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Experimental Analysis of Utilization of Heat Using Methanol - Diesel Blended Fuel in Four Stroke Single Cylinder Water Cooled Diesel Engine

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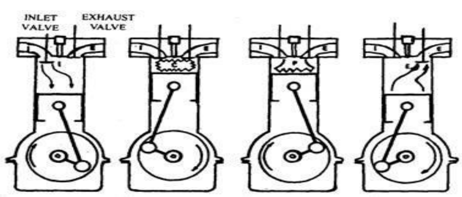
***Abstract*— In this paper an attempt has been made to investigate the utilization of heat in a four stroke single cylinder water cooled diesel engine using pure diesel and methanol-diesel blended fuel. During the investigation the ratios of methanol: diesel was taken 6:94, 12:88 and 18:82 respectively by volume. The different loads considered during the analysis were 0 kg, 7 kg, 10.4kg, and 12.6 kg respectively. The experiment has been performed on the basis of 1st law of thermodynamics. The effect of utilization of heat has been studied with the help of pie diagram. From the study, it has been revealed that, the heat distribution of methanol-diesel (12:88) blended fuel is almost similar to the heat distribution of pure diesel. From the experiment, it has been also observed that the 12:88 methanol-diesel blended fuel is the best replacement of pure diesel.**

***Keywords*— methanol-diesel blended fuel, heat distribution, ratio of methanol*.

I. INTRODUCTION

Internal combustion engines can be seen every day in automobiles, trucks and buses. There are two types of internal combustion engines, such as SI engines and CI engines. The internal combustion engines can also be classified according to their number of strokes, i.e. two stroke and four stroke engines. Here research has been carried out in four stroke single cylinder water cooled diesel engine. In four stroke engines the piston accomplishes four distinct strokes for every two revolutions of the crankshaft i.e. suction, compression, expansion and exhaust. The schematic diagram of CI engines is shown FIGURE I.

FIGURE I



A number of studies have been carried out in the field of testing of performance using various mixing fuel, emission testing using various different types of diesel engine. Murray et al [1] investigated the performance of methanol-coconut oil blends in diesel engines, using coconut oil, biodiesel (CME) as a co-solvent in 2012. Six fuels were tested in a diesel engine test unit; diesel, neat CME, neat coconut oil, a coconut oil-CME blend, a blend containing 10% methanol by volume and another containing 30% methanol by volume. From investigation it was found that the methanol blends had better engine performance, when compared to neat coconut oil operation. Again the methanol blends exhibited similar and even better engine performance than diesel operation, with a BTE of 28.6% for the 30% methanol blend as compared to 22.9% for diesel operation. Tippayawong et al [2] tested the durability of a small agricultural engine running on dual fuel operation in 2010. Diesel and biogas were used for the study. After the completion of 3500 hours run they found that Biogas has the potential to be utilized in a dual fuel long term engine operation without involving any engine modification. Li et al [3] in 2005 used 5%, 10%, 15% and 20% of ethanol with 95%, 90%, 85%, 80% and 100% of petroleum diesel respectively on diesel engine. In overall working conditions, the tests point out Brake Specific Fuel Consumption and Brake Thermal Efficiency was improved, as percentage of Ethanol increased, emissions of smoke were reduced, particularly because E10D90 and E15D85 were used. Exhaust emissions such as Carbon Monoxide and NO_x were decreased although total hydrocarbons increased considerably. In 2010 Zhang et al [4] studied the mixture of decontaminated Methanol and pure conventional diesel to check exhaust emissions of the diesel engine by using five different loads with constant speed. They showed that engine Brake Thermal Efficiency was reduced at low engine loads with a slight increase at high engine loads; NOx exhaust emissions and particulate mass were decreased but carbon monoxide emissions, nitrogen dioxide emissions, and hydrocarbons emissions were increased. Again, it also found that controlled and uncontrolled exhaust emissions were decreased with the use of diesel oxidation catalyst. Chu Weitao [5] investigated the influence of M0, M5and M15 methanol / diesel fuel mixture on diesel engine performance in a single-engine ZS195. Test results show that with adding of methanol, the driving force of the engine was weaker; fuel economy was improved; diesel smoke and CO emissions are significantly reduced; NOx emissions are more at M5, but were reduced about 8% at M15; HC emissions were increased when the diesel engine parameters remained unchanged. Suresh et al. [6] modified a single cylinder vertical air cooled diesel engine to use methanol dual fuel mode to study the performance, emission and combustion characteristics. Dual fuel engine showed a reduction in oxides of Nitrogen and smoke in the entire load range. However, it suffers from the problem of poor brake thermal efficiency and high hydrocarbon and carbon monoxide emissions, particularly at lower loads due to poor ignition. In order to improve the performance at lower loads, a glow plug was introduced inside the combustion chamber. The brake thermal efficiency improved by 3% in the glow plug assisted dual fuel mode, especially at low load and also reduced the hydrocarbon, carbon monoxide, and smoke emissions by 69%, 50% & 9% respectively. The presence of glow plug had no effect on oxides of nitrogen. From the performance review of literature, it is observed that there exists a void as far as the study on the utilization of heat in a diesel engine with respect to load and different percentages of blended fuels are concerned. Therefore, in this paper an endeavour has been made to study the utilization of heat in a diesel engine with respect to various loads and percentages of blended fuels and suitable alternative of diesel.

II. MATHEMATICAL FORMULATION

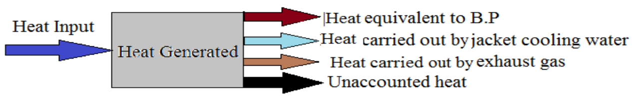
The calorific value of pure diesel and different percentages of blended fuels have been assessed on the basis of experiment, which performed by the help of bomb calorimeter. The result has depicted on the TABLE I.

TABLE I

Blended Fuel	Calorific Value (kJ/kg)	load	Fuel Consumption
Pure diesel	42528.16	0	0.369
		7	0.555
		10.4	0.655
		12.9	0.748
6:94 methanol: diesel	34264.42	0	0.390
		7	0.601
		10.4	0.658
		12.9	0.743
12:88 methanol: diesel	33254.55	0	0.452,
		7	0.668
		10.4	0.755
		12.9	0.855
18:82 methanol: diesel	30797.81	0	0.432
		7	0.733
		10.4	0.741
		12.9	0.769

The heat distribution through the engine has been experimented on the basis of first law of thermodynamics. From the FIGURE II, it has been observed that heat generated in the engine will be equal to the heat distributed through BP, jacket cooling water, exhaust gas and unaccounted heat.

FIGURE II



The mathematical formulation has given below [7].

$$\text{Heat input} = C.V \times F.C \text{ kJ/hr} \quad (1)$$

Where,
C.V. = Calorific Value in kJ/kg
F.C = Fuel Consumption in kg/hr

$$\text{Heat equivalent to B.P} = B.P \times 3600 \text{ kJ/hr} \quad (2)$$

Where,
B.P = 2πNT/1000×60 kW
N = speed in rpm
T = torque in N-m

Heat carried out by jacket cooling water =

$$m_{cw} \times c_{pw} \times (T_2 - T_1) \text{ kW} \quad (3)$$

Where,
m_{cw} = mass of cooling water flowing per hour (kg/hr)
c_{pw} = specific heat of water (kJ/kg K)

Heat carried by exhaust gas =

$$m_g \times c_g \times (T_3 - T_1) \text{ kW} \quad (4)$$

Where,
m_g = mass flow rate of exhaust gas(kg/hr)
c_g = specific heat of exhaust gas (kJ/kg K)

Unaccounted heat = [Total heat input - (heat equivalent to b.p + heat carried by cooling water + heat carried by exhaust gas)] kW
(5)

III. RESULTS AND DISSCUSSION

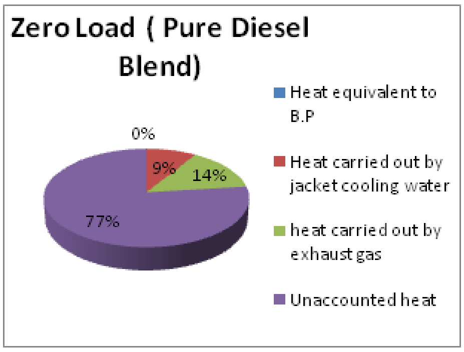
In this study, the analysis of utilization of heat of a single cylinder four stoke water cooled diesel engine has been carried out. All the calculations during analysis have been performed on the basis of experimented result. The intension of this study is to find the best replacement of pure diesel at a particular type of engine. The analysis has been carried out based on first law of thermodynamics. The different load considering during the analysis are 0 kg, 7 kg, 10.4 kg, and 12.6 kg respectively.

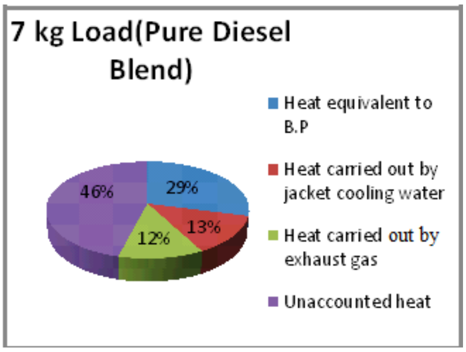
A. Effect of utilization of heat on load for pure diesel

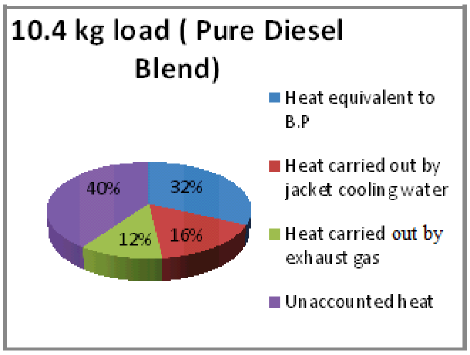
TABLE II

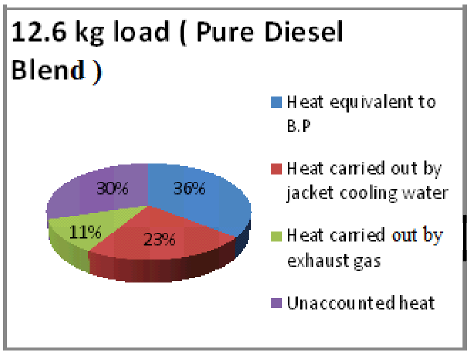
Constant	Variables
Diesel-methanol blended fuel	Load (kg)
Ambient temperature	Temperature rise in cooling water

FIGURE III









At a particular type of fuel (pure diesel) heat equivalent to B.P increases with increase in load.

Similarly, heat carried out by jacket cooling water increases with the increase in load.

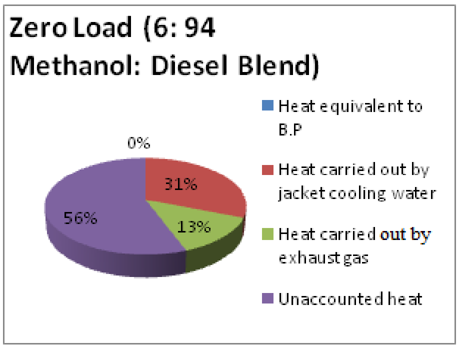
Whereas, heat carried out by exhaust and unaccounted heat is decreases with the increase in load.

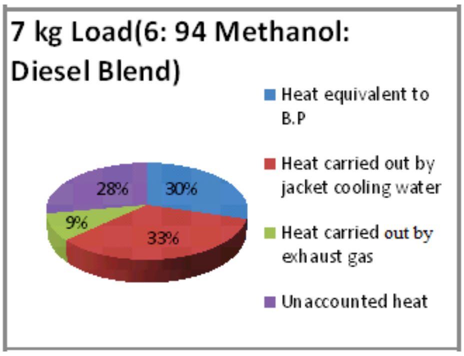
B. Effect of utilization of heat on load for 6:94 methanol: diesel blend

TABLE III

Constant	Variables
Diesel-methanol blended fuel	Load (kg)
Ambient temperature	Temperature rise in cooling water

FIGURE IV





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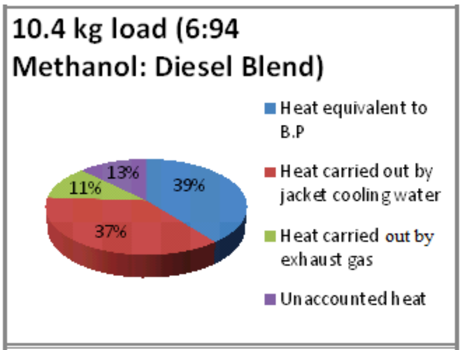
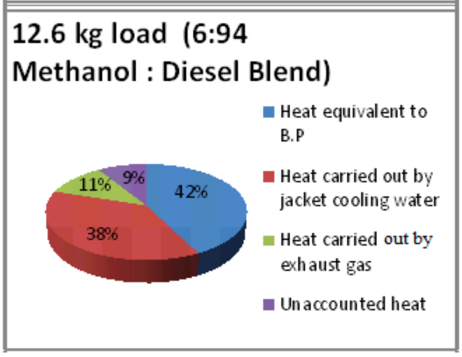




At a particular type of fuel (6:94 methanol diesel blend) heat equivalent to B.P increases with increase in load.

Similarly, heat carried out by jacket cooling water increases with the increase in load.

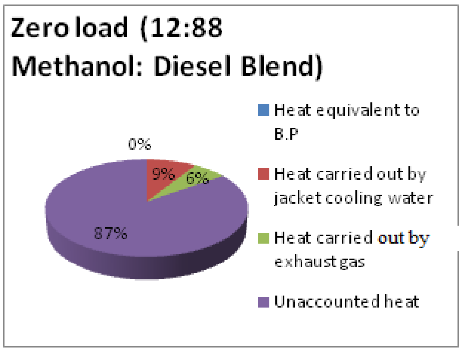
Whereas, heat carried out by exhaust and unaccounted heat is decreases with the increase in load.

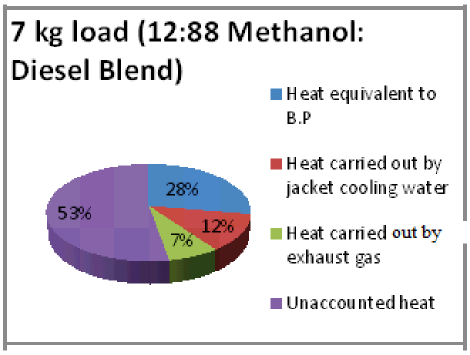
C. Effect of utilization of heat on load for 12:88 methanol: diesel blend

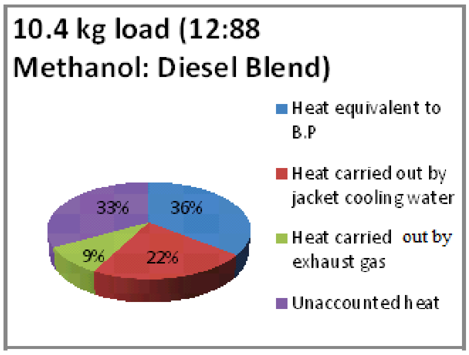
TABLE IV

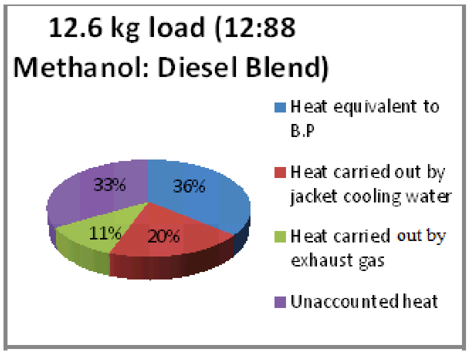
Constant	Variables
Diesel-methanol blended fuel	Load (kg)
Ambient temperature	Temperature rise in cooling water

FIGURE V









At a particular type of fuel (12:88 methanol diesel blend) heat equivalent to B.P increases with increase in load.

Similarly, heat carried out by jacket cooling water increases with the increase in load.

Whereas, heat carried out by exhaust gas is increase with the increase in load.

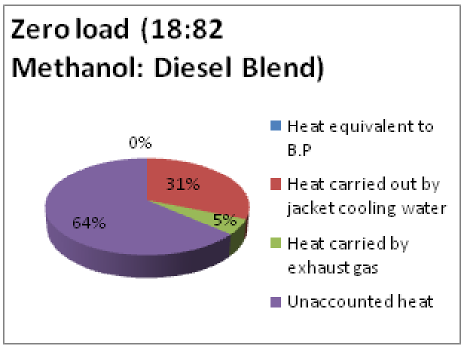
Again, unaccounted heat is decreases with the increase in load.

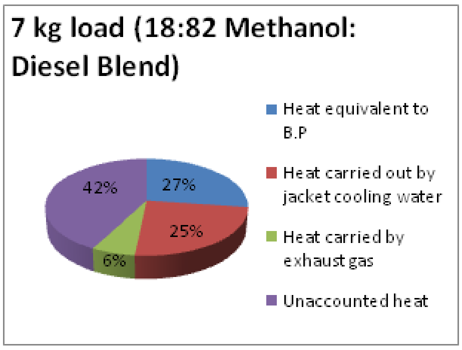
D. Effect of utilization of heat on load for 18:82 methanol: diesel blend

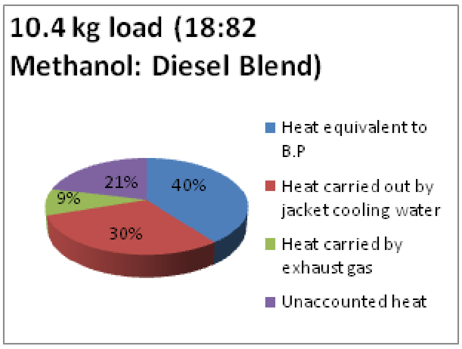
TABLE V

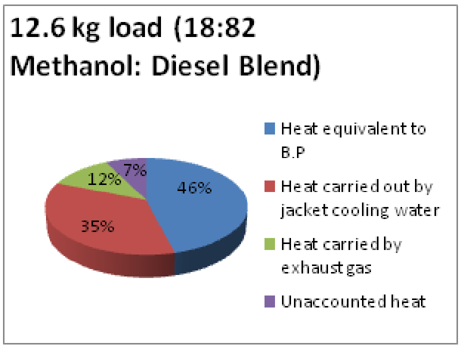
Constant	Variables
Diesel-methanol blended fuel	Load (kg)
Ambient temperature	Temperature rise in cooling water

FIGURE VI









At a particular type of fuel (18:82 methanol diesel blend) heat equivalent to B.P increases with increase in load.

Similarly, heat carried out by jacket cooling water increases with the increase in load.

Whereas, heat carried out by exhaust gas is increase with the increase in load.

Again, unaccounted heat is decreases with the increase in load.

IV. CONCLUSION

The study in this paper presents the utilization of heat in four stroke single cylinder water cooled diesel engine on the basis of first law of thermodynamics. The effect of variation of load on output parameters, i.e. heat equivalent to B.P, heat carried out by exhaust gas, heat carried out by cooling water and unaccounted heat for pure diesel and various ratios of blended fuels has been assessed. The results of these analyses provide the following conclusions.

1. At a particular mixture heat equivalent to B.P increases with the increase in load. Again, at a particular load, heat equivalent to B.P increases with the increase in percentage of methanol except 12:88 diesel methanol blend.
2. At a particular mixture heat carried out by cooling water increases with the increases in load. Similarly at a particular load, heat carried out by cooling water increases with the increases in percentage of methanol except 12:88 diesel methanol blend.
3. At a particular mixture the heat carried out by exhaust gas decreases with the increase in load, for pure diesel and 6:94 methanol: diesel blend. Whereas, for 12:88 and 18:82 methanol: diesel blended fuel the heat carried out by exhaust gas increases with the increase in load.
   Again, at a particular load, the heat carried out by exhaust gas decreases with the increase in percentage of methanol.
4. Again, at a particular mixture unaccounted heat is decrease with the increase in load. Similarly, at a particular load, it can be seen that the values of different mixture are criss-crossing each other. This happened due to some uneven mixing of the fuel and knocking inside the combustion chamber.

The heat distribution of pure diesel and 12: 88 methanol: diesel blended fuel are quite similar, that is why it may be concluded that, the aforesaid blended fuel could be the best possible alternative of pure diesel for the experimented engine.

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NOMENCLATURE

C.V. = Calorific Value in kJ/kg.
F.C = Fuel Consumption in kg/hr.
B.P = Brake Power in kW.
N = speed in rpm.
rpm = revolution per minute
T = torque in N-m.
m_{cw} = mass of cooling water flowing per hour in kg/hr.
c_{pw} = specific heat of water kJ/kg K
m_g = mass flow rate of exhaust gas kg/hr
c_g = specific heat of exhaust gas kJ/kg K

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