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Application of Heat Pipe in Compression Ignition Engine

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Abstract: *Aim of this paper is to review the literature on methods to recover the exhaust energy of compression ignition engine, emphasized over the application of heat pipe to improve the performance of the engine. The amount of heat carried away by exhaust gas is more compare to the heat utilized in another way. Part of this energy can be used to improve the performance of the engine. To recover energy from exhaust gas various methods were studied. It was found that noise level of engine reduces. It also reduces the pollution by improving the performance of the engine. Use of heat pipe instead of simple heat exchanger increases the heat transfer rate. It helps to recover maximum part of the energy from the exhaust gas.*

Index Terms: *Diesel Engine, Heat pipe, Waste heat recovery*

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1. INTRODUCTION

A diesel engine is an IC engine which operates using the diesel cycle. Diesel engines have the maximum thermal efficiency of any internal or external combustion engine, because of their compression ratio. Diesel engines are made in two stroke and four stroke versions. The diesel internal combustion engine different from the gasoline powered Otto cycle by using a higher compression of the air to ignite the fuel rather than using a spark plug for this basis it is known as compression ignition and the petrol engine is referred as spark ignition engine. In the diesel engine, only air is supplied into the combustion chamber. The air is then compressed with a compression ratio typically between 15 and 22 resulting into a 42 bar (approx. 600 psi) pressure compared to 12 bar (approx. 200 psi) in the gasoline engine. This high compression heats the air to 520 °C. Fuel is introduced directly into the compressed air in the combustion chamber using fuel injection system. [2]

A heat pipe is a heat-transfer device which operates on the principles of thermal conductivity as well as the phase transition to manage the transfer of heat between two solid interfaces. Due to the very high heat transfer coefficients for steaming and condensation heat pipes are highly effective thermal conductors a heat pipe is a closed evaporator-condenser component with a hollow tube whose inside walls are made up of capillary structure called as wick structure. When heat is given to the heat pipe, the liquid in the wick heats and evaporates. As the evaporating fluid filled in the heat pipe it diffusing throughout its length. Condensation of the vapor carried out when the temperature is slightly below that of the evaporation area. As it condenses, the vapor gives up the latent heat it's during evaporation. This effective thermal conductance helps to maintain constant temperatures along the length of the pipe. Attaching a heat sink to a portion of the heat pipe makes condensation take place. The liquid then returns to the hot interface through capillary action, centrifugal force, or gravity, and the cycle repeats.

The lower end of the heat pipe is installed in a hot stream and the top end is fitted into a colder stream. The hot and the cold streams are separated by a separation plate, into which the heat pipe is fitted, with a seal between the hot and the cold sides. The part of the heat pipe immersed in the hot stream absorbs heat, causing the liquid inside the pipe to evaporate. The evaporated liquid (steam) then travels to the top of the heat pipe. When this steam reaches the top of the heat pipe it gives up its enthalpy of evaporation to the cold stream, heating up the cold stream and causing the steam to condense back into a liquid. The liquid then flows back to the bottom of the heat pipe and the cycle will continue as long as there is a temperature difference between the hot stream and the cold stream. Due to the difference in density of the working fluid in its liquid and vapor phases a natural circulation cycle operates inside the heat pipe. [1]

Reducing fuel consumption of engines is one of the main issues in research and development of IC Engines. Almost one-third of fuel energy in internal combustion engines is wasted through the exhaust flow. Heat recovery system turns waste thermal losses from the exhaust into usable energy. As an efficient way to save fuel and reduce vehicles CO_2 emissions. This technology can be used either as a hybrid system or a conventional one: it produces either electrical or mechanical energy.

2. WASTE HEAT POTENTIAL

Waste heat is a heat generated in process of fuel combustion or in any chemical reaction carried out and then released to the environment even some useful energy still can be reused. During operation of engine the Heat is dissipated from exhaust gas, engine jacket cooling water, lube oil cooling water, and turbocharger cooling to the atmosphere that can be reused as a useful energy. Only the 38% of the energy is converted to the required work remaining are the losses .using Waste heat energy recovery methods the waste exhaust energy can be converted into useful work. [3]

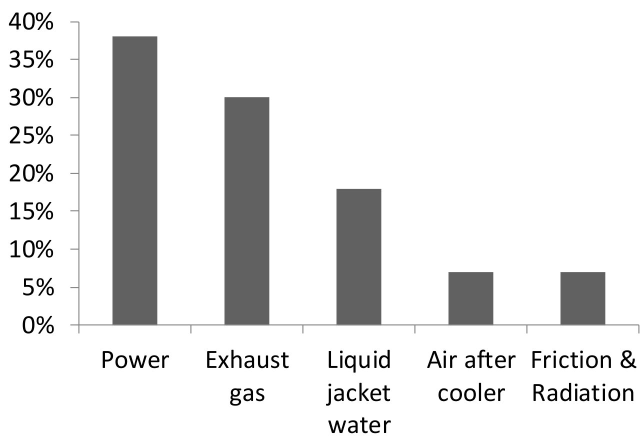

Fig.1 Amount of heat dissipated from the engine [3]

3. REVIEW OF VARIOUS METHODS USED TO RECOVER EXHAUST GAS ENERGY TO IMPROVE THE PERFORMANCE OF ENGINE

Sprouse etal. (2012) presented an open literature review on organic rankine cycles for internal combustion engine exhaust waste heat recovery in which explained the heat potential from the exhaust waste gases can be reused to increase the efficiency of engine. The different types of waste heat recovery (WHR) systems such as Rankine cycle, Brayton cycle, kalian cycle; thermoelectric devices etc. had been explained also an Advantages and limitations of each WHR systems. Among the other WHR systems Rankine cycle was found to be the best WHR system due to its advantages like low operating cost, design simplicity & effect on efficiency.

Chaurasia etal. (2016) performed an experiment on effect of preheated inlet air using Heat pipe on single cylinder 4 stroke CI engine .The various parameters were analyzed such as various loading conditions with respect to time. Most of the parameters were calculated at the inlet temperature of 30°C, 35°C, 40°C & 45 °C. Also plotted graphs like i)Engine torque vs. engine speed with and without pre heated Inlet ii) output power vs. engine speed iii) SFC for different inlet temperatures iv) Break thermal efficiency with various load conditions v) Exhaust gas temperatures at various load conditions. From the experiment it was found that torque curve behaves normal and preheated air is quite constant with small variation.SFC decreases with increase in inlet temperature of air. Also break thermal efficiency increases with increase in load conditions

Agarwal etal. (2016) explained the design of heat pipe construction, working of heat pipe used in Exhaust energy recovery in 4-stroke CI engine. Further performed experiment to analyze different parameters like break thermal efficiency, sound pressure level with and without preheated air and concluded that preheated inlet air in CI engines can be used to increase the efficiency also there has been decrease in sound pressure level.

Remeli etal. (2015) uses Hybrid Heat pipe And thermoelectric generator (HP-TEG) in waste heat recovery system from exhaust. A Bismuth Telluride (Bi_2Te_3) basedon thermoelectric generators (TEGs), which are sandwiched between two finned heat pipes to achieve a temperature gradient across the TEG for thermoelectricity generation were used. Theoretical model were developed and analysis carried out and concluded that HP-TEG system has the capability of recovering 1.345 kW of waste heat and generating 10.39 W of electrical power using 8 installed TEGs.

Hatami etal. (2014) presented a review on different types of heat exchangers that can be used as an Exhaust waste heat recovery methods in CI engines. They further explained the design of different heat exchangers, there used, limitations, operating conditions.

Caton (1981) et al. were described about the attachment in the engine exhaust port and made an experiment where instantaneous cylinder pressure and exhaust temperature for different range and for different engine operating condition was calculated. An analysis based on their jet velocity through the valve opening correctly estimated the heat transfer due to large scale motion.

Vasiliev et al. (1981) analyzed that the wastage of heat energy through internal combustion is a major problem. In urban areas use of large automobile vehicles leads to change in climatic conditions. Many organizations are searching new ways to facilitate engine start-up periods. Thermal accumulator works to absorb and reject heat energy at the solid liquid phase change. Author experimented on pre heating devices for starting of carburetor engines and analyzed the data received.

Hatami et al. (2014) performed the Exhaust Heat recovery experiment using finned type heat exchanger and calculated results using numerical methodology for IC Enginesanalyzed two cases of heat exchanger, (HEXs) which were used in exhaust of internal combustion engines (ICEs) are modeled numerically to recover the exhaust waste heat. The best vicious model were used to obtain favorable result. One of the HEX was used in compression ignition (CI) Engine with cold fluid and other is used in spark ignition (SI) engine with mixture of 50% water and 50% ethylene glycol as a cold fluid. Size and fins affect the amount of heat transfer and the transferred heat to cold fluid is calculated as the recovered heat.

Rath et al. (2017) experimented based on IC engine and concluded that pollution emitted through IC engine is an important problem. In the experiment, air pre heating as well as pre heating of IC engine was studied to ensure increment in efficiency and reduction in pollution. A thermal energy storage device as an air pre heater is used which contains Paraffin as a phase changing material. From the experiment it was observed as (CO), (HC) and smoke emissions were reduced during engine pre-heating.

4. CONCLUSION

Heat pipe easily transfer high flux with small temperature difference and has no mechanical device moving inside it. CI Engine's exhaust temperature is very high; exhaust energy can be recovered by using heat pipe as the temperature of air, sucked by engine increases, delay period decreases. It can be result in smooth operation of engine and performance of engine may increases exiguously as considering the effect on volumetric efficiency.

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