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Automobile Waste Heat Recovery System Using Thermoelectric Generator

Vaibhav R. Patel[1], Mit C. Patel[2]

[1](Silver Oak college of Engineering & Technology, India)
[2](Mechanical Department, Silver Oak College of Engineering & Technology, India)
[1]Corresponding Author: vaibhavpatel3930@gmail.com

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Abstract: *Energy crisis is major problem in this era. Thermoelectric generator is a promising solution for this problem. This research aims to recover waste heat energy from automobile by converting it into electrical energy using thermoelectric generator. Thermoelectric generator is applied at automobile exhaust system to produce electrical energy from heat energy directly with a phenomenon called see-beck effect. This work develops a heat exchanger model with thermoelectric generator for automobile waste heat recovery in which heat source and cold sink are actually modeled. Main emphasis is put on effective temperature difference across the TEGs to get better performance of the exhaust waste heat recovery system. This research shows that the model is able to produce up to 2.67 W energy using 3 Numbers of TEGs in this design.*

Keywords*: Thermoelectric Generator, Automobile Exhaust system, Automobile waste heat recovery, see-beck effect*

I. Introduction

In recent years, research on automobile waste heat recovery is very active because of global energy crisis. Among various waste heat recovery techniques, thermoelectric generators are considered very promising field as they have the advantages of silent operation, simplicity, no moving parts, pollution free and absence of working fluid which makes it the perfect research area for future. Thermoelectric generators are working on the principle of see-beck effect of semiconductors through which it can directly convert heat energy into electrical energy.

In the case of TEG for waste heat recovery power generation, there have been many designs which are capable of obtaining power generation through this technique. Ikoma et al. [3] applied an array with 72 pieces of TEG module to gasoline engine vehicles. By maintaining 563 K temperature difference between hot and cold sides of the module, 35.6 W electric power was generated. Niu et al. [1] constructed an experimental TEG unit with parallel-plate heat exchanger, hot liquid and cold liquid, the two operation parameters such as the hot fluid inlet temperature and flow rate are found to affect the power output. He et al. [2] presented that a thin- plate exchanger should be used in the TEG system owing to its high-power output. They expected to improve the performance of automobile TEG systems by further increasing the heat amount transferred into the TEG module.

II. Model

Geometric model is prepared for the automobile exhaust waste heat recovery system. In this model, a rectangular duct is designed with hot side and cold side aluminum fins attached. In this design, thermoelectric generators (TEGs) are placed between hot side aluminum fins and cold side aluminum fins which increases the heat transfer rate across the TEGs. Temperature difference across the TEGs is the significant parameter for see-beck effect. Higher the temperature difference, Higher power produced from the system. In this design, rectangular duct is for passing exhaust gases from automobile exhaust system.

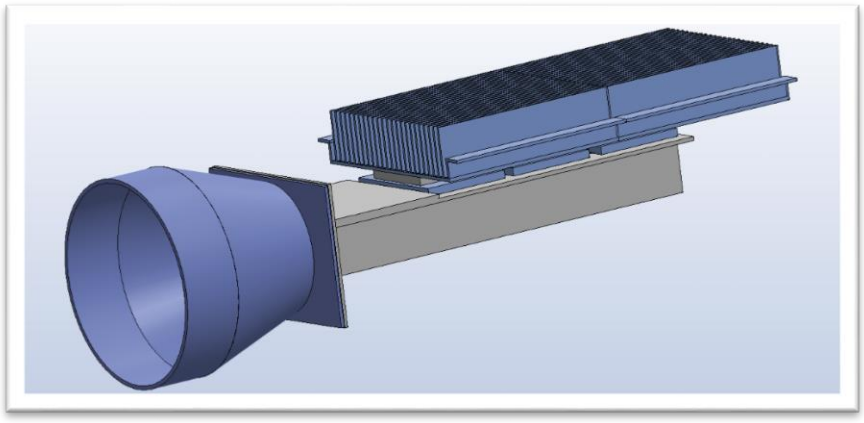

Fig1 Geometric model

This geometric model is prepared in solid-works software.

III. Experimental Investigation

Experimental set up is prepared based on geometric model from solid-works. In this set up, a rectangular duct is made in which hot side fins are fitted inside the duct such that upper surface of the fins comes in direct contact with TEGs placed. In this research 3 numbers of TEGs are used which are placed on the duct. Above those TEGs, cold side aluminum fins are placed.

TEGs are made of semiconductors which can convert heat energy into electrical energy with the see-beck effect. Here, a TEG is shown in Fig 2 which have two surfaces. One surface will be placed on hot side and one surface will be placed on cold side. These three TEGs are connected in series to get higher voltage during experiment.

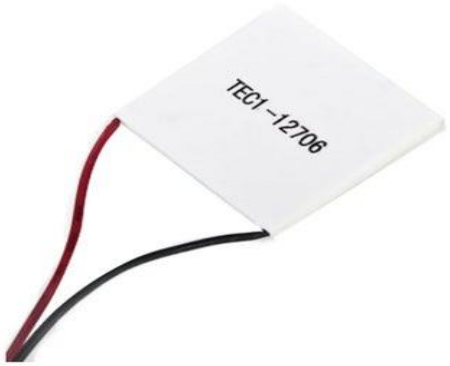

Fig 2 Thermoelectric Generator

Experimental investigation takes place with using actual automobile with 1.2 Liter I.C. Engine of a car. In this experiment, the exhaust recovery model (Fig 3) is attached at the end of automobile exhaust system. With the engine running in healthy condition, readings are taken.

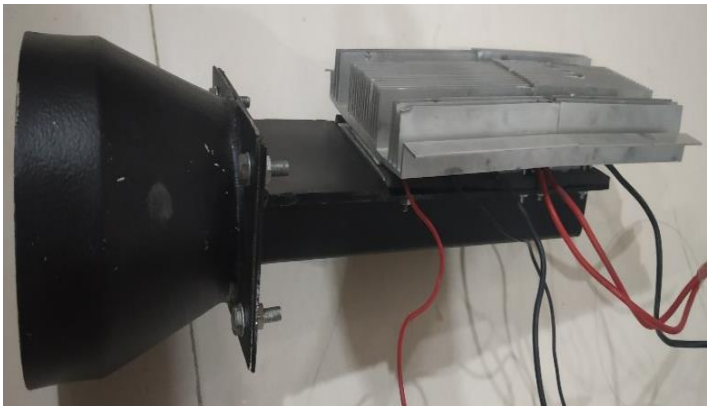

Fig 3 Experimetnal model

Table 1 shows the measurements taken during experiment in which velocity of exhaust gases are taken as input parameter and power produced with the help of three TEGs are taken as output result.

Table 1 Power Produced

Sr no.	Velocity of Exhaust Gases (m/s)	Power (watt)
1	5.18	1.458
2	7.4	2.298
3	11.1	2.526
4	14.8	2.673

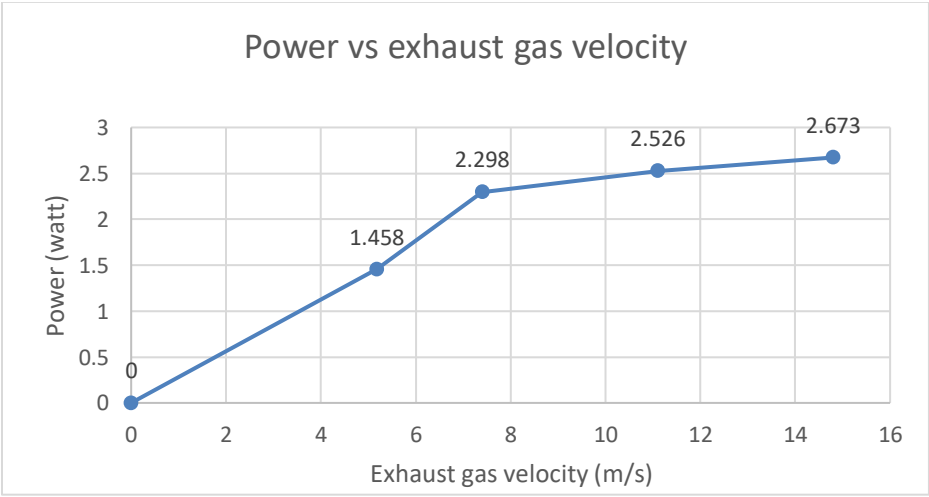

Fig 4 graph of power produced vs exhaust gas velocity

IV. Results and Discussion

This research shows that this design is able to produce power up to 2.67 watt using only 3 number of TEGs in this design. Table 1 and graph shows that with the increase in velocity of the exhaust gases, power produced also increases.

V. Conclusion

Based on the above experiment and research, it is concluded that velocity of hot gases passing through the system significantly affect the performance of the system. Other than that temperature falls at the end of the automobile exhaust system which can be improved by putting this design on the muffler where temperature will be maintained at higher degree.

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