ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 3, Issue 4, July 2016

CONVERSION OF WASTE HEAT ENERGY FROM INTERNAL COMBUSTION ENGINE USING THERMO ELECTRIC GENERATOR

M.V.Harsha Vardhan

U.G. Student, Automobile Engineering, Acharya Institute of Technology, Bangalore-560 107

harsha9741@gmail.com,

Prashanth.K.P

Assistant Professor, Automobile Engineering, Acharya Institute of Technology, Bangalore-560 107

prashanthkp13@gmail.com

Venkatesha B K

Research scholar, University Visvesvaraya College of Engineering, Bangalore University, Bangalore-560 001

venkatesharvc@gmail.com

ABSTRACT

In the conventional method for generate electricity is converting thermal energy into mechanical energy then to electrical energy. In recent years, due to environmental issues like global warming, emissions, etc., are the limiting factor for the energy resources are required to generate electric power. Thermoelectric generators have emerged as a promising another green technology due to their diverse advantages. Thermo Electric Generator directly converts Thermal energy into Electrical energy. The application of this green technology in converting waste heat energy directly into electrical energy can too improve the overall efficiencies of energy conversion systems. In this paper we attempt to extract the waste heat energy from an automobile IC engine and then convert it into useful electrical energy, thus finally charging a battery.

Keywords: Thermoelectric generator, waste-heat energy, green technology, direct energy conversion, thermocouple, Seebeck effect, Cooling system, Battery.

I. INTRODUCTION

A Thermoelectric generator (TEG) is a solid state device that provides direct energy conversion from thermal energy into electrical energy based on “Seebeck effect”. Normally the energy conversion from thermal to electrical takes place by first converting the thermal energy into mechanical energy and then from the mechanical energy into electrical energy. But if a thermoelectric generator is used then there is a direct conversion from thermal energy to electrical energy is very effective [1] as shown in Fig.1. In 1821 Thomas

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 3, Issue 4, July 2016

Johann Seebeck found that a circuit made from two dissimilar metals with junctions at different temperatures would deflect a compass magnet. Seebeck initially believed this was due to magnetism induced by the temperature difference. However, it was quickly realized that it was an electric current that is induced, which by Ampere's law deflects the magnet. More specifically, the temperature difference produces an electric potential (voltage) which can drive an electric current in a closed circuit. Today, this effect is known as the Peltier–Seebeck effect [2]. Thermoelectric materials generate power directly from heat by converting temperature differences into electric voltage [3].

Fig. 1 Thermoelectric generator

Some of the properties of thermoelectric generators are,

- **Environmentally friendly:** As the conversion involves no moving parts or any type of harmful emissions, it is environmentally friendly.
- **Utilizes waste heat:** These devices utilize waste heat and converts it into other form of energy.
- **Scalability:** This device can be applied to any size of heat source from a water heater to manufacturer's device.
- **Reliable power source:** As long as the temperature difference is maintained a constant output will be present.
- **Low noise operation:** During its operation the noise generated is either minimal or not present.
- **Can be used as a cooler/heater:** If input voltage is given then it can be used for applications of cooling or heating.
- **No moving elements:** Due to direct conversion from thermal energy to electrical energy taking place.
- **Decrease petroleum consumption:** When used in automobiles it decreases the consumption of petroleum to an extent.

But there are some disadvantages of thermoelectric devices too. The initial cost of TEG's is high. And their efficiency is very low (about 5% to 8%). Voltage generation takes place only if a temperature difference is

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 3, Issue 4, July 2016

present, but to maintain a constant temperature difference is very difficult as due to the heat present on the hot side of the thermoelectric generators, even the cold side also starts heating up, thus over time if the heat is not removed from the cold side, there will be no temperature difference and voltage generated will be equal to zero. Thus maintaining a temperature difference is very important to generate an output voltage using a thermoelectric generator.

II. OBJECTIVE

The increasingly worldwide problem regarding rapid economy development and a relative shortage of energy, the internal combustion engine exhaust waste heat and environmental pollution has been more emphasized heavily recently. Out of the total heat supplied to the engine in the form of fuel, approximately, 30 to 40% is converted into useful mechanical work; the remaining heat is expelled to the environment through exhaust gases and engine cooling systems, resulting in to entropy rise and serious environmental pollution, so it is required to utilized waste heat into useful work. The recovery and utilization of waste heat not only conserves fuel (fossil fuel) but also reduces the amount of waste heat and greenhouse gases damped to environment. The objective of the paper is to convert this waste heat energy into useful electrical energy which can further be utilized for other useful work. In the paper TEG device is used to convert this heat being wasted into useful electrical energy.

III. MATERIALS AND METHODS

Figure 2 shows experimental setup of thermoelectric generator (TEG). It mainly consists of cooling system, Booster circuit, Battery, etc.

At first the electricity was attempted to be extracted by using only TEG. The hot side of the thermoelectric generator was placed on the engine surface of an automobile and the cold side was let to face atmospheric air. The problem faced with this setup was that, both the sides of the thermoelectric generator came to the same temperature in a short span of time, thus a temperature difference was not present.

Fig. 2 Experimental setup

In the next trial a computer cooling fan was placed on the cold side of the thermoelectric generator and the hot side was placed on the surface of the automobile engine. The output held up longer, compared to first

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 3, Issue 4, July 2016

trial but after a span of time again the thermoelectric generator heated on both the sides. Thus temperature difference was not present.
In the third trial thermoelectric coolers were used. Thermoelectric coolers gave a better output, but they were not reliable as they stop working abruptly.

In the fourth trial a liquid cooling system was built by using a DC pump and copper pipes (radiator). A reservoir was present to help circulation of the liquid (water). Here a constant voltage output was achieved. Now this voltage was boosted using a boost circuit as shown in Fig.3 and then the boosted voltage was used for charging of a battery.

Fig. 3 Cooling system

IV. RESULTS AND DISCUSSION

The output voltages for different temperature differences were calculated and tabulated in Table 1.

Table 1 Different output voltage and current for different temperature differences.

Trial No.	Engine Temp (^{o}C)	Water Temp (^{o}C)	Output Voltage (V)	Output Current (mA)
1	95	75	.97	225
2	95	55	1.8	368
3	95	35	2.4	469
4	95	15	3.6	558
5	95	-5	4.8	669

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 3, Issue 4, July 2016

From the above table we can see that for different temperature differences, different output voltages can be extracted. Now these output voltages can be boosted to required higher voltages using a booster circuit. In this work, 3V was boosted to 12V and this boosted voltage was used to charge a battery.

V. CONCLUSIONS

The heat being wasted was converted using a thermoelectric generator and then boosted using a booster circuit. This conversion of electricity doesn't involve any moving parts or any chemicals being used and conversion is environment friendly. With the help of two or more thermoelectric generators connected in series if higher amount of voltage needs to be extracted without using booster circuit. This electricity can be used for a many number of issues in an automobile such as lighting system, to run a compressor thus reducing load on the engine, and music system, etc.

ACKNOWLEDGMENT

We would like to take this opportunity to thank my project guide who helped us with all our doubts and involved in active discussion at all times. We would also like to thank my HOD for giving us an opportunity to work on project. Also, we thank the staff members of Automobile Engineering, AIT, Bangalore for the help provided.

REFERENCES

[1] A.Jacks delightus peter, Balaji.D, and D. Gowrishankar, "Waste heat energy harvesting using thermo electric generator", IOSR Journal of Engineering, ISSN: 2278-8719, Vol. 3, no.7, pp. 01-04, July 2013.

[2] Enn Velmre, "Thomas Johann Seebeck (1770–1831)", Proc. Estonian Acad. Sci. Eng., vol.13, no.4, pp.276–282, 30 October 2007.

[3] J. S. Jadhao, and D. G. Thombare, "Review on Exhaust Gas Heat Recovery for I.C. Engine", International Journal of Engineering and Innovative Technology, ISSN 2277-3754, Vol. 2, Issue 12, pp. 147-159, June 2013.

[4] P. Mohamed Shameer, and D. Christopher, "Design of Exhaust Heat Recovery Power Generation System Using Thermo-Electric Generator", International Journal of Science and Research, ISSN 2319-7064 , vol.4, issue 1, pp. 1522-1526, January 2015.

[5] Priscilla A. J. Stecanella, Messias A. A. Faria, Elder G. Domingues, Pedro H. G. Gomes, Wesley P. Calixto, Aylton J. Alves, "Electricity generation using thermoelectric generator–TEG", Environment and Electrical Engineering (EEEIC), IEEE 15th International Conference, Rome, ISBN 978-1-4799-7992-9, pp. 2104-2108, 10-13 June 2015.

[6] Andreas Bitsch, "Modelling of thermoelectric devices for electric power generation", Doctor of Science Thesis, 2009.

[7] Seijiro Sano, Hiroyuki Mizukami, Hiromasa Kaibe, "Development of High-Efficiency Thermoelectric Power Generation System", Volume 49, No.152, 2003.

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 3, Issue 4, July 2016

[8] Richard J. Buist, Paul G. Lau, "Thermoelectric Power Generator Design and Selection from TE Cooling Module Specifications", USA.

[9] P.G. Lau, R.J. Buist, "Calculation of Thermoelectric Power Generation Performance Using Finite Element Analysis", Proceedings of the XVI International Conference on Thermoelectrics, August 26-29, 1997, Dresden, Germany.

[10] Riffat SB, Ma X, "Thermoelectrics: A review of present and potential applications", Applied Thermal Engineering, vol.23, no.8, pp. 913–935, 2003.

[11] Yazawa K, Shakouri A, "Energy Payback Optimization of Thermoelectric Power Generator Systems", Proceedings of the ASME 2010 International Mechanical Engineering Congress & Exposition IMECE2010, November 12-18, 2010.

[12] Bass J, Elsner N.,Ghamaty S.,V, Jovanovic V, Krommenhoek D, "Performance and Testing of Novel Quantum Well Thermoelectric Devices", Proceedings of the ASME 2010 International Mechanical Engineering Congress & Exposition IMECE 2010, vol.5, ISBN 978-0-7918-4429-8, November 12-18, 2010.

[13] Ramesh Kumar C, Ankit Sonthalia, and Rahul Goel, "Experimental study on Waste Heat Recovery from an Internal Combustion engine using Thermo Electric Technology", Journal of Thermal Science, Vol .15, No. 4, pp. 1011-1022, 2011.

[14] Adavbiele A.S., "Generation of Electricity from Gasoline Engine Waste Heat", Journal of Energy Technologies and Policy, Vol.3, Issue 3, ISSN 2225-0573, 2013.

[15] Jumade S R, Khond V W, "A Survey on Waste Heat Recovery from Internal Combustion Engine Using Thermoelectric Technology", International Journal of Engineering Research & Technology, Vol. 1, Issue 10, | ISSN: 2278-0181, December- 2012.

[16] Chethan R Reddy, Shrikantha S Rao, Vijay Desai, and Karthikeyan Ramachandran, "Modeling of an Automotive Thermo Electric Generator", International Journal of Science and Research, ISSN: 2319-7064, Vol. 2, Issue 5, May 2013.

[17] Ajay Chandravanshi, and Suryavanshi J.G., "Waste Heat Recovery from Exhaust Gases through I C Engine Using Thermoelectric Generator", International Journal of Applied Research, Vol.3, Issue 7, ISSN 2249-555X, July 2013.

[18] Taguchi Tomanari, "Exhaust heat recovery power generation device and automobile equipped therewith", US Patent- US20070193617, 2007.

[19] V. Pandiyarajan, M. Chinna Pandian, E. Malan, R. Velraj, and R.V. Seeniraj, "Experimental investigation on heat recovery from diesel engine exhaust using finned shell and tube heat exchanger and thermal storage system", Applied Energy 88, pp. 77–87, 2011.

[20] Baskar P, Seralathan S, Dipin D, Thangavel S, Norman Clifford Francis I J, and Arnold C., "Experimental Analysis of Thermoelectric Waste Heat Recovery System Retrofitted to Two Stroke Petrol Engine", International Journal of Advanced Mechanical Engineering, ISSN 2250-3234, Vol. 4, pp. 9-14, 2014.