IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X,
PP 84-87
www.iosrjournals.org

Waste Heat Recovery from Engine Exhaust by using Heat Wheel.

Pradip G. Karale [1], Dr. J.A Hole [2]
[1](Mechanical Engineering Dept. Rajarshi Shahu College of Engineering, Pune, Maharashtra, India.)
[2](Mechanical Engineering Dept. Rajarshi Shahu College of Engineering, Pune, Maharashtra, India.)

Abstract: *In case of I.C Engine the heat generated during the combustion of fuel is partially converted into work and remaining is wasted to the atmosphere through exhaust gas and coolant. Out of the total heat supplied to the I.C engine in the form of fuel 30-40% heat is converted into useful work and remaining 60-70 % as a part of waste heat as friction, exhausts gas and engine cooling system. Through the exhaust of engine 30-40 % of heat is lost to the environment. The efficiency of the engines is between 20% and 30%.This paper highlights provision for incorporating a heat wheel for preheating air from engine exhaust gas waste heat before admitting in to the cylinder of a diesel engine. Heat wheel is a rotary air to air heat exchanger. It comprises porous wire mesh as a Matrix material and Electric motor for driving wheel. The effect of preheated air on standard diesel fuel engine indicated a good result in performance of engine and on emission control. Higher inlet air temperature increases Brake Thermal Efficiency and decreases the specific fuel consumption. Easy vaporization and better mixing of air and fuel occur due to warm up of inlet air, which causes lower CO emission. Higher inlet air temperature causes lower ignition delay, which is responsible for lower NOx formation Uniform or better combustion is occurred due to pre-heating of inlet air, which also causes lower engine noise.*

Keywords: *Air preheating, C.I Engine, Emission characteristics, Heat wheel, Waste Heat Recovery*

I. Introduction

The I.C engine is a device which converts the chemical energy of fuel into heat and again heat energy in to mechanical work. It is the fact that the total heat supplied to the engine in the form of fuel approximately only 30-40% get converted in to useful mechanical work and remaining almost 70% of the energy released from fuel due to combustion is lost mainly in the form of Heat. Approximately 25-30% of the total energy generated by the engine is dissipated in the form of Exhaust loss energy [1]. Increase in economy the energy demand also increases which results in more usages of fossil fuels which causes the emission of harmful green house gases. Large amount of heat is released in the atmosphere from the engines without utilizing for any purpose. If some amount of this waste heat could be recovered it possible to reduce the primary fuel required. Waste heat utilization is the major source of cost saving. If exhaust gases of engines are directly released into atmosphere it will not only waste heat but also causes the environmental problems, so it is required to utilize the waste heat for useful work to increase the efficiency of engine [2].

In particular, interest in heat wheels is increasing due to their low pressure drop and high effectiveness compared to conventional plate heat exchangers [3]. Diesel engine efficiency depends on multiple complex parameters like heat losses during cooling of engine, heat losses in exhaust gases, friction loss, transmission efficiency losses etc. However intake air temperature plays a predominant role in achieving better efficiency. Heat wheel is used for Air Intake pre Heating from engine exhaust heat to take advantage of waste heat recovery as well as intake air preheating for diesel engine leading quick, reliable, and environmentally friendly working of diesel engine Lower temperature intake air leads to inadequate final compression temperature, increase in emission delay, longer time between the injection of the fuel to ignition, local over-enrichment, incomplete combustion and high pressure gradients due to abrupt mixture conversion in the cylinder. These factors lead to knocking of the diesel engine, increase in emission of hydrocarbons in the exhaust gas leading to severe loading of the environment. In order to avoid this heat wheel is introduced to heat intake air during running.

1.2 Benefits of waste heat recovery from I.C Engine.

Benefits of waste heat recovery from engines can be broadly classified in two categories

I) Direct Benefits: Recovery of waste heat has a direct effect on the combustion process efficiency. This is reflected by reduction in the utility consumption and process cost.

II) Indirect Benefits:

a) Reduction in pollution: A number of toxic combustible wastes such as carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx), and particulate matter (PM) etc, releasing to atmosphere. Recovering of heat reduces the environmental pollution levels.

b) Reduction in equipment sizes: Waste heat recovery reduces the fuel consumption, which leads to reduction in the flue gas produced. This results in reduction in equipment sizes.
c) Reduction in auxiliary energy consumption:
Reduction in equipment sizes gives additional benefits in the form of reduction in auxiliary energy consumption. [4]

1.3 Effect of low temperature intake air
1. An inadequate final compression temperature occurs.
2. Increase in emission delay.
3. Time from the entry of the fuel into the combustion chamber until the ignition of the same becomes too long.
4. Local over-enrichment.
5. Incomplete combustion and high pressure gradients occur as a result of abrupt mixture conversion in the cylinder.

Consequences of Low Temperature Intake Air
1. Increase in emission of hydrocarbons in the exhaust gas.
2. Knocking of the diesel engine.
3. Severe loading of the environment.

II. Project Overview

This project relates to incorporating of a heat wheel for preheating intake air leading to an internal combustion engine for recovering exhaust waste heat. Air is drawn from the upstream side of an intake manifold using an air supply unit. The air is heated using a waste heat from exhaust gas by using heat wheel. In this way, vaporization of the fuel is enhanced. One feature of the present disclosure provides an intake air heating apparatus having capability of waste heat recovery. By heating an intake air in a circulation passage to a sufficiently high temperature, high-temperature air flows into a combustion chamber during cranking and, therefore, vaporization of fuel is promoted. A warm air intake is better than a cold air intake on a diesel engine, which improves fuel economy on a gas engine because the warm air improves the vaporization of the fuel as well as improves the flame speed. The warm air is less dense, so the throttle opens up more to get the same air, therefore throttling losses are reduced.

2.1 Components Used
1. Single cylinder diesel engine.
2. Heat Wheel, Motor and Casing.
3. Necessary piping.
4. Dynamo meter.

2.2 Instrumentation Used
1. K Type thermocouples.
2. Tachometer.
3. Emission checking instrument.

III. Experimental Setup

The engine used in this experimental work was a four stroke, Single Cylinder, water cooled Diesel Engine. Heat wheel is connected to the engine exhaust piping as shown in Fig.(1) and various piping connections are made. A typically Air intake heater system for an engine comprises the following:
1. Heat wheel adopted to be positioned in communication with an intake and exhaust gas passage way of an engine.
2. A speed controller to modulate power to the heat wheel by switching on and cutting of as when required
3. Temperature sensor to provide a temperature at inlet and outlet streams in heat wheelThe fresh intake air for combustion is taken from atmosphere through air filter and passed through heat wheel. On the other hand the hot exhaust gases from engine exhaust are passed through the heat wheel in counter flow direction. During the rotation of heat wheel the heat exchange from engine exhaust to fresh air takes place and air gets heated. This hot air is supplied to engine cylinder through filter. And exhaust gases are exhausted in atmosphere. The test is conducted at various engine loads and heat wheel speed and performance of engine is obtained by preparing heat balance sheet at various conditions

The emissions from the engine are measured using AVL Gas analyser. The gases HC (ppm), CO (%), CO2 (%) and NOx (ppm) with this analyser. The fuel flow rate is measured by volume basis using a burette and stop watch. The fuel from tank is supplied to the engine through a graduated burette using a two-way valve.

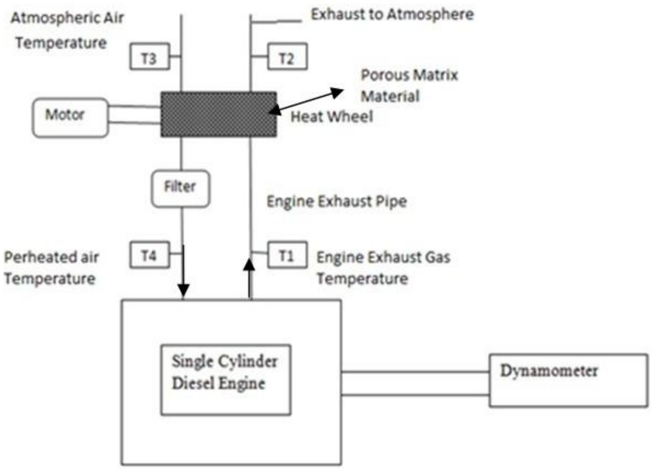

Fig. (1). Schematic Diagram of Experimental setup of intake air preheating by using Heat wheel.

IV. Fabrication of heat wheel

Mostly wheel matrix is made from porous material. Metallic wire screen mesh is used due to large values of surface area density; these structures are found to be effective in dissipating heat within a limited designed space. [5] Heat wheel is fabricated from small Aluminum wire mesh. Regarding thermal conductivity Aluminum has good thermal conductivity and it is much greater than that of steel. Aluminum is also highly resistant to corrosion attack. Aluminum is light in weight and it also has a bright appearance [6].

A number of wire meshes strips are kept over each other and circular thick Mesh is formed. It cuts in to three equal parts for assembly. Outer circular cover- ring is used to hold all wire meshes together to make it as a single wheel. (Fig. 2). Wheel is rotated by electric motor. Wheel is enclosed in Casing. Arbitrary the standard dimensions are taken for heat wheel from Technical Manual.

Fig. (2) Heat Wheel

V. Effectiveness of Heat Wheel [7]

The heat exchanger effectiveness (ε) is defined as the ratio of actual heat transfer to the maximum possible heat transfer.

$$\varepsilon = \frac{Actual\ heat\ transfer}{Maximum\ possible\ heat\ transfer}$$

$$\varepsilon = \frac{Q}{Q_{min}} \quad \text{.................................... (1)}$$

$$\epsilon = \frac{(mC_P\ \Delta T)_{Hot\ or\ Cold\ Fluid}}{(mC_p)_{Small}\ (Th1 - Tc1)} \quad \text{...(2)}$$

Where,
Cc = (.Cp) c=Cold fluid capacity rate.
Ch= (m.Cp) h = Hot fluid capacity rate.
T_{h1}= Inlet temperature of hot fluid
T_{h2}=Outlet temperature of hot fluid
Tc_1= Inlet temperature of cold fluid
T_{c2}= Outlet temperature of cold fluid.

VI. Discussion

The waste heat from exhaust gas of engine is utilized for intake air preheating which results in reduction in waste heat admitted in environment. Temperature of intake air is affected by speed and wire mesh density of heat Wheel. Heat Input required for the engine reduces with increase in intake air temperature. Since heat input reduces with increase in intake air temperature Brake Thermal Efficiency increases. It reduces the environmental pollution. The CO content in exhaust gas slightly reduces with increase in temperature where as NOx content slightly increases with increase in intake air temperature, the CO2 and O2 content remains unaltered.

VII. Conclusion

It has been observed that there is a large amount heat is waste from the engine. Approximately heat lost by exhaust as is same to useful work produced by engine. It is identified that there is large potential of energy saving through the use of waste heat recovery technologies. The recovery and utilization of waste heat not only conserves fuel but also reduces the green house gases and waste heat by increasing efficiency of engine. The new concept of Heat wheel can be used for exhaust gas heat recovery for intake air preheating of Diesel engine.

Acknowledgment

I gratefully acknowledge Mechanical Engineering Department of RSCOE, Pune for technical support. I would also like to thank to Dr. A.A Pawar (HOD Mech Dept.) Dr. J.A Hole, Dr.P.A. Deshmukh and Dr. M.S. Deshmukh for their help and dedication toward my work. Also my friends for their directly & indirectly help, support and co-operation.

References

[1]. Pradip G.Karale, J.A Hole “ A Review on waste heat recovery and utilization from exhaust gas of I.C. Engine” International Journal for scientific research and Development, Vol.3 ,2015.
[2]. S.L Nadaf ,P.B Gangavati,” A Review on waste heat Recovery And Utilization from Diesel Engine” International Journal of advanced Engineering Technology Vol-V Dec-2014.(31-39)
[3]. Eurovent Certified Performance. Available online: http://www.eurovent-certification.com (accessed on 1 September 2014).
[4]. Monali S. Bhojane, M.S. Deshmukh,”Effect of air preheating on performance of C.I Engine using Energy Wheel, “Third International Conference on Emerging Trends in Engineering and Technology 2010 IEEE.
[5]. J.Xu, J.Tain ,T.J.Lu, H.P Hodson “ On the thermal performance of wire screen meshes as a heat exchanger material” Internal Journal of heat and Mass Transfer ,Elsevier 2006.
[6]. A. Malaisamy, P. Balashanmungam “Fabrication of Efficiency increser by using preheating method” International journal For Scientific research, volume 3, 2014
[7]. Swapnil Nilange, Bhavesh Kakulte, Bhushan Maheshwari, Jagdish patil “Experimental Inveatigation of effectiveness of Heat Wheel as a Rotary Heat Exchanger” Internal National Journal of Research in Engineering and technology volume 2, issue 4, 2013.