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Experimental Analysis of Waste Energy from Exhaust of an Internal Combustion Engine

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Abstract

Exhaust gas occurs as a result of the combustion of fuels such as natural gas, gasoline/petrol, diesel, fuel oil or coal. It is discharged into the atmosphere through an exhaust pipe or flue gas stack. The exhaust gas from an internal combustion engine carries away about 30% of the heat of combustion. The energy available in the exit stream of many energy conversion devices goes as waste, if not utilized properly. The main objective of the proposed project is to utilize heat from the exhaust gases of a diesel engine and convert heat to useful work. In the present work, a shell and finned tube heat exchanger integrated with an setup to extract heat from the exhaust gas and a thermal energy storage tank used to store the excess energy available is investigated in detail. Energy supplied to an engine is the heat value of the fuel consumed. But only a part of this energy is transferred into useful work. From heat balance sheet of a typical CI engine I find out that the total heat loss is around 33-45%, of which 33% is due to exhaust gases and the rest is lost to the surroundings. If we can reduce this figure by 10% also then it will be a substantial contribution. So as according to the aim I used the heat exchanger at the exhaust of twin cylinder diesel engine and a low boiling fluid ie. Diethyl ether which used the heat from the exhaust pipe of the engine and vaporize the low boiling fluid which is further used to rotate the turbine which is basically other working unit attached to the engine. The heat used by the heat exchanger is used to vaporize the working fluid and this working fluid is used to rotate the small blade just like turbine ,this blade coupled with another side with compressor .This compressor compress the fresh atmospheric air and supplied to the inlet of the engine .This compressed air increased the power efficiency of the engine by using waste energy. There is reduction in the loss of exhaust heat. The performance parameters pertaining to the heat exchanger and such as amount of heat recovered, heat lost, and increased efficiency are evaluated**.**

Keywords: Exhaust gas, Energy, Diethyl ether, heat exchanger, IC engine.

1. Introduction

In case of a diesel engine the total heat loss is around 33-45%, of which 33% is due to exhaust gases and the rest is lost to the surroundings. Here, conditions in the engine are different from in a spark-ignition engine, because power is controlled by controlling the fuel supply directly, not by controlling the air supply. As a result, when the engine is running at low power, there is enough oxygen present to burn the fuel, and diesel engines only make significant amounts of carbon monoxide when running under load.

In thermal power stations, mechanical power is produced by a heat engine that transforms thermal energy, often from combustion of a fuel, into rotational energy. Most thermal power stations produce steam, and these are sometimes called steam power stations. Not all thermal energy can be transformed into mechanical power, according to the second law of thermodynamics. Therefore, there is always heat lost to the environment. If this loss is employed as useful heat, for industrial processes or direct heating, the power plant is referred to as a cogeneration power plant or CHP (combined heat-and-power) plant.

Present methods to reduce exhaust gas temperature

i) Turbo charging
ii) Exhaust gas recirculation (EGR)

2. Literature Review

The present review includes the studies on the development of the heat exchanger based waste heat recovery from an IC engine. In [1] E.F. Doyle there is categories of heat exchangers involved in heat recovery applications. In this category the recovered heat is directly used for application or the storage system is integrated with the heat exchangers. In the other category, a separate HTF is used to recover the heat from the exhaust gas and the HTF is allowed to circulate through the storage tank, and the energy transfer between the HTF and PCM takes place in the storage system.

In the present research, a finned shell and tube heat exchanger is selected, designed and fabricated to extract heat from the exhaust gas and a separate thermal energy storage tank filled with oil, and a PCM encapsulated in cylindrical containers is used to store the heat. Hence a survey has bee made both on the studies that deal with the heat recovery heat exchangers ttached to IC engines and also about PCM based storage systems. The details of the survey made are presented in this section

The potential for re-using the waste heat in different branches of industry, and new ways to recover the discharged heat from industrial equipments, have received much attention in the recent years due to the energy and environmental crises. E.F. Doyle [1] have done a lot work on work on WHR systems for an internal combustion engine exhaust gas and coolant, using two different liquids operating at different pressure and temperatures in two separate circuit paths. M. Pons, Ph. Grenier [3] carried out a thermodynamic analysis on a turbocharged engine integrated a with absorption refrigeration unit. The authors studied the feasibility of combining a turbocharged and intercooled diesel engine with an exhaust gas driven absorption refrigeration unit. M. Pons, Ph. Grenier [3] have carried out the thermodynamic analysis to evaluate the performance of a naturally aspirated diesel engine integrated with an absorption refrigeration unit to produce the cooling effect. b Zhang and Wang [6] presented a numerical study of the dynamic performance of an absorption cooling system for automobile M. Pons, Ph. Grenier[3] has studied the performance of a shell and dimpled tube heat exchangers for waste heat recovery. The exchanger heat duty, overall heat transfer coefficient, effectiveness and tube side friction factor, are investigated as functions of the tube surface geometry (plain or dimpled), the flow pattern (counter or parallel) in the tube, the Reynolds number and the shell side heat capacity. In the analysis, water is used as the tube side fluid and the exhaust gas from the diesel engine is used as the shell side fluid carried out the thermodynamic analysis to evaluate the performance of a naturally aspirated diesel engine integrated with an absorption refrigeration unit to produce the cooling effect. b Zhang and Wang [6] presented a numerical study of the dynamic performance of an absorption cooling system for automobile M. Pons, Ph. Grenier[3] has studied the performance of a shell and dimpled tube heat exchangers for waste heat recovery.

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3. PRESENT WORK

To estimate the exhaust gas temperature, we conducted an experiment on the twin cylinder Diesel engine available so that the exhaust gas temperature could be estimated The engine was tested at different loads starting from 5 kg to 30 kg at different time intervals, by connecting a thermocouple at the engine's exhaust The engine was running at a constant rpm of 1500 rpm.The twin cylinder diesel engine was water cooled and a dynamometer was attached at the output.

Selection of low boiling point fluid

For the purpose of experiment a low boiling point fluid was selected from the list of low boiling point fluids. Taking into consideration all the aspects the most appropriate fluid was Diethyl Ether

Properties of Diethyl ether

Diethyl ether, also known as ether and ethoxy ethane, is a clear, colorless, and highly flammable liquid with a low boiling point and a characteristic odor. It is the most common member of a class of chemical compounds known generically as ethers. It is an isomer of butanol. Diethyl ether has the formula CH_3-CH_2-O-CH_2-CH_3.

Results of the experiment with diethyl ether as the working fluid

IV RESULT AND DISCUSSION

The twin cylinder diesel engine was operated. Diethyl ether which will extract the heat from the exhaust gas and hence convert it into steam.by initially taking diesel oil as the working fluid and then introducing a low boiling point fluid .The mass flow rate of the low boiling point fluid was determined for optimum heat recovery. Due to the heat exchange, the liquid will become vapor and then it will be directed to the rotor blade this rotor blade coupled with air compressor.this air compressor compress the air and supplied this compressed air to the inlet port of the diesel engine. diesel engine compressed the air inside cylinder.if we provide compressed air in place of fress air then the efficiency of the engine incressed by used of waste heat

After conducting the experiment we find that the exhaust gas temperature increases with increasing load and reaches a maximum of 44^{0}C for full load condition. The experiment was carried out at different loads starting from 5 kg to 30 kg. The readings were also noted down for zero load case. When we used diethyl ether as the working fluid to extract heat we find that the exhaust gas temperature drops which may due to the heat extracted by the exhaust gas inside the heat exchanger.

5. CONCLUSION & FUTURE SCOPE

In this experiment we found out that while using a low boiling point fluid i.e. diethyl ether the heat from the exhaust gas when passed through a blower with increased pressure can save input for multi stage compression. The exhaust gas temperature shows a reduction by 5-7% which may be explained due to the heat extracted by the low boiling point fluid.

As from this conclusion we have easily says that the exhaust heat loss from the internal combustion engines is reduced to such a level that the efficiency of the engine is increased to 10 to 15 percent easily. At present the CI engines used do not have the special features but in future the engines comes with various accessories like heat exchangers, economizers and turbocharger in normal engines also. Due to this there is also reduction in the hazardous gases like CO, NOx, and Sox and the environment pollution is also reduced.

Sl no.	**Mass flow rate (g/s)**	**Load (Kg)**	**Air inlet temp**	**Exhaust gas temp**	**Water inlet temp**	**Water outlet temp**	**Vapor inlet pressure(bar)**	**Vapor outlet pressure(bar)**
1.	0.008	0	26	270	28	42	0.30	0.50
2.		5	26	285	28	42	0.40	0.55
3.		10	26	330	28	42	0.45	0.60
4.		15	26	355	28	42	0.50	0.70
5.		20	26	385	28	42	0.70	0.85
6.		25	26	410	28	42	0.80	1.00
7.		30	26	420	28	42	1.00	1.10

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