seen in Table-1.

Table-1. T1 and T2 temperature values of hot and cold fluids respectively and the obtained Vdc voltage values.

Temperature of hot water T_1 (°C)	**Temperature of cold water T_2 (°C)**	**Obtained Voltage V_o (Volt)**
50	26	0,55
49	26,4	0,56
48	26,5	0,53
47	26,8	0,50
46	27,3	0,45
45	27,3	0,44
45	27,4	0,41
44	27,5	0,40
44	27,6	0,38
43	27,7	0,37
43	27,8	0,35
42	27,9	0,34
41	28	0,31
40	28,1	0,28
39	28,2	0,26
38	28,1	0,24
38	28,1	0,21
37	28,1	0,20
37	28,2	0,18
36	28,1	0,17

Moreover, the obtained values of output power P_o (mW) and temperature difference ΔT (°C) are given in Table-2.

Table-2. The obtained output powers P_o (mW) against the applied temperature difference ΔT (°C) in the experiment.

ΔT(°C)	**P_o (mW)**
22,6	21,28
21,5	19,61
20,2	16,75
18,7	14,35
17,7	13,20
17,6	11,84

16,5	10,80
16,4	10,03
15,3	9,43
15,2	8,71
14,1	8,12
13	6,91
11,9	5,46
10,8	4,78
9,9	4,00
9,9	3,19
8,9	2,88
8,8	2,41
7,9	2,09

While ΔT temperature difference is maximum (24°C), the obtained voltage is 0.55 Vdc as seen in Table-2. While ΔT temperature difference is minimum (namely 7.9°C), the obtained voltage is only 0.17. While average ΔT temperature difference is 15.3°C, the obtained voltage is 0.37 Vdc. The relation of the values of output power P_o (mW) and temperature difference ΔT (°C) is seen in Figure-3.

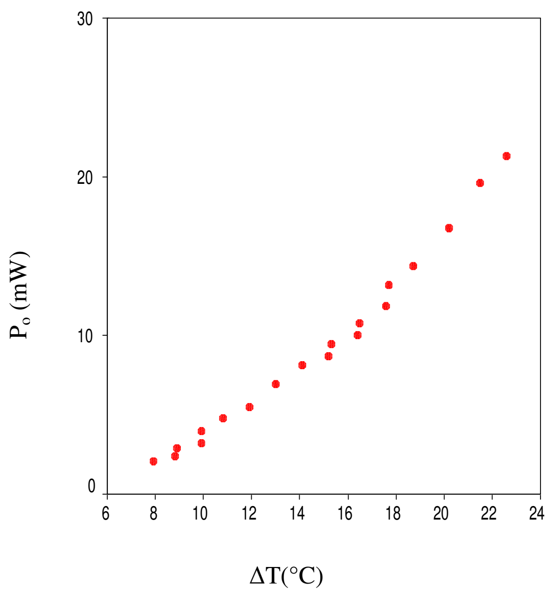

Figure-3. Illustration the relation between the values of ΔT(°C) and P_o (mW).

As seen in Figure-3, while increasing the temperature values ΔT(°C), the obtained power P_o (mW) also increases. From the experimental data, the related equation was approximately obtained as follows;

$$Y=7.48x+0.77 \quad (2)$$

According to the equation, it is seen that there is a linearity between the values of ΔT(°C) and obtained power P_o (mW). As seen from the Equation (2), higher temperature differences (ΔT) must be applied in order to get higher powers from the system. But, nevertheless, the converting system must be in its working temperature range because the thermoelectric converting materials have been selected according to their application fields.

IV. Conclusion

The affirmative results obtained from the experimental data show that electrical energy can be obtained by means of TEC units thrown from chimneys in form of heat energy in the experimental study. It is seen that the voltage values Vdc decreases with respect to decreasing values of temperature differences ΔT applied on the TEC units as seen in Table-1 and 2. At the end of experiment, it is seen that this method is suitable for the generation of electrical energy in some quantity from the heat energy such as a chimney system and it can be developed for future works.

V. References

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