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Experimental Analysis of Thermoelectric Generation using Different Modes

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ABSTRACT

The waste heat from energy company consumption sectors, when rejected into atmosphere, are useless and it contributes to global warming. Nowadays industrial activities and energy sectors (power stations, oil refineries, coke ovens, etc.) are the most energy consuming sectors worldwide and, consequently, the responsible for the release of large quantities of industrial waste heat to the environment by means of hot exhaust gases, cooling media and heat lost from hot equipment surfaces and heated products. Recovering and reusing these waste heats would provide an attractive opportunity for a low-carbon and less costly energy resource. Moreover, reducing the environmental impact. Thermoelectric generator is the one of the methods which helps to recover this waste heat, designing of thermoelectric generator was based on the range of temperature produced in industries and the objective is to generate optimum power with optimum material, COMSOL Multiphysics software is the tool, which has been used to get the simulation results. High manganese silicide (HMS) has been chosen according to the properties of waste heat from industries, the simulation results shows that thermoelectric generator can be a good way to recover waste heat from local industries and converted to useful power, for instance to supply small sensing electronic equipment in the plant

KEYWORDS: Thermoelectric generator; Waste heat recovery; Thermoelectric system; Thermoelectric manufacturing; Thermoelectric power generation

1. INTRODUCTION

The manufacturing or process industry consumes vast amount of energy and around its half eventually lost as waste heat to the environment in the form of flue gases and radiant heat energy. There is a clear need to improve the situation by capturing at least some of the waste heat (harvesting) and converting it back into useful energy such as electricity to supply for instance small sensing electronic devices of the plant system, to increase the efficiency of system. Also, recuperating it, helps to reduce the emission which contributes to global warming. There are a lot of technologies which are being used to capture the waste heat; these different methods which are normally used to recover waste heat, differ each other with respect to the intensity of waste heat, for instance some of them are not adequate for low temperature, others require moving part to converts waste heat into useful energy, and others are not environment friendly. This study is focusing on thermoelectric generators, which use thermoelectric effects to produce power.

This technology is an interesting one, for direct heat to power conversion. Thermoelectric generators present potential applications in the conversion of low-level thermal energy into electrical power. Especially in the case of waste heat recovery, it is unnecessary to consider the cost of the thermal energy input, and there are additional advantages, such as energy saving and emission reduction, so the low efficiency problem is no longer the most important issue that we have to take into account. Thermoelectric generators work even at low temperature applications, there are a renewable energy sources and do not produce noise. This project is focusing on the design, modelling and manufacturing thermoelectric generator for waste heat recovery applicable in local industries, by using COMSOL Multiphysics software as the tool. The design is based on the shape of the chimney, environment and cost of manufacturing; cost is found by considering all materials used in process, this helps to give conclusion weather the system should be adopted in local processing industries.

2. LITERATURE REVIEW

M G Jadhav, J S Sidh u Types of thermoelectric generator: - thermoelectric generator materials and their temperatures range is as follows. There are number of materials known till date but few are identified as thermoelectric materials. This project aims to find a possible way to recover the waste heat from the exhaust of I.C. engine as well as to design and fabricate one such system to serve the aim. Experimentally it is found that when two thermoelectric generators are connected in series. This generated power either directly used to run some auxiliary devices of an automobile or may be stored in the battery and used later. The engine performance is unaffected by the designed system because the exhaust manifold which does not affected the working of engine.

B. Orr a, A. Akbarzadeh, M. Mochizuki, R. Singh Both thermoelectric generators and heat pipes are solid state, passive, silent, scalable and durable. Heat pipes can reduce the thermal resistance between the thermoelectric generator and gases. Heat pipe can reduce the pressure losses in the gas stream due to reduced fin surface area. Heat pipes can be used for temperature regulation of the thermoelectric generator. Thermoelectric generator has limitations such as relatively low efficiency and maximum surface temperatures.

Y.Y Hsiao, W.C. Chang, S.L. Chen The simulation result of mathematical model has been verified with experimental data and showing consistence. Under designed working condition, a maximum power of 0.43 W was generated at 0.35 a current. Maximum power density was 511.3 W/m^2. The output voltage, according to the seebeck effect, also increased as the temperature difference increase.

K. Zeb, S.M. Ali, B. Khan, C.A. Mehmood, N. Tareen, W. Din, U. Farid, A. Haidera Although thermoelectric generator has high capital cost but its operational cost makes it feasible for implementation on large scale. Recently, thermoelectric generator is extensively commercializing in various areas, i.e., domestic and industrial electric power generation, refrigeration, biomedical, aerospace, military, automobiles, watches, and remote applications. The thermoelectric generator series and parallel arrangement increases voltage and current capability as well as wattage of module respectively.

X. Liu, Y.D. Deng, Z. Li, C.Q. Su Because of the increasing emphasis on environmental protection, applications of thermoelectric technology are being extensively studied. How to transfer the waste heat from exhaust automotive thermoelectric generator system was constructed and large output power of 944 W obtained. To further improve the power generation, the exhaust pipe needs to be improved to decrease the effect of thermal contact and increase the hot-side temperature. Moreover, the connection method could also be optimized. To concern the optimization design, energy conversion efficiency and system power capacity that would be very important for prototype vehicle in next generation.

Eid S. Mohamed the TEG system was mounted to the exhaust pipe of a light diesel vehicle in order to supply heat. The airflow around TEG has been simulated in the cold side to reject heat. The exhaust gas temperatures increase as a function of engine speed. It can be found that maximum temperatures of input and outlet are 340

°C and 300 °C at 3750 rpm respectively. The TEG output power is proportional to the vehicle engine speed; the maximum TEG output power is approximately 214W at 3750 rpm. The experimental results shown indicate that a reduction of exhaust gas emissions with actuation thermoelectric generator system.

Jihad G. Haidar, Jamil I. Ghojel, "waste heat recovery from the exhaust of low- power Diesel engine using thermoelectric generators, 20TH international conference on thermoelectric (2001), p413-417 From literature survey 1 we studied how to recover waste heat and how to utilize waste heat from different industries

There are numerous works that have age proceng machine learning algorithms.

J.E. Cross[1] has investigated methods to recover the maximum amount of available information from an image. Some radio frequency and optical sensors collect large-scale sets of spatial imagery data whose content is often obscured by fog, clouds, foliage and other intervening structures. Often, the obstruction is such as to render unreliable the definition of underlying images. Various mathematical operations used in image processing to remove obstructions from images and to recover reliable information were investigated, to include Spatial Domain Processing, Frequency Domain Processing, and non-Abelian group operations.

John C. Russ[2] has investigated techniques of image processing. These are operations that start with a grey scale (or color) image and return another grey scale image. The next chapter will deal with some additional techniques that operate on grey-scale images for purposes of locating feature edges in the context of isolating features for measurement.

J. M. White[3] and G. D. Rohrer, "Image Thresholding for Optical Character Recognition and Other Applications Requiring Character Image Extraction," in IBM Journal of Research and Development have researched on Two new, cost-effective thresholding algorithms for use in extracting binary images of characters from machine- or hand-printed documents.

However there has been little to no work put into the viability of image processing to achieve electronic automated invoicing.

3. EXPERIMENTAL SETUP

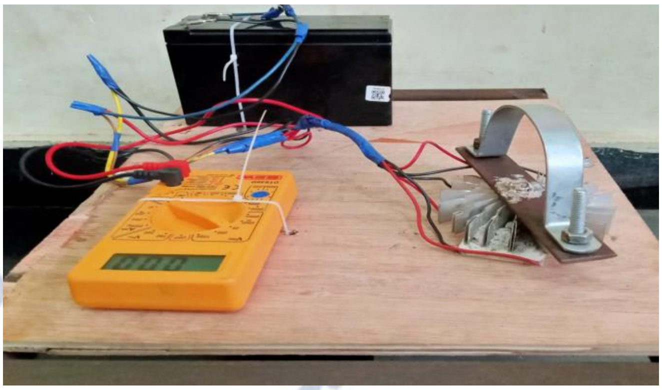

Fig 1 Experimental Setup

Thermoelectric generator is a useful and environment friendly device with the advent of semiconductor materials the efficiency of a TEG can even be an alternative for the conventional heat engines. For the sustainable development of humankind and to stop climate change as outlined in the Kyoto Protocol.

In above fig 1 it shows the connections of the components. A TEG produces a voltage when there is a temperature difference between the hot- side and cold-side of TEG. Thermoelectric effect includes See beck effect, Peltier effect and Thomson effect; it also accompanies with other effects, such as Joule an effect and Fourier effect. Thermoelectric generation is a technology for directly converting- thermal energy into electrical energy.

The waste heat source is selected, which could be from a variety of sources such as industrial processes, engines, and solar energy. The temperature of the waste heat source is measured and characterized to ensure it is suitable for TEG operation. The Electrical connections are made to the TEG to allow for power generation.

The electrical output of the TEG is conditioned to provide a stable and usable source of electrical power. Heat source selection: The waste heat source is selected, which could be from a variety of sources such as industrial processes, engines, and solar energy

4. COMPONENTS

4.1. Peltier

4.2. U Clamp

4.3. Wire

4.4. 12V Battery

4.5. Multimeter

4.1. PELTIER

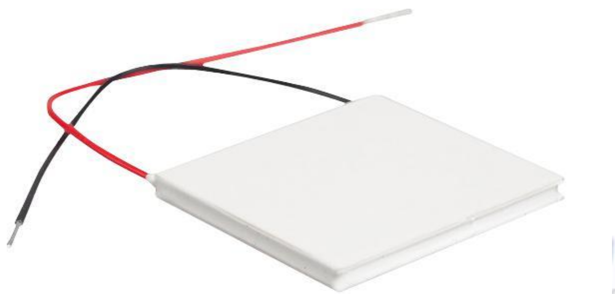

Fig 2 Peltier

Peltier module (thermoelectric module) is a thermal control module that has both "warming" and "cooling" effects. By passing an electric current through the module, it is possible to change the surface temperature and keep it at the target temperature

4.2.U CLAMP

Fig 3 U Clamp

A clamp is a fastening device used to hold or secure objects tightly together to prevent movement or separation through the application of inward pressure.

In the term clamp is United Kingdom often used instead when the tool is for temporary use for positioning components during construction and woodworking; thus, a G clamp or a sash clamp but a wheel clamp or a surgical clamp.

4.3. WIRE

A wire is a flexible strand of metal. Wire is commonly formed by drawing the metal through a hole in a die or draw plate. Wire gauges come in various standard sizes, as expressed in terms of a gauge number.

Wires are used to bear mechanical loads, often in the form of wire rope. In electricity and telecommunications signals, a "wire" can refer to an electrical cable, which can contain a "solid core" of a single wire or separate strands in stranded or braided forms.

4.4.12V BATTERY

Fig 4 12V Battery

A 12-volt battery has six single cells in series producing a fully charged output voltage of 12.6 volts. A battery cell consists of two lead plates a positive plate covered with a paste of lead dioxide and a negative made of sponge lead, with an insulating material (separator) in between. Your 12V battery system will power most of your basic systems like your lights and some appliances in your RV. You'll charge this battery system while plugged into shore power and draw from it while traveling or boondocking.

4.5. MULTIMETER

Fig 5 Multimeter

A multimeter is a measuring instrument that can measure multiple electrical properties. A typical multimeter can measure voltage, resistance, and current, in which case it is also known as a volt-ohm-milliammeter (VOM), as the unit is equipped with voltmeter, ammeter, and ohmmeter functionality. Some feature the measurement of additional properties such as temperature and capacitance.

5. RESULTS & DISCUSSION

The waste heat from energy company consumption sectors, when rejected into atmosphere, are useless and it contributes to global warming. The TEG helps to convert the waste heat into useful energy source.

In this study the TEG is placed in contact with the waste heat source. The U-clamp is fixed the TEG, that can be placed in the vehicle exhaust. On the other side the TEG is connected to the multimeter to measure the voltage. The temperature sensor is placed in the heat source to measure the temperature.

The below represented graphs will show the relation between Temperature & Voltage with respect to Time. Two sources have been taken to test the kit.

5.1. IRONBOX

TIME-TEMPERATURE

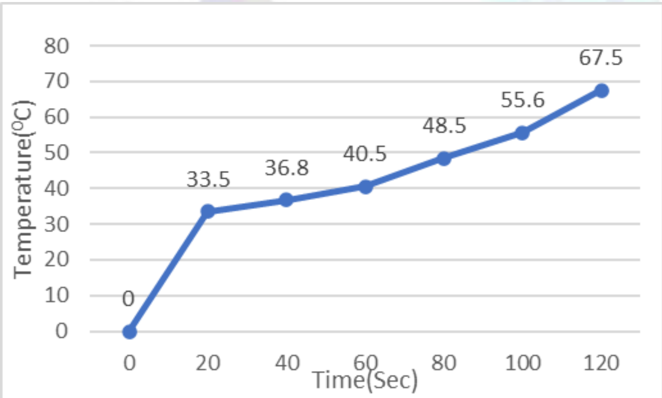

Fig 6 Time Temperature

In the fig 6 it shows the relation between Time and Temperature. The temperature increases gradually with respect to time. From the temperature 0^{0}C. At 0 sec the temperature is 0^{0}C.

At 40 sec the temp is 36.8^{0}C. At 80 sec the temperature raised to 48.5^{0}C. After 100 sec the temperature is 55,6^{0}C and so on. It reaches the maximum of 67.5^{0}C at the end point.

VOLTAGE-TIME

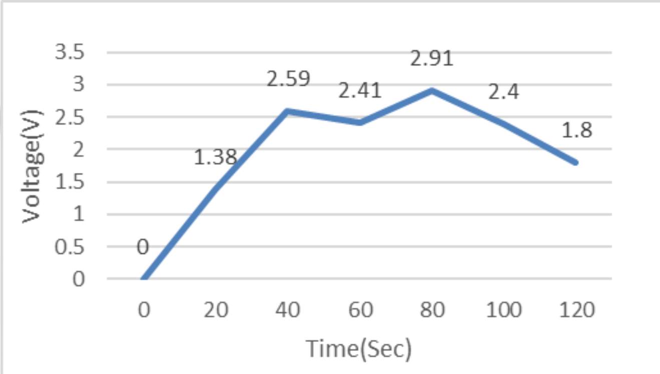

Fig 7 Voltage Time

The above-mentioned fig 7 the relation between the voltage and time has been shown. At initial state both the conditions remain constant. After 20 sec there is a gradual rise in voltage state as 1.38V. After 60 sec the rise in voltage remains 2.41V. After 100 sec the temperature gradually dropped to 2.4V Once the Ironbox reaches the maximum temperature it turns OFF. So, the gradual decrease in the voltage with respect to time.

TEMPERATURE-VOLTAGE

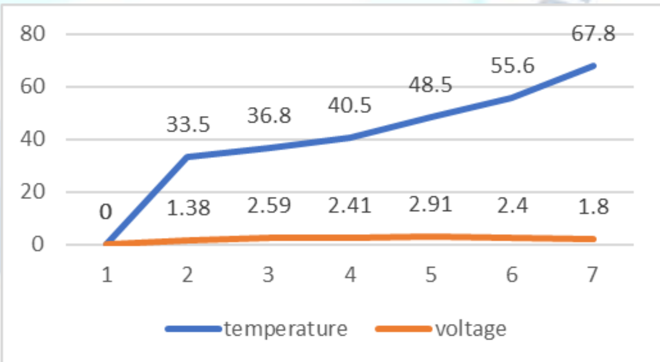

Fig 8 Temperature Voltage

In the fig 8 the comparison between the two graphs fig 6 & fig 7. when the gradual rise between the voltage occurs with time basis the comparision is made with temperature. Which shows the state of variation among them.

5.2. HEAT FLAME

TIME-TEMPERATURE

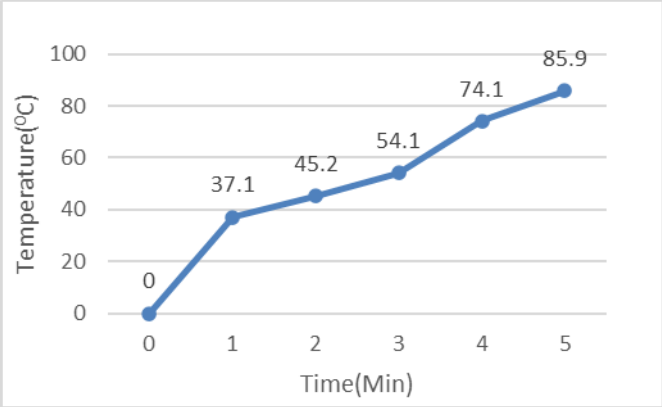

Fig 9 Time Temperature

In the fig 9 it shows the relation between Time and Temperature. The temperature increases gradually with respect to time. At 0 sec the temperature is 0^{0}C. At 2 min the temp is 45.2^{0}C. At 3 min the temperature raised to 54.1^{0}C. After 4 min the temperature is 74.1^{0}C and so on. From the temperature 0^{0}C it reaches the maximum of 85.9^{0}C at the end point

VOLTAGE-TIME

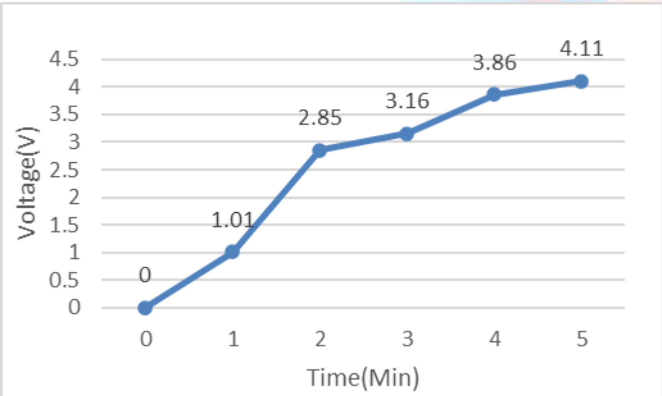

Fig 10 Voltage Time

The above-mentioned fig 10 the relation between the voltage and time has been shown. At initial state both the conditions remain constant. After 1 min there is a gradual rise in voltage state as 1.01V. After 3 min the rise in voltage remains 3.16V. After 4 min the temperature gradually dropped to 3.86V. In this case when the heat flame will heat the TEG constantly. So, the voltage drops never occur in this case.

TEMPERATURE-VOLTAGE

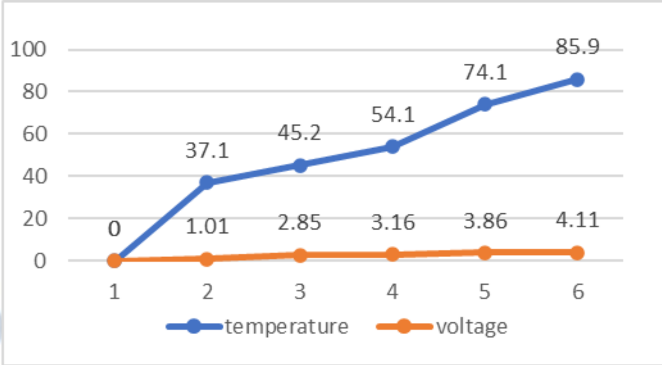

Fig 11 Temperature Voltage

In the fig 11 the comparison between the two graphs fig 9 & fig 10. It shows the variation between temperature and voltage. Both temperature and voltage are compared and both have been increased.

6. FUTURE SCOPE AND CONCLUSION

As comparing the both cases (Ironbox & Heat flame) the heat flame (85.9^{0}C) produces the more amount of heat than the Ironbox (67.8^{0}C). So, the production of voltage is also high in Heat flame.

Vast quantities of untapped natural heat are available together with huge amount of waste heat, most of which is below 1000^{0}C and is discharged into the environment. Thermoelectric generation is an environmentally friendly technology which can convert this unused heat, and in particular lower temperature heat, into electricity. It resulted in research and development in this area of thermoelectric technology progressing rapidly in the near future thermoelectric waste heat recovery make a significant contribution over a wide range of applications, in reducing fossil fuel consumption and global warming.

As the conclusion by comparing the two modes i.e., Ironbox and Heat flame, the Heat flame produces the maximum heat of 85.9^{0}C with the voltage of 4.11V.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

References

[1] C.Q. So, W.S.Wang, X.Liu, Y.D.Deng, Simulation and experimental study on thermal optimization of the heat exchanger for automotive exhaust based thermoelectric

generators, Case Studies in Thermal Engineering 4(2014)85–91.
[2] Chengjiang Bai, Hong liang Lu, Ting Wu, XianglinYin, XunSh, Lihong Chen, Numerical and experimental analysis for exhaust heat exchangers in automobile thermoelectric generators, Case Studies in Thermal Engineering 4(2014)99– 112.
[3] Ting Ma, Jaideep Pandit, Srinath V. Eked, Scott T. Huxtable, Samruddhi Deshpande, Qiuwang Wang, Study on thermoelectric hydraulic performance of longitudinal vortex generators in a large- scale thermoelectric power generator, Energy Procedia 75 (2015) 639 – 644.
[4] Bari, S N Hossain, Design and Optimization of Compact Heat Exchangers to be Retrofitted into a Vehicle for Heat Recovery from a Diesel Engine, Procedia Engineering 105 (2015) 472 – 479.
[5] M. Taka Shiri, T. Shirakawa, K. Miyazaki, H. Tsukamoto Fabrication and characterization of bismuth– telluride-based alloy thin film thermoelectric generators by flash evaporation method A 138 (2007) 329–334 |
[6] Bongkyun Jang, Seung woo Han, Jeong-Yup Kim Optimal design for micro thermoelectric generators using finite element analysis Microelectronic Engineering 88 (2011) 775– 778
[7] P. Phagwa, A. Vora-Ud, T. Setiawan Invention of Low-Cost Thermoelectric Generators Procedia Engineering 32 (2012) 1050 – 1053
[8] M G Jadhav J S Sidhu, "Design and Fabrication of Silencer Waste Heat Power Generation System Using Thermo-Electric Generator", International Journal of Advanced Mechanical Engineering. ISSN 2250-3234 Volume 7, Number 1 (2017), pp. 1-14
[9] B. Orr a, A. Akbar Zadeh, M. Mochizuki, R. Singh," A review of car waste heat recovery systems utilising thermoelectric generators and heat pipes", (IJEIT) Volume 2, Issue 12, June 2013
[10] Y. Y Hsiao, W.C. Chang, S.L. Chen, "A mathematical model of thermoelectric module with application on waste heat recovery from automobile engine", Energy 35 (2010) 1447–1454
[11] K. Zeb, S.M. Ali, B. Khan, C.A. Mehmood, N. Tareen, W. Din, U. Farid, A. Haider A survey on waste heat recovery: Electric power generation and potential prospects within Pakistan", Renewable and Sustainable Energy Reviews (2016), http://dx.doi.org/10.1016/j.rser.2016.11.096
[12] Hiao-kang Ma, Ching-Po Lin, How-Ping Wu, Chun-hao Peng, Chai-Cheng Hsu," Waste heat recovery using a thermoelectric power generation system in a biomass gasifier", Applied Thermal Engineering (2014), http://dx.doi.org/10.1016/j.applthermaleng.2014.09.