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Review of Waste Heat Recovery from Exhaust Gas of IC Engines

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Abstract – In this time period, world has come closer due to rapid developments of communication and transport technologies. This also results into massive growth of automobile industry which has literally flooded streets with vehicles. But with this development the field of automobile is facing challenges like fuel efficiency of IC engines and emissions. Most of the fuel energy in IC engine is lost through exhaust gases in the form of heat. If this heat is recovered then fuel efficiency of engines can be increased. This paper provides a review on research work conducted on different methods and techniques to recover exhaust waste from exhaust gases. It is observed that exhaust waste heat recovery provides high fuel efficiency but its application is only economical if it is designed and installed with great care. Use of thermoelectric generator for waste heat recovery is very simple and economical method of waste heat recovery and it can be used for many vehicles.

Keywords— Waste Heat Recovery, Thermoelectric Generators, IC Engines.

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INTRODUCTION

The IC engines are prime source of mechanical energy in number of applications like automobiles, machines, ships etc. Even though IC engines are use in number of applications on tremendous scale, the efficiency and emissions of IC engines are arising as a concern to different researchers in the world. The efficiency of IC engine is very low as large part of supplied energy is lost into the mechanical thermal losses. IC engine uses chemical energy of fuel and converts it into heat and pressure by combustion due to which large amount of heat is produced inside combustion chamber, most of this heat is lost to the engine body which then requires cooling arrangement and other heat leaves through exhaust gases. Only a small portion of the chemical energy can be converted as output for useful work. This loss of energy cannot be avoided completely but it can be reduced by improving design of IC engines which provides preventive action to the heat losses even though this method has its own limitations. Hence there is another corrective action present for the heat loss known as Waste heat recovery. Waste heat recovery uses heat from the exhaust gases of IC engines which can be used for any useful applications like battery recharging, cooling, heating air [7], electricity source etc. But applying waste heat recovery systems in automobiles is not easy task due to weight, space and other design considerations. Recovering waste heat from exhaust gases is very crucial task which requires thorough study and feasible setup. There are number of ways to recover heat from exhaust gases of IC engines. [5]. But thermoelectric generation is a very reliable method for recovering waste heat from automobile exhaust [3]. Recovering heat using thermoelectric generators provides good fuel efficiency as it is observed that more than one third of energy can be converted into useful work. [6] Waste heat recovery leads to energy conservation and It is also best solution for reducing emissions and increasing fuel efficiency of the engine [9].

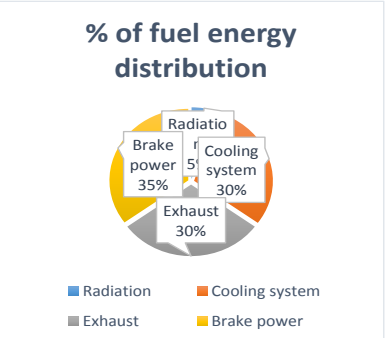

Fig 1: Percentage of fuel energy distribution in an I C engine

THERMOELECTRIC GENERATORS

Thermoelectric generator works on the principle of conversion of temperature difference into electricity that is Seebeck effect. Large quantity of exhaust gases flow out from combustion chamber at very high temperature. The high temperature of exhaust gases shows that there is a large amount of heat which lost to the environment which is actually a loss of fuel energy.

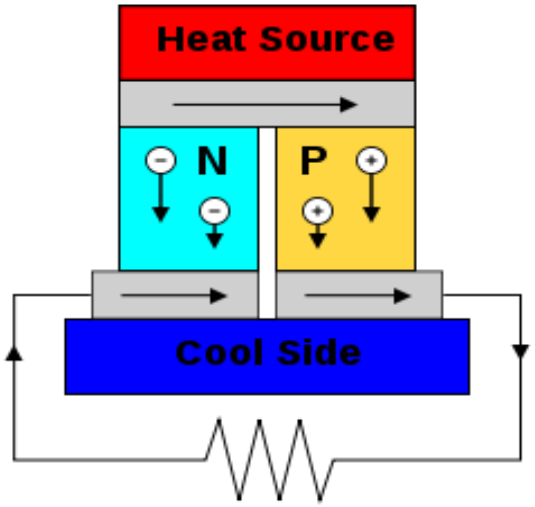

Fig 2 Working principle of thermoelectric generator

Fig. 2 shows working principle of thermoelectric generator. In this heat from hot side triggers flow of electron in between p and n type semiconductors, this flow of electrons generates current which can be used for different applications. Thermoelectric devices are lightweight and simple because of their special power generation method in which thermal energy is directly converted into electricity without any moving or heavy parts. These thermoelectric generators can be used to recover heat from exhaust of IC engines as they are simple, lightweight and effective.

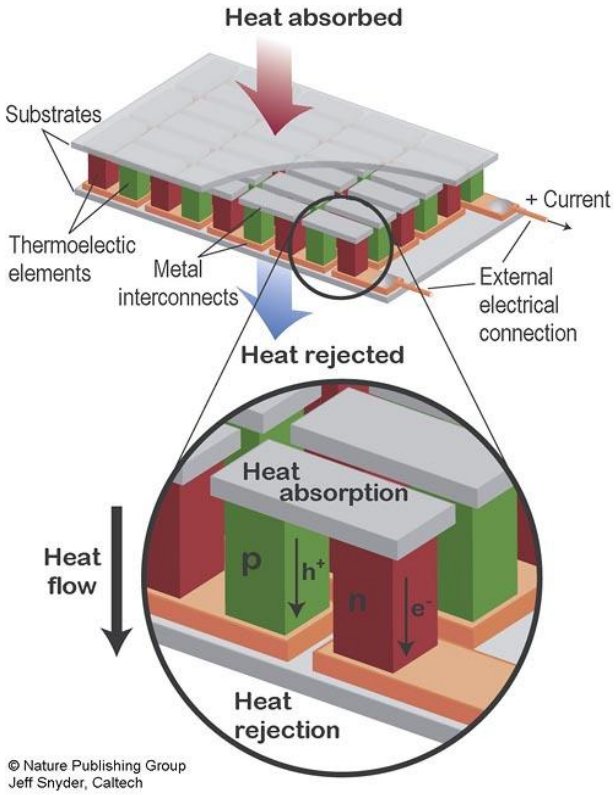

Fig. 3 Thermionic principle of operation

WASTE HEAT RECOVERY FROM EXHAUST GASES

The recovery and use of recovered waste heat not only saves energy, but this also considerably reduces thermal and air pollution. It is required to give attention towards the pollution problem as IC engines are one of the major contributors to the pollution. Hence by waste heat recovery one can reduce both thermal pollution and emission of greenhouse gases into the environment. Waste heat recovery finally also results into the reduction in the energy required by the engine which also reduces the consumption of fossil fuels, this shows that use of waste heat recovery technique has number of advantages, and almost no disadvantages. The evolution of Internal Combustion Engine has replaced steam engines as primary power source for transportation over the past century. Emissions of exhaust gases is a major disadvantages of IC engines and the main emission gases are carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx), and particulate matter (PM). Reduction in emissions and improvement in energy efficiency can be obtained by single technique that is waste heat recovery. As increasing energy conversion efficiency can reduce both the fuel consumption and emissions of engine, different academic and industrial scientists and engineers have done lots of successful research which provided techniques to improve engine thermal efficiency,

These techniques involve supercharge, lean mixture combustion, etc. In this study different techniques of waste heat recovery are studied, Heat recovery from engine exhaust heat is best technique which can provide energy efficiency.

P. Mohamed Shameer et al [1] has proposed a thermoelectric waste heat energy recovery system which is used in internal combustion engine of both vehicles gasoline vehicles and hybrid electric vehicles.

Fig.4 Experimental Setup: Two Wheeler Silencer with TEG

In this technique surface heat energy of automotive waste heat is directly converted into electrical energy with the help of thermoelectric generator (TEG). The generated electrical power is then stored into the battery. The conclusions of this study comments that this system can work well under different working conditions, and can be promising for automotive industry.

Baleshwar Kumar Singh et al [2] provided a review on the modern changes and technologies to recover waste heat from exhaust gas of internal combustion engine. In this, review on the thermoelectric generator, turbocharger, and exhaust gas through I.C engine etc. provided. Generally only maximum 40% of chemical energy in fuel is converted into useful mechanical work and remaining 60% is lost through engine body, exhaust gases and other losses. Waste heat lost in the form of hot gases in air through I.C engine exhaust manifold, in which different exhaust gases (NOx, CO, CO_2 etc.) and particulates are present. Which causes thermal and air pollution which leads to global warming? Hence this waste heat can be used for other supplementary works which will not only increases fuel efficiency but it also decreases the pollution. Hence, the author has main objective is to evaluate this technology based on the total waste heat converted into the useful mechanical work and other possible methods of waste heat recovery system from IC engine. The author concluded that waste heat recovery from the IC engines and its utilization shall be helpful in future.

There are some researchers also present who are working to improve thermo electric generation techniques also like Saniya LeBlanc et al. [3] who studied that waste-heat recovery with thermoelectric power generators, authors observed that use of thermoelectric power generators can improve energy efficiency. There are new thermoelectric materials present in the market which can be used in thermoelectric generators, these materials provide performance enhancements in thermoelectric generators. This improvement in thermoelectric generators increases popularity of these devices. Thermoelectric generator is very sophisticated technique but product development of thermoelectric generator requires crucial effort in the field of materials development and systems engineering. This review provides discussion on these fields and it shows the paths to improve performance of traditional thermoelectric materials.

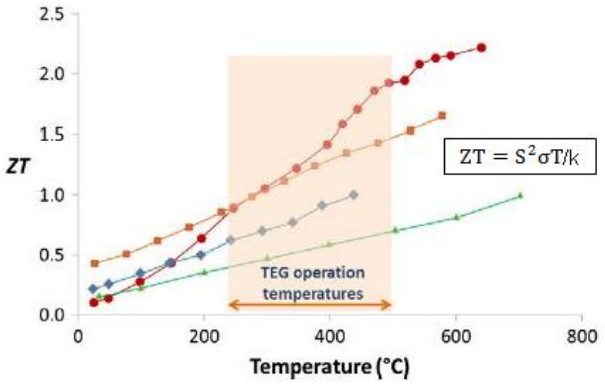

Fig. 5 The temperature range for typical waste-heat sources and TEG hot side

B. Orr et al. [4] studied that the IC engine convert chemical energy into mechanical energy but this conversion is not efficient. A huge part of this chemical energy is thrown into environment in the form of heat through exhaust and coolant. By using a waste heat recovery system this energy can be utilized. Thermoelectric generators (TEGs) and heat pipes can be very useful for the waste heat recovery. Both TEGs and heat pipes has properties which are suitable for waste heat recovery systems like solid state, passive, silent, scalable and durable.

S.L Nada et al [5] commented that the diesel engine is still far away from perfection and there is a huge scope in their improvement. As environmental pollution in increasing, energy demand is rising and fuel prices are continuously increasing there is a strong need for their improvement. Many scientists are working to provide improvement in IC engines so that energy efficiency of these engines can be improved. The exhaust gas heat recovery can be helpful to achieve this goal hence to reduce fossil fuel consumption and reducing emissions with providing

extra source of electricity. The author's main objective is to study and compare different waste heat recovery technologies depending on current developments, research trends and its potential future applications in IC engines and automobile sector.

Andres F. Agudelo et al. [6] conducted a research work which shades a light on the potential for system of waste energy recovery from exhaust gases in a diesel vehicles mounted in a chassis dynamometer. In this study, New European Driving Cycle was studied and used, for recording different operating variables. Experimental tests are conducted for three temperature conditions, and also exergy analysis was used to find the ability of exhaust gases to generate work at six different points in the exhaust system of IC engine. These six points are tested separately and their potential for work generation is studied. From results mean temperature at each point and the energy quality index is found out and these results show that 33% energy collected from exhaust gas can be used for work.

Atulkumar Suthar et al. [7] studied that temperature of intake air plays an important role in increasing efficiency of the engine. Manifold heaters are used in diesel applications require quick, reliable, and environmentally friendly starts. Heaters are used to obtain highest output with the low input intake air. They concluded that air intake heaters reduce emissions, smoke, engine wear, battery consumption and fuel consumption of the engine. The heat input required for the engine reduces with increase in intake air temperature. With increase in intake air temperature CO emissions reduces.

Chirtravelan M. et al. [8] studied experimentally the effect of preheated air on standard diesel fuel engine. The heating chamber contains a heater for heating the air which flows over it. The preheated air provides lower exhaust emissions in diesel engines. It is also observed that NOx and CO emissions decrease with increase in intake air temperature. Increase in inlet air temperature leads to lower ignition delay, which results into low NOx emissions. Pre- heating of air leads to uniform combustion of the fuel which also reduces knock and detonation. High temperature of intake air also facilitates better mixing of air and fuel which also reduces CO emissions.

The waste heat recovery system is also implemented on heavy automobiles like trucks, Doyle and Patel [9] have designed a device which can recover heat from the exhaust gas heat, this device is based on Rankine cycle and is installed on a truck engine. In this work, the experimentation is carried out for the working of engine for 450 kilometers which gives the results from which it can be concluded that this device can save fuel consumption by 12.5%.

CONCLUSION

Many researchers are working in the field of waste heat recovery from IC engines and it is observed that waste heat recovery techniques can save energy considerably. With installation of these devices in different vehicles, one can save tremendous amount of fuels every day. However it is observed that for small vehicles these devices might not be economic but further development in this technology can avoid these limitations. Even though there are many techniques of waste heart recovery thermoelectric method is very effective and economical compared to the other methods.

REFERENCES

[1] P. Mohamed Shameer "Design of Exhaust Heat Recovery Power Generation System Using Thermo-Electric Generator" International Journal of Science and Research, Index Copernicus Value (2013): 6.14.

[2] Baleshwar Kumar Singh "Exhaust Gas Heat Recovery for C.I Engine-A Review" International Journal of Science and Research, Singh, 3(11): November, 2014.

[3] Saniya LeBlanc "Thermoelectric generators: Linking material properties and systems engineering for waste heat recovery applications" Science Direct, February 2014.

[4] B. Orr "A review of car waste heat recovery systems utilizing thermoelectric generators and heat pipes" RMIT University, Bundoora, Victoria, Australia, 2015.

[5] S.L Nadaf "A Review on Waste Heat Recovery and Utilization from Diesel Engines" International Journal of Advanced Engineering Technology, E-ISSN 0976-3945, 2016.

[6] Andres F. Agudelo "Potential for exhaust gas energy recovery in a diesel passenger car under European driving cycle" science Direct, 2016.

[7] Atulkumar Suthar "Effect Of Preheating Of Inlet Air To Study The Performance & Exhaust Emission Of I.C. Engine: A Review" International Journal of Engineering Sciences & Emerging Technologies, Nov., 2015,Volume 8, Issue 3, pp: 166-170.

[8] Chirtravelan M "Design and Fabrication of Air Pre Heater for Diesel Engine" International Journal of Innovative Research in Science,

Engineering and Technology, Volume 4, Special Issue 2, February 2015.

[9] E.F. Doyle, P.S. Patel, "Compounding the truck diesel engine with an organic rankine cycle system," 760343, Society of Automotive Engineers (SAE), 1976.

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