JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Electricity Generation from Waste Heat of Thermal Power Plant by Using Thermoelectric Generator

Anusha M K[1] , Kavya H S[2] , Kiran H S[2*] , Ruchitha Y A[2] , Sahana N[2]

[1]Assistant professor, Department of Electrical and Electronics Engineering, PES College of Engineering, Mandya, India 571401
[2] Research Students, Department of Electrical and Electronics Engineering, PES College of Engineering, Mandya, India 571401

Abstract: This paper presents a study on the utilization of waste heat from a thermal power plant through the implementation of a thermoelectric generator (TEG) to generate electricity. The TEG utilizes the Seebeck effect, where a temperature gradient across a semiconductor material produces an electric current. By placing TEG modules in high temperature areas of the power plant, waste heat can be directly converted into electricity. The study focuses on the design, optimization, and performance evaluation of the TEG system. It considers parameters such as the selection of suitable thermoelectric materials, the arrangement and configuration of TEG modules, and the overall system integration. Various thermoelectric materials are reviewed to identify the most suitable candidates with high conversion efficiency and temperature stability. The optimization process involves determining the optimal operating temperature range for the TEG system based on the thermal characteristics of the waste heat source. The arrangement and configuration of TEG modules are also optimized to maximize power output and system efficiency. Performance evaluation includes measuring key metrics like power output, efficiency, and conversion efficiency. The study investigates the impact of operating conditions, such as temperature gradients and heat flow rates; on the system's performance. The results demonstrate the feasibility and potential of using a TEG system to harness waste heat from thermal power plants for electricity generation. This research contributes to the development of sustainable energy solutions by improving overall power generation efficiency and reducing reliance on fossil fuels. Additionally, the utilization of waste heat through TEG systems can help mitigate greenhouse gas emissions and promote a greener and more sustainable energy.

Keywords: Thermoelectric power, Electrical power, Thermoelectric power generation, seebeck effect.

I. INTRODUCTION: The generation of electricity from waste heat has emerged as a promising approach to improve the energy efficiency and sustainability of thermal power plants. Conventional power generation processes, such as those based on fossil fuels, often suffer from significant heat losses, leading to reduced overall efficiency and increased environmental impact. Waste heat recovery technologies aim to capture and convert this otherwise wasted heat into useful electrical energy, thereby enhancing the efficiency of power generation and reducing greenhouse gas emissions. One such technology that shows great potential is the thermoelectric generator (TEG) [3], which utilizes the principles of the Seebeck[6] effect to directly convert temperature gradients into electrical power [11]. The Seebeck effect is based on the phenomenon that certain materials generate an electric voltage when subjected to a temperature difference across their surfaces. By exploiting this effect, TEGs offer a direct and efficient means of converting waste heat into electricity without the need for mechanical components or moving parts. The application of TEGs [8] in thermal power plants presents a unique opportunity to harness waste heat and offset a portion of the electricity consumption within the plant. By integrating TEG modules into high-temperature areas, such as the flue gas path or exhaust systems, the waste heat can be efficiently converted into electrical power. This approach not only improves the overall energy efficiency of the power plant but also reduces the dependence on external electricity sources, resulting in economic and environmental benefits.

1.1Objective: To build a device which can efficiently convert the wasted heat energy into electricity at low cost.To reduce the heat radiation and to control global warming.

1.2 Proposed system: Thermoelectric Generators are basically used in where the power production is less. In automobile vehicle produce heat that can be used for generating electricity by using TEG. Recharge the battery where ever waste heat is obtained. By using proper heat sink material help to increase the output voltage.

A concept of power generation system using heat pipe and thermoelectric generators was developed uniquely for waste heat recovery based on counterflow type system in the School of Aerospace, Mechanical and Manufacturing Engineering, RMIT University. The system is composed of TEG sandwiched between two copper blocks containing 4 heat pipes to transfer the heat from lower duct to heat up one side of TEG and then discharge the heat to upper duct such that the other side of TEG is cooled down. The air flowing through the duct is facilitated by the fans placed at the inlet of the two ducts.

The variable-speed fan is placed at the inlet of the upper duct while the fixed-speed fan is placed at the inlet of lower duct. The heat source in lower duct is supplied with a variable-temperature heater placed next to the fixed-speed fan in order to heat up an incoming air to the heat pipes. Due to the heat transfer from the lower and the upper duct of the system, the temperature difference between the TEG will result in power generation due to the temperature gradient. Furthermore, the designed system will likely enable a high recovery ratio of waste heat since the temperature of flowing air over lower heat pipe is increased by the preheated air from the upper heat pipe. The module of thermoelectric cell sandwiched by copper blocksand the proposed concept of the counter-flow type system.

II. Gap identified*:*

After studying below reference we can observe that the temperature difference between the flue gas entering and leaving an air preheater, as well as the temperature of the atmospheric air fed into the preheater. This information can be used to harness the waste heat from the flue gas and transfer it to the incoming air, thus increasing the efficiency of the overall system. By utilizing the temperature difference between the hot flue gas (120-150°C) and the cold atmospheric air (30°C), you can implement a heat exchange process in the air preheater. This can be achieved by passing the incoming air through a heat exchanger where it is heated by the waste heat from the flue gas. The heat exchanger allows for the transfer of thermal energy from the hot flue gas to the colder air stream.

III. Methodology:

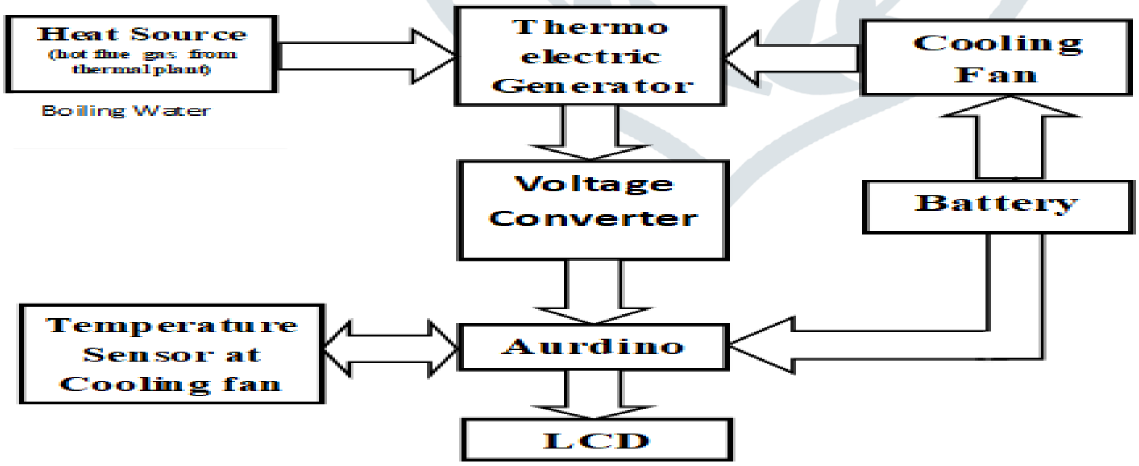

Fig (1) Block diagram of thermoelectric module Module Description:

- Thermo electric generator is sandwiched between heat source taken from hot flue gas from thermal power plant and cooling fan.
- Voltage generated is fed to voltage converter.
- Then is fed to Aurdino which measures the generated voltage.

- Thermal sensor takes supply from Aurdino and gives the temperature of the cold body i.e., cooling fan here.
- Then Aurdino is connected to LCD display which displays the value of generated voltage and temperature of cold body.

IV. Proposed Block Diagram:

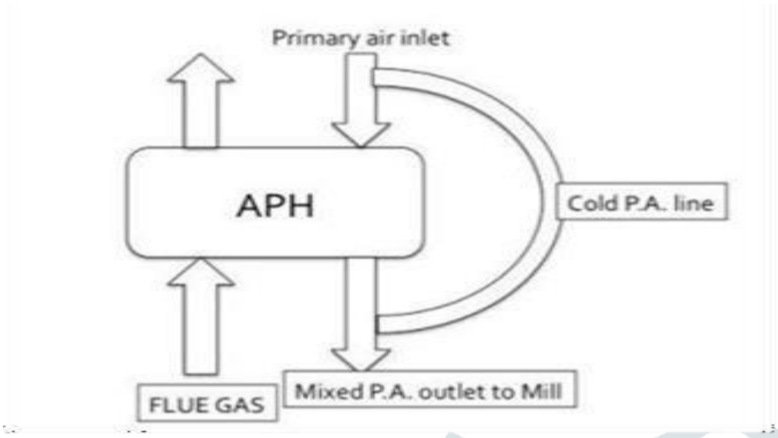

Fig (2) Current arrangement of air pre heater

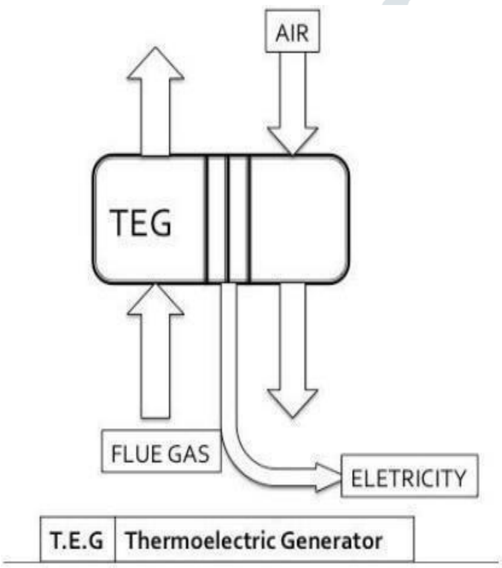

Fig (3) Replacement of Air-preheater by Thermoelectric generator

This paper proposes to replace the air-preheater with thermoelectric generator. There will be lots of benefits for this as follows: We do not have to supply energy in order to operate air preheater that is 10 kilowatts.

(a) For temperature regulation of air-preheater outlet, the cold primary air pipe is bifurcated before entering the airpreheater and re-joins the heated primary air pipe after it passes through air-preheater as shown in figure 4. Continuous regulation of mass flow rate of air in between cold primary air and hot primary air is maintained in order to get desired outlet primary air temperature. This is done in order to limit the temperature of primary air so that coal does not get ignited in pulveriser itself.

(b) The energy getting lost after air preheater from flue gases can also be utilized.

Hardware Components:

- Aurdino Uno
- Thermoelectric Generator
- Resistor
- LCD

- Battery
- Step Up Module
- Temperature sensor

- **Aurdino Uno:** The Arduino Uno is an open- source microcontroller board based on the Microchip ATmega328P microcontroller (MCU) and developed by Arduino.cc and initially released in 2010. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits

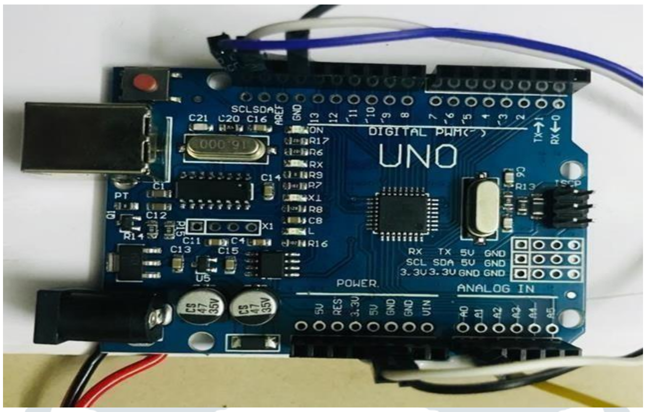

Fig (4) Arduino Uno

 Thermoelectric Generator: A thermo electric generator (TEG), also called aSeebeck generator, is a solidstate device that converts heat flux (temperature differences) directly into electrical energy through a phenomenon called the Seebeck effect (a form of thermoelectric effect). Thermoelectric generators function like heat engines, but are less bulky and have no moving parts.

Fig (5) Thermoelectric Generator

- **Resistor:** A resistor is a passive two- terminal electrical component that implements electrical resistance as a circuit element. In
electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses. High- power resistors that can dissipate many watts of electrical power as heat may be used as part of motor controls, in power distribution systems, or as test loads for generators.

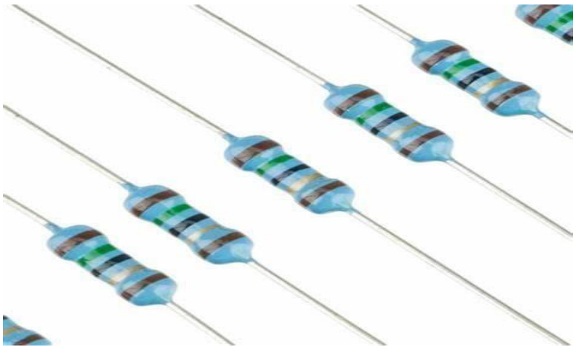

Fig (6) Resistor

- **LCD:** 16×2 LCD is 32 digits display screen for all kinds of CMOS/TTL devices. This word comes from the liquid crystal and16X2 represents its screen size. In Liquid crystal display 16×2, there are 2 rows and 16 columns. Besides, 5×8 pixel makes a single digit. Any digit from ASCII code is viewable on the module.

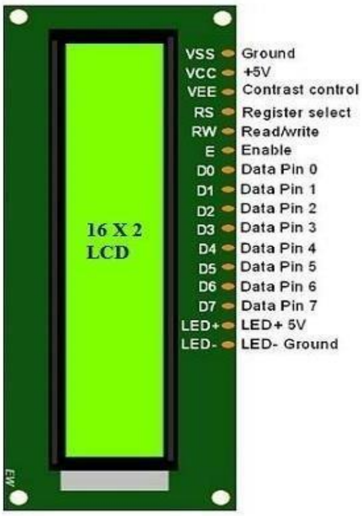

Fig (7) LCD

- **Battery:**

18650 - 3800mAH 3.7V Battery [High Quality]

- **Temperature sensor:** A temperature sensor is a device used to measure temperature. This can be air temperature, liquid temperature, or the temperature of solid matter. There are different types of temperature sensors available and they each use different technologies and principles to take the temperature measurement**.**

Fig (8) Temperature sensor

- **Step Up Module:** XL6009 DC-DC Step-Up Converter Performance Ultra LM2577 Booster.

Circuit Board: This CN6009 XL6009 DC – DC
Step-up converter module is a non-isolated step-up (boost) voltage converter featuring adjustable output voltage and high efficiency. The module uses the second generation of high frequency switching technology
XL6009E1 core chip performance than the first- generation technology LM2577. XL6009 boost module at a lower cost, superior performance.

It equips 4A high-efficiency MOSFET switches, to provide a conversion efficiency of up to 94%. High switching frequency 400 KHz, can use a small -capacity filter capacitors that can achieve very good results.

Fig (9) Step up module

Result and Conclusion:

We carried out an experiment that entailed measuring the difference in temperature between the cold ambient air's temperature of 30 degrees Celsius and the hot flue gas's temperature of 150 degrees. A 120-degree Celsius temperature differential was the effect of this. We fed the thermoelectric generators this gradient of 120 degrees Celsius, which resulted in an output voltage of about 4V.Concerns about emissions, especially global warming, and electricity supply constraints have prompted extensive research into new electrical power generation technologies. Furthermore, a significant amount of excess heat is emitted into the atmosphere. Thermoelectric power generation is a promising technique for directly converting waste heat energy to electricity. The rate of heat excess power which thermoelectric generators could explicitly transform into electrical power specifies whether such implementations are small or large. As a result, nanotechnology is predicted to become more prevalent in these applications in the future. The macro-scale waste heat applications included domestic, truck, industrial, and solid waste heat in thermal power plants. By harnessing the waste heat that is typically released into the environment, TEGs offer a promising solution to improve energy efficiency, reduce greenhouse gas emissions, and promote sustainable energy generation.

Future Scope: Although the efficiency of TEGs is low and their installation costs are high, their usage areas are expanding. Thanks to their long-life operation under extreme conditions without requiring maintenance, and their ability to harvest electrical energy from thermal energy. In this paper, the TEG applications for different purposes have been presented. These applications required high costs for installations. Therefore, it has a limited sector. Moreover, TEGs have proven their extreme reliability through these applications. The application of TEGs in various sectors is within certain perspectives. Some of the researchers achieved success in various TEG applications. Interest in these applications has revived with the advent of modern technology that makes it possible to overcome the critical hurdle of TEG applications. In terms of efficiency and environment, current solutions are focused on the development of TEG applications with efficient nanostructured thermoelectric materials with interconnected electrical and thermal properties of these materials, and their new designs can allow for better integration into energy conversion systems**.**

References:

[1] Stecanella, P.A., Faria, M.A., Domingues, E.G., Gomes, P.H., Calixto, W.P. and Alves, A.J., 2015, June. Electricity generation using thermoelectric generator- TEG. In Environment and Electrical Engineering (EEEIC), 2015 IEEE 15th International Conference on (pp. 2104-2108). IEEE.

[2] Champier, D., 2017. Thermoelectric generators: review of applications. Energy Conversion and Management, 140, pp.167181.

[3] Peter, A.J.D., Balaji, D. and Gowrishankar, D., 2013. Waste heat energy harvesting using thermo electric generator. IOSR Journal of Engineering (IOSRJEN) Vol, 3, pp.01-04.

[4] Haidar, J.G. and Ghojel, J.I., 2001. Waste heat recovery from the exhaust of low-power diesel engine using thermoelectric generators. In Thermoelectric, 2001. Proceedings ICT 2001. XX International Conference on (pp. 413-418). IEEE.

[5] Fleurial, J.P., 2009. Thermoelectric power generation materials: Technology and application opportunities. Jom, 61(4), pp.79-85.

[6] Dalala, Z.M., 2016, April. Energy harvesting using thermoelectric generators. In Energy Conference (ENERGYCON), 2016 IEEE International (pp. 1-6). IEEE.

[7] Min, G., and Rowe, D.M., 2002. Recent concepts in thermoelectric power generation. In Thermoelectric, 2002. Proceedings ICT'02. Twenty-first International Conference on (pp. 365-374). IEEE.

[8] Liu, C., Chen, P. and Li, K., 2014, February. A 1 KW thermoelectric generator for low- temperature geothermal resources. In Proceedings, Thirty-Ninth Workshop on Geothermal Reservoir Engineering, StanfordUniversity, Stanford, California.

[9] Sztekler, K., Wojciechowski, K. and Komorowski, M., 2017. The thermoelectric generators use for waste heat utilization from conventional power plant. In E3S Web of Conferences (Vol. 14, p. 01032). EDP Sciences.

[10]Remeli, M.F., Kiatbodin, L., Singh, B., Verojporn, K., Date, A. and Akbar Zadeh, A., 2015. Power generation from waste heat using heat pipe and thermoelectric generator. Energy Procedia, 75, pp.645-650.

[11] Cheng, M.T. and T, H.Z., 2015. Calculation and analysis of acid dew-point temperature in coal-fired boiler gas.

[12] Riffat SB, Ma X. Thermoelectric: A review of present and potential applications. Appl Therm Eng 2003; 23: 913-935.

[13] Omer SA, Infield DG. Design and thermal analysis of two stage solar concentrator for combined heat and thermoelectric power generation. Energy Conversion & Management 2000; 41: 737756.Yadav A, Pipe KP, Shtein M. Fiber-based flexible thermoelectric power generator. J Power Sources 2008; 175: 909-913.

[14] Jinushi T, Okahara M, Ishijima Z, Shikata H, Kambe M. Development of the high-performance thermoelectric modules for high temperature heat sources. Mater Sci Forum 2007; 534-536: 15211524.

[15] Rowe DM, Min G. Evaluation of thermoelectric modules for power generation. J Power Sources 1998; 73: 193-198.

[16] Stevens JW. Optimal design of small T thermoelectric generation systems. Energy Conversion and Management 2001; 42: 709-720.

[17] Rowe DM. Thermoelectric waste heat recovery as a renewable energy source. Int J Innov Energy Syst Power 2006; 1: 13-23.

[18] Rowe DM. Thermoelectric, an environmentally- friendly source of electrical power. Renewable Energy 1999; 16: 12511265.

[19] Yodovard P, Khedari J, Hirunlabh J. The potential of waste heat thermoelectric power generation from diesel cycle and gas turbine cogeneration plants. Energy Sources 2001; 23: 213224.

[20] Chen L, Li J, Sun F, Wu C. Performance optimization of a two-stage semiconductor thermoelectric-generator. Apply Energy 2005; 82: 300-312.

[21] Cengel YA, Boles MA. Thermodynamics: An engineering approach. 6th ed. McGraw-Hill press, New York, 2008, 623-652.

[22] Available from: http://www.ferrotec.com

[23] Available from: http://www.customthermoelectric.com

[24] Min G, Rowe DM, Kontostavlakis K. Thermoelectric figure-of merit under large temperature differences. J Phys D: Appl Phys 2004; 37: 1301-1304.

[25] Available from: http://www.customthermoelectric.com