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Performance Analysis of Single Cylinder C.I. Engine with different Coolants

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Abstract: A cooling curve test was done to demonstrate the effect of using different types of coolant in an I.C. Engine. The types of coolant used are: 1.Water 2.Ethylene glycol based coolants 3.Glycerol based coolants. Coolant concentration of 50% in both ethylene glycol and glycerol were examined. The experiment was conducted in a vertical Kirloskar diesel engine. The main parameters of the experiment were brake thermal efficiency and specific fuel consumption. Coolant outlet temperature was varied, while the engine speed was kept constant. The flow rate required to achieve a particular temperature for ethylene glycol based coolants and glycerol based coolants have been determined and compared with the flow rate of water.
Keywords: Coolant, Cooling Curve Test, Brake Thermal Efficiency.

I. INTRODUCTION

There has been a continuous improvement in the designing of cooling system and in the quality of engine coolants. The engine coolant used in early days was water. But the inability of water to remain in the liquid state at higher temperatures made it less likely to be used as an engine coolant. In addition to the low boiling point, high freezing point also contributed to the demerits of using water as an engine coolant. The internal combustion engine requires some form of heat dissipation techniques to remove the excess heat because all of it was not transformed into mechanical energy. An operating engine typically converts only one third of the energy derived through the combustion of fuel into work that moves the vehicle. The other two thirds is converted into heat, of which one third goes out with the exhaust. This leaves the remaining third in the engine block, necessitating the need for a coolant to absorb this heat, transport it to the radiator and dissipate it into to the environment. Through the removal of this heat by the coolant fluid, the engine is able to operate in an efficient manner. Therefore engine coolant is a generic term used to describe fluids that remove heat from an engine, in effect cooling the engine. Selection of the proper fluid is influenced by the environment in which the engine is used and the interaction of the fluid with the materials that comprise the engine. Some environments such as those found in northern latitudes may expose an engine to periods of extreme cold, requiring the fluid remain liquid in order to function properly. In effect, the heat transfer fluid must be impervious to freezing or expressed in other terms, it must possess anti-freezing characteristics. It is for this reason that engine coolant is sometimes referred to as antifreeze.

II. LITERATURE SURVEY

In the early part of 20th century the main two engine coolants were water and air. So the engine cooling systems were broadly classified into two categories.1.Air cooled engines and 2.Water cooled engines. In early days air cooling systems have gained much popularity because the engines at that time were running at low horse power hence less excess heat to be removed. To obtain proper heat transfer in air cooled systems, the outer surface of engine should be exposed to the surrounding air, which can also be described as a drawback of the air cooled systems because the amount of heat transfer was limited by the outer surface in contact with the surrounding air. In water cooled engines, water is used as the heat transfer fluid which carries away the excess heat and flows to the radiator, where the excess heat could be dissipated to the air. But the low boiling point (100oC) and the high freezing point (0oC) were the main disadvantages of using water as an engine coolant. As a result of this drawbacks salts were introduced to water for the depression of freezing point. Alcohol-water mixtures were successfully used for many years, but they lack the characteristic of high boiling point hence not allowing to operate at higher temperatures. Petroleum products got eliminated from the picture very fast because the heat transfer characteristics were not satisfactory. Flammability of these materials were also another problem in using them as an engine coolant. Petroleum products like kerosene, oil etc were more flammable than desired. In order to address the issue of low boiling point and high freezing point ethylene glycol was introduced. The antifreeze characteristics shown by ethylene glycol

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was very good. Pure ethylene glycol had a freezing point of -9ºC.The freezing point and boiling point of 50%ethylene glycol water mixture is -36.8oC and 107oC respectively[2]. A study conducted on the thermal conductivities of ethylene glycol + water, diethylene glycol + water and triethylene glycol + water mixtures, measured at temperatures ranging from 25°C to 40°C and concentrations ranging from 25 wt. % glycol to 75 wt.% glycolshowed that increasing the concentration of glycol leads to decrease of thermal conductivity.

Increasing the temperature of mixture resulted in slight increase in thermal conductivity[3]. In the early years of antifreeze/coolants (1920s and 30s) glycerine saw some usage, but because of higher cost and weaker freeze point depression, it was not competitive with ethylene glycol.

Glycerin is a by-product of the manufacture of biodiesel (fatty acid methyl esters) made by reacting natural vegetable or animal fats with methanol. Biodiesel fuel is becoming increasingly important and is expected to gain a large market share in the next several years. Regular diesel fuels blended with 2%, 5%, and 20% biodiesel are now commercially available[4]. Today glycerol is considerably cheaper than both ethylene and propylene glycol currently used in engine coolants.For this reason and lower toxicity comparable to that of propylene glycol , glycerol was rapidly reconsidered as base for a number of commercial antifreeze and coolant products[7].

The freezing point and boiling point of 50% glycerol solution is - 27.5ºC and 109ºC respectively[5].Most liquid-cooled engines use a mixture of water and chemicals such as antifreeze and rust inhibitors. The industry term for the antifreeze mixture is engine coolant. Some antifreezes use no water at all, instead using a liquid with different properties, such as propylene glycol or a combination of propylene glycol and ethylene glycol. Most "air-cooled" engines use some liquid oil cooling, to maintain acceptable temperatures for both critical engine parts and the oil itself. Most liquid-cooled engines use some air cooling, with the intake stroke of air cooling the combustion chamber. An exception is Wankel engines, where some parts of the combustion chamber are never cooled by intake, requiring extra effort for successful operation [6]. Properties of the coolant also affect cooling.If the viscosity of the coolant is high then pumping power increases which reduces the net power output of the engine.If the specific heat transfer of the coolant is low then the amount of coolant required to attain a particular temperature will be high.

III. EXPERIMENTAL PROCEDURE

The aim of the experiment is to find the influence of coolant on brake thermal efficiency and fuel consumption by varying the coolant outlet temperature and also to find out the change in flow rate of each coolant to attain a specific temperature. Procedure is as follows:

A. Compute the maximum tension on the brake drum for the rated shaft power ,at rated speed
B. Open the fuel supply and coolant supply. Start and load the engine at half load and adjust the speed to the rated rpm
C. Coolant flow is adjusted to maximum. Allow engine to run for 2 to 3 minutes to attain steady conditions. Note the time for consuming a fixed quantity of fuel
D. Repeat the observations for six different coolant outlet temperatures by reducing the flow rate, keeping the load constant.

IV. CALCULATIONS

Brake power PB = (□□D+d)N(W-S))/60000 (kW) (1)
Where, D = Brake wheel diameter (in m), d = Band thickness (in m), N = speed in rpm, W = tight side tension (in N), S =slack side tension(in N)
Fuel consumption m = (v*3600*□)/1000*t (kg/hr) (2)
Where, v=volume of fuel consumed , t=time taken for fuel consumption (in s)
Specific fuel consumption = m/PB (kg/kW-hr) (3)
Brake thermal efficiency □bt = (PB*3600)/m*Q (4)
Where, Q = calorific value of Diesel
Percentage increase in flow rate = (flow rate of coolant- flow rate of water)/flow rate of water

V. RESULTS

Cooling curve test on three samples of engine coolant was carried out.The three samples were 1.Water 2.50%ethylene glycol-water mixture. 3.50%glycerol-water mixture. From (1) Brake power will be always 2.78 kW and the half load for ruston engine is 6.6 kg.

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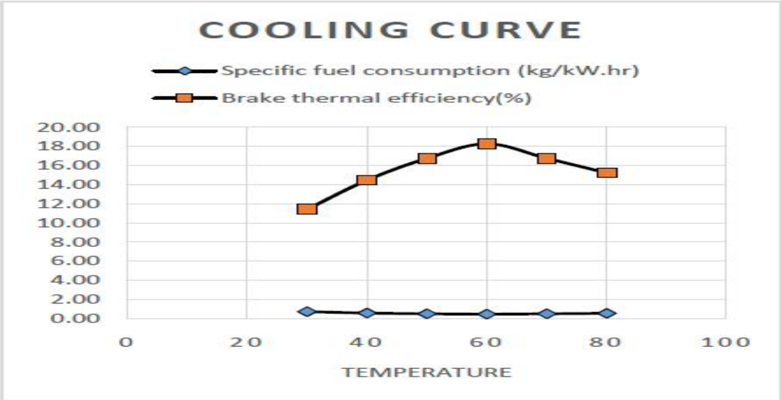
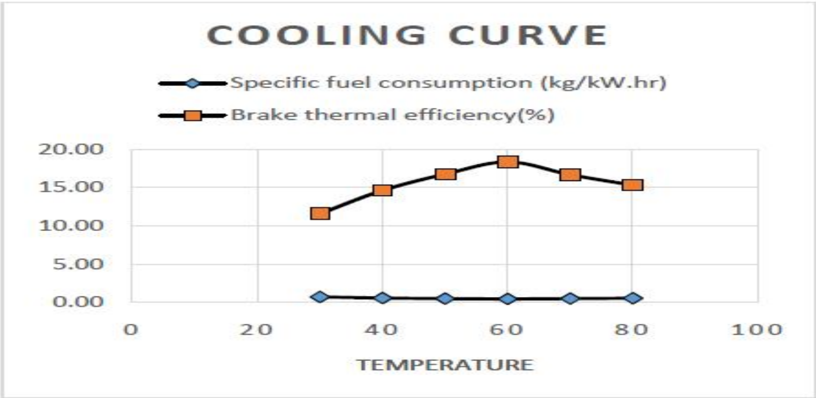
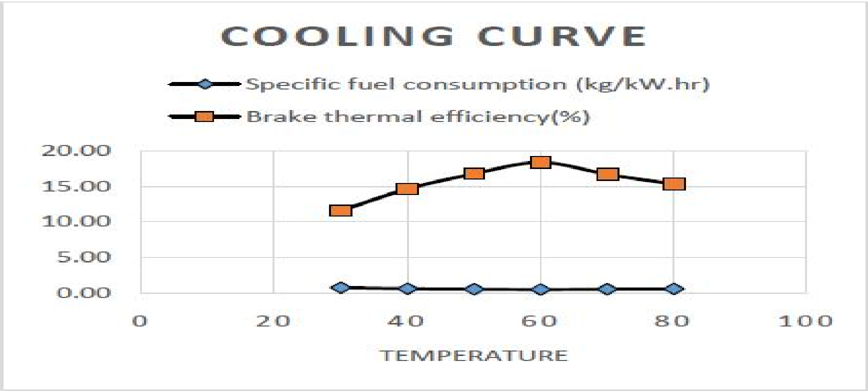
A. *Cooling Curve Test For Water*



B. *Cooling Curve Test For 50% Ethylene Glycol-Water Mixture*



C. *Cooling Curve Test For 50% Glycerolwater Mixture*



From the experiment conducted on the above three samples, it is seen that there is no significant change in the fuel consumption and brake thermal efficiency.

VI. CONCLUSION

It was found out that optimum coolant outlet temperature is 60oC, that is the temperature at which maximum brake thermal efficiency and maximum fuel economy was observed. There was no change in the optimum temperature and fuel economy by changing the coolant alone, but there was a change in flow rate. For proper heat transfer, system with ethylene glycol-water mixture and glycerol-water mixture, the circulated volume must be increased compared to a system only with water.

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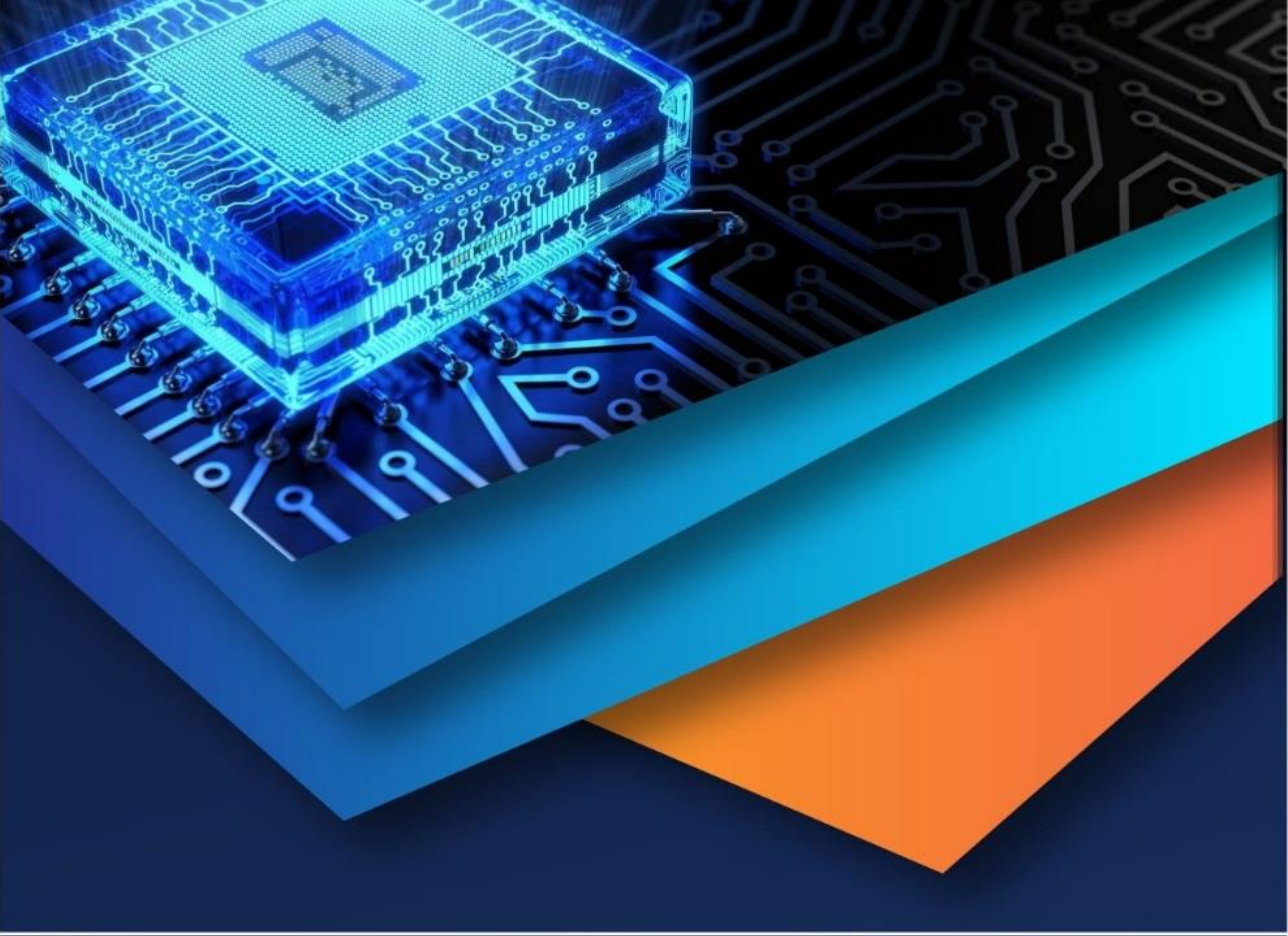

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