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PERFORMANCE INVESTIGATION OF FOUR STROKE DIESEL ENGINE USING PREHEATED INLET AIR

Saurabh Chaurasia[1], Dr. Jitendra kumar Pandey[2], Prof. Mahendra Dawande[3]

[1]ME Deptt, Birt Bhopal, (India)

[2]Prof. & Head, Me Deptt, Birt Bhopal, (India)

[3]ME Deptt, Assistant Prof, Birt Bhopal, (India)

ABSTRACT

The performance analysis of single cylinder four stroke diesel engines is carried out with preheated or without preheated air is used at inlet of the diesel engine. The air is preheated by the use of exhaust energy or gases through heat pipe. The experiments are conducted under various loading conditions as well with respect to the time. Varying the parameters under constant loading conditions the performance are analyzed. Also keeping other controlling factors and issues most of the parameters are calculated at the inlet temperature 30°C, 35°C , 40°C, and 45°C respectively. From the experiments and graph the various parameters are analyzed in which the Torque for normal inlet air and preheated inlet air, the curve is quite constant with a small gap between maximum and minimum value. The output power for normal air is lower compared to preheated inlet air at any ratio and the power output of diesel engine increases. SFC decreases with the increase in temperature of inlet air. The inlet air temperature at 35°C gives 8.6% lower BSFC as compare to 45°C. When Load increases brake thermal efficiency is also increases. At constant temperature condition (40°C), the brake thermal efficiencies obtained are 6.75%, 13.08%, 12.02% and 11.05% for the 25%, 50%, 75% and 100% load condition respectively. The exhaust gas temperature increases with increase in brake power at full load only.

Key Words- Diesel Engine, Performance Parameter, Preheated Air, Different Load, Efficiencies

I. INTRODUCTION

The I.C engine is a Device which changed 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 out from fuel due to combustion is lost mainly in the form of Heat. Approximately 28-40% of the total energy generated by the engine is dissipated in the form of Exhaust loss energy. The use of waste heat 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 can be utilized the waste heat for useful work to increase the efficiency of engines. In particular, interest in heat pipe is increasing due to their low pressure drop and high effectiveness compared to conventional system for waste heat recovery. Diesel engine efficiency depends on many complex parameters such as heat losses during cooling of engine, heat losses in exhaust gases, friction loss, transmission efficiency losses etc. though intake air temperature plays a predominant role in achieving better efficiency. Heat pipe is used for air intake preheating 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, incomplete combustion, local over-enrichment and high pressure gradients due to abrupt mixture conversion in the cylinder. These factors lead to knocking of the diesel engine and increase in emission of hydrocarbons in the exhaust gas leading to severe loading of the environment. In order to avoid this heat pipe is introduced to heat intake air during running.

II. DIESEL ENGINE

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 40 bar (approx 600 psi) pressure compared to 14 bar (approx 200 psi) in the gasoline engine. This high compression heats the air to 550 °C. At about this instant (the exact moment is determined by the fuel injection timing of the fuel arrangement), fuel is introduced directly into the compressed air in the combustion chamber.

2.1 Availability of Waste Heat from I.C. Engine

The quantity of waste heat contained in a exhaust gas is a function of both the temperature and the mass flow rate of the exhaust gas: Where, is the heat loss (kJ/min); is the exhaust gas mass flow rate (kg/min); is the specific heat of exhaust gas (kJ/kg°K); and is temperature gradient in °K. In order to enable heat transfer and recovery, it is necessary that the waste heat source temperature is higher than the heat sink temperature. Moreover, the magnitude of the temperature difference between the heat source and sink is an important determinant of waste heats utility or “quality”. The source and sink temperature difference influences the rate at which heat is transferred per unit surface area of recovery system, and the maximum theoretical efficiency of converting thermal from the heat source to another form of energy (i.e., mechanical or electrical). Finally, the temperature range has important function for the selection of waste heat recovery system designs.

Table 1: Power Output and Waste Heat

Sr. No.	Engine Type	Power Output KW	Waste Heat
1	Small air cooled diesel engine	35	30-40% of Energy Waste loss From I.C. Engine
2	Small agriculture tractors and construction machines	150	
3	Water air cooled engine	35-150	
4	Earth moving machineries	520-720	
5	Marine applications	150-220	
6	Trucks and road engines	220	

2.2 Benefits of Waste Heat Recovery From I.C Engine

1. Benefits of waste heat recovery from engines can be broadly classified in two categories.
2. 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.
3. 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:

d) Reduction in equipment sizes gives additional benefits in the form of reduction in auxiliary energy consumption.

III. THE FUNCTION OF HEAT PIPES IN HEAT RECOVERY AND ENERGY CONSERVATION

In recent times, researchers have created developments of high interest in heat pipe technology for heat recovery. Studies have analyzed the approach, design, construct, thermal performance and application of heat pipes. The use of heat pipes for waste heat recovery is an outstanding way to save energy and prevent global warming. A heat pipe heat exchanger (HPHE) is utilized as an efficient air-to-air heat recovery device in both commercial and industrial applications. The HPHE is the best choice, with almost no cross-leakage between the exhaust gas and supply air. It possesses many advantages, such as its heat recovery effectiveness, compactness, light weight, small pressure drop on the air side, complete separation of hot and cold fluids, relative economy, lack of moving parts, and reliability. The HPHE has been applied extensively in many industries (e.g., energy engineering, chemical engineering and metallurgical engineering) as waste heat recovery systems. One of the most important applications of HPHEs is the recovery of the heat from exhaust gases in a furnace stack. The use a HPHE both reduces the primary energy consumption and protects the environment. still, research on the use of heat pipes for heat recovery, especially with regard to energy savings and environmental benefits, is needed.

3.1 Functions of Heat Pipe In I.C Engine

One of the most exciting application of heat pipe in IC Engines is known as VAPIPE. while fitted to a car engine, it appreciably reduces both the fuel utilization and exhaust emission by using heat extracted from exhaust emission by using the heat extracted from exhaust gas for vaporizing petrol mixture from carburetor prior to it enters the engine. The vaporized combination (Diesel + air) makes a homogeneous mixture and improves combustion.

3.2 System Description

In this study, single cylinder 4-stroke compression ignition engine was used for experimental analysis. This is a 12-liter, compression ignition, single-cylinder engine with linear arrangement. The studies were performed with engine load of 100% and engine speeds of 800 to 1600 rpm that consumes diesel oil. Its technical characteristics and specifications were presented in table 4.1 as main engine characteristic. The speed is measured by Digital RPM Indicator. The temperature is measured through multi - Channel digital Temperature Indicator. Also, every desired point is connected with thermocouple which indicates the temperature digitally. Clearance Volume (V_c) is 35 Cm^3 and Swept Volume (V) is 256 Cm^3. Loading (BHP, Maximum) of the engine is measured by Rope Brake Dynamometer.

The cooling system is water cooling for auxiliary Head. Exhaust gas calorimeter is used Shell and Tube Type Calorimeter for calculation of energy and making Heat balance sheet. Further Engine Output (Kg.) is measured by spring balance for dynamometer. Air flow is measured by mild steel tank, Orifice plate, and a Manometer. At the last the fuel flow rate is measured through glass Burette with cover installed in the experimental setup. The whole setup is fitted on M.S. Frame & Control panel, with Proper Rigid Concrete foundation.

The engine fuel system is modified by adding a custom tank and a flow metering system which used for fuel consumption measurement. A two glass burette of known volume is used to measure the fuel. A large air box fitted with an orifice plate is used for measuring air consumption rate using differential pressure transducer model Setra 239 having differential pressure range of 0-12.7 cm water column with accuracy of 1%. The exhaust gases temperature is measured using calibrated K type thermocouple with accuracy of 0.5%. Ambient air temperature, intake air temperature inside the intake air manifold is measured using calibrated K type thermocouple probes. The cylinder pressure is measured using piezoelectric pressure transducer model Kistler 6123, 0-200 bar as pressure range with sensitivity of 16.5 pc/bar and accuracy of 1.118 %. A slotted disk is fitted to the end of the crankshaft and an optical sensor for measuring engine speed and crankshaft angle position. The signals from the pressure transducers, optical sensors, and thermocouples are digitized and recorded. The brake mean effect pressure (BMEP) is calculated from engine power, speed and engine geometry specification.

IV. PERFORMANCE ANALYSIS

4.1 Torque

The graph (Figure-1) for torque shows the decreasing curve as the engine speed increases for normal inlet air i.e. cold air. The same trend is being followed for the preheated inlet air. However, for normal inlet air and preheated inlet air, the curve is quite constant with a small gap between maximum and minimum value.

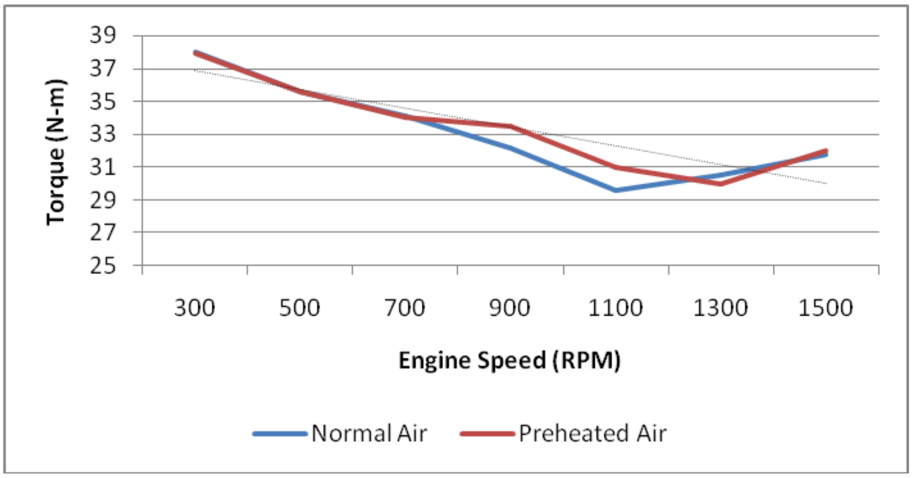

Figure 1: Engine Torque vs. Engine Speed With And Without Preheated Inlet Air

4.2 OUTPUT POWER

Figure 2 shows the comparisons of hot and cold air in inlet and its effect on output power.The output power for normal air is lower compared to preheated inlet air at any ratio and the power output of diesel engine increases with the amount of fuel injected with preheated inlet air but it is usually limited by the increased smoke emissions.

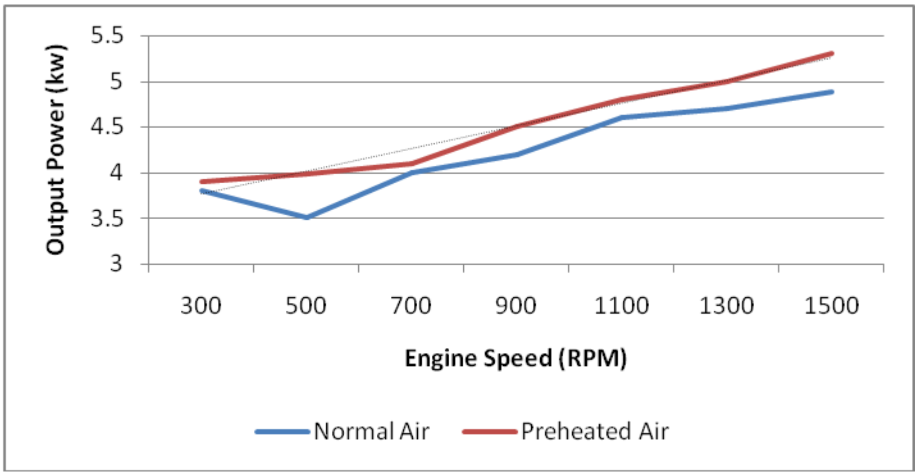

Figure 2: Output Power vs. Engine Speed

4.3 Specific Fuel Consumption

At a little bit higher temperature of the inlet air the effect of proportion of consumption of diesel on specific fuel consumption (SFC) are shown in figure 3. It indicate that SFC decreases with the increase in temperature of inlet air. The inlet air temperature 30°C and 40°C shows the higher BSFC whereas at 35°C gives 8.6% lower BSFC as compare to 45°C.

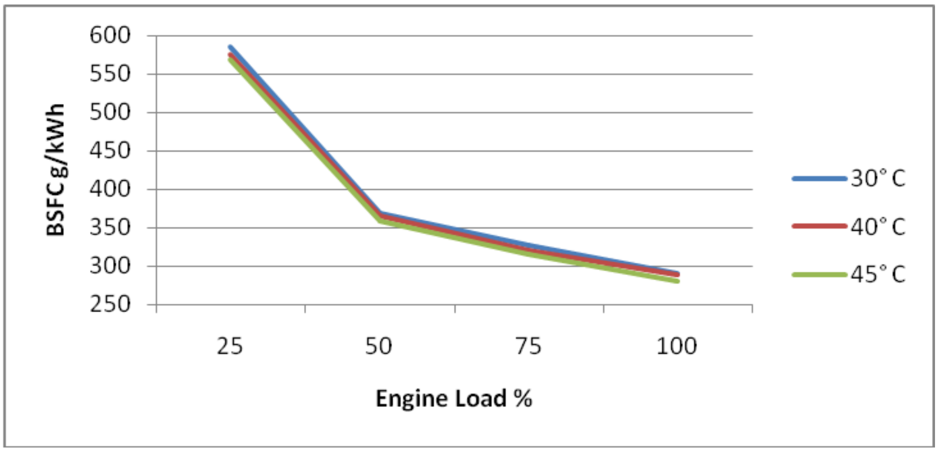

Figure 3: Comparisons of BSFC

V. BRAKE THERMAL EFFICIENCY

Brake thermal efficiency is the ratio of the power output to the energy supplied through fuel injection. Figure 4, shows the variation of brake thermal efficiency with respect to the increased value of inlet air temperature (Constant 40°C) at different loads. Load increases brake thermal efficiency is also increases for diesel engine. At constant temperature condition (40°C), the brake thermal efficiencies obtained are 6.75%, 13.08%, 12.02% and 11.05% for the 25%, 50%, 75% and 100% load condition respectively.

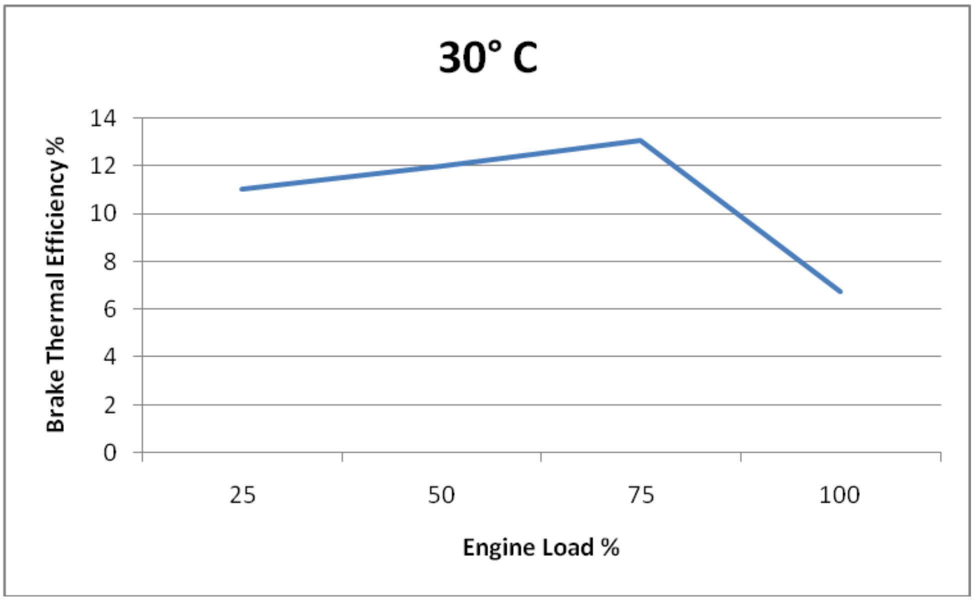

Figure 4: Variation Of Brake Thermal Efficiency With Engine Load At Constant Temperature 30°C

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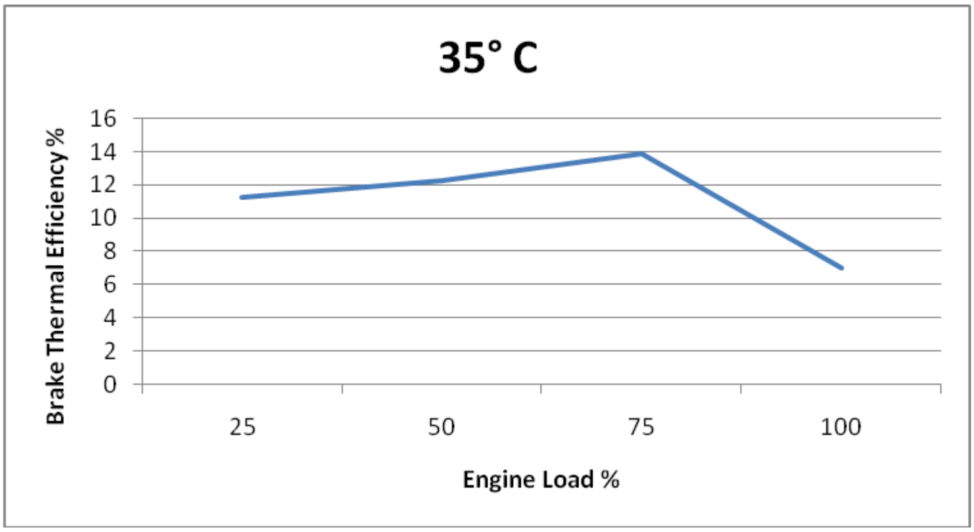

Figure 5: Variation of Brake thermal efficiency with engine load at constant temperature 35°C

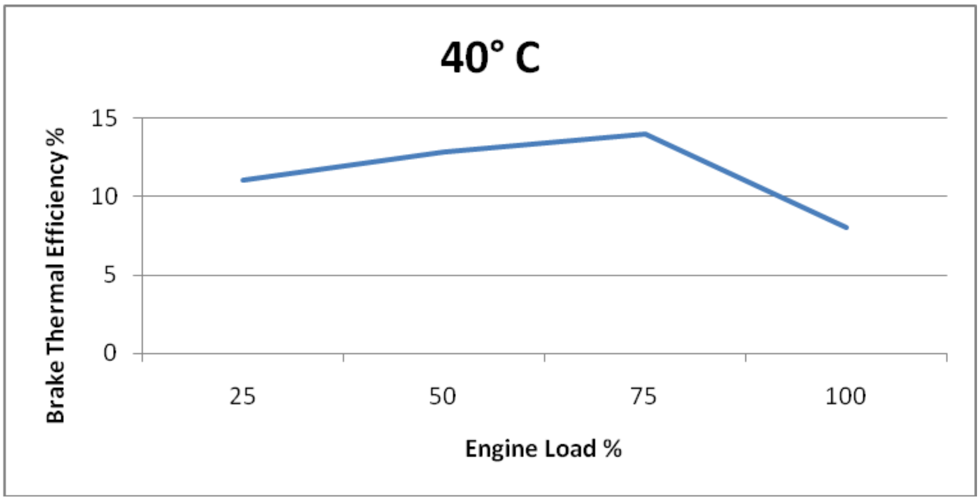

Figure 6: Variation of Brake thermal efficiency with engine load at constant temperature 40°C

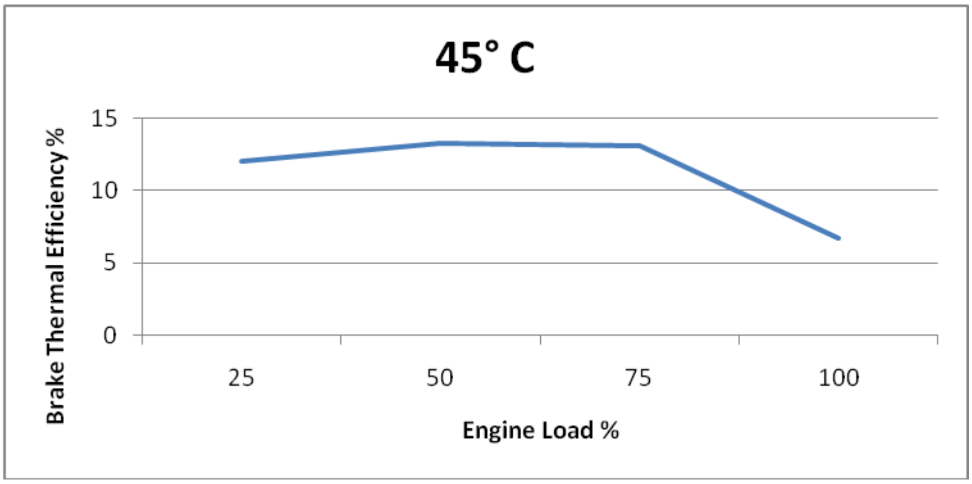

Figure 7: Variation of Brake thermal efficiency with engine load at constant temperature 45°C

VI. EXHAUST GAS TEMPERATURE

The exhaust gas temperature increases with increase in brake power at full load only. The exhaust gas temperature at no load is 6% and at part load 15% higher than in normal condition of diesel. The exhaust gas temperature (EGT) increased with increase in engine load for all the temperature condition of inlet air. The maximum exhaust gas temperature was obtained at full load condition for all the temperature condition of inlet air tested and was 375°C, 420°C and 418°C for three different inlet temperature 30°C, 40°C and 45°C respectively as compared to 137°C, 134°C and 139°C at no load condition.

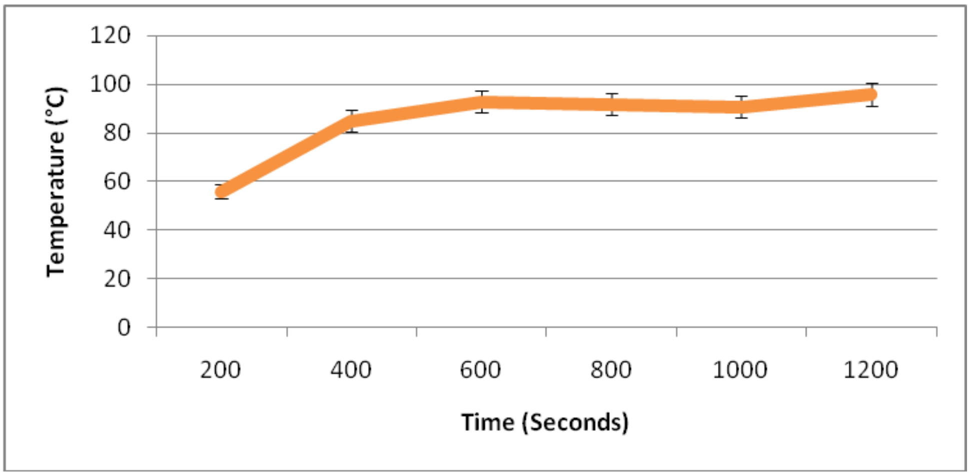

Figure 8: Variation of exhaust temperature with no load

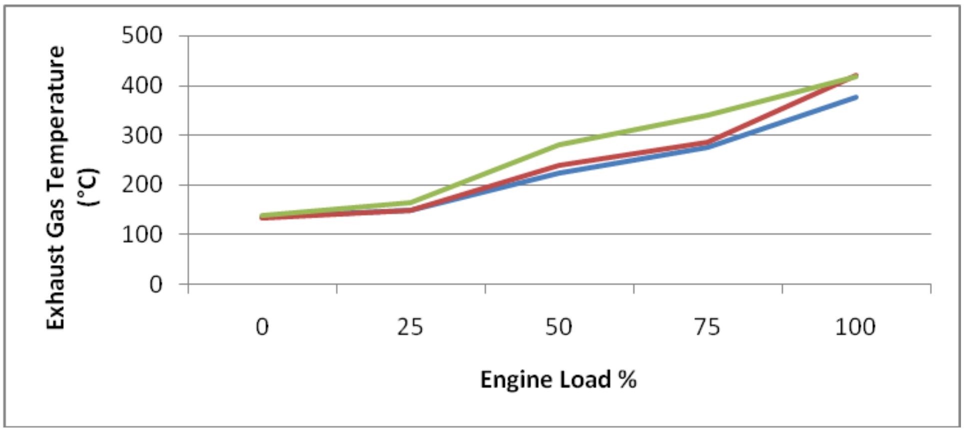

Figure 9: Exhaust Gas Temperature at different loading condition for different inlet temperature.

VII. CONCLUSION

From the experiments and graph the various parameters are analyzed in which the Torque for normal inlet air and preheated inlet air, the curve is quite constant with a small gap between maximum and minimum value. The output power for normal air is lower compared to preheated inlet air at any ratio. SFC decreases with the increase in temperature of inlet air. Load increases brake thermal efficiency is also increases for diesel engine and the Exhaust gas temperature increases with increase in brake power at full load only.

FUTURE SCOPE

The following points are analyzed for future work which is as follows.

- Analysis of exhaust gas emission may also be done by using preheated air on different temperature range.
- Thermal analysis of exhaust gas may also be done.
- Due to the unavailability of exhaust gas analyzer Analysis of exhaust gas has not carried out. There is a scope of exhaust gas analysis on different preheated air temperature at inlet of CI diesel engine.
- Modification in the design of engine cylinder for further improvement in the Performance Parameters are also done in future.

REFERENCES

[1] K.T. Wojciechowski, M.Schmidt, R.Zybala, J.Merkisz, P.Fuc and P.Lijewski. Journal of Electronic Materials.10.1007/s11664-009-1010-1.
[2] Opat R, Ra Y, Gonzalez MA, Krieger R, Reitz RD, Foster DE, et al. Investigation of mixing and
[3] temperature effects on HC/CO emissions for highly dilute low temperature combustion in a light duty diesel
[4] engine. SAE tech paper; 2007. SAE 2007-01-0193.
[5] Stone R. Motor vehicle fuel economy, Macmillan Education Ltd., UK, 1989.
[6] K.M.Saqur ,M.K.Mansour and M.N.Musa, Journal of Automotive technology.9,155(2008)
[7] Bobba MK, Musculus MPB. Laser diagnostics of soot precursors in a heavy-duty diesel engine at low temperature combustion conditions. Combust Flame 2012; 159:832–43.
[8] Jacobs TJ, Assanis DN. The attainment of premixed compression ignition low temperature combustion in a
[9] compression ignition direct injection engine. P Combust Inst 2007; 31:2913–20.
[10] Kim DS, Kim MY, Lee CS. Combustion and emission characteristics of partial homogeneous charge
[11] compression ignition engine. Combust Sci Technol 2005; 177:107–25.
[12] Asad U, Zheng M, Han X, Reader GT, Wang M. Fuel injection strategies to improve emissions and efficiency of high compression ratio diesel engines. SAE tech paper; 2008. SAE 2008-01-2472.
[13] Mosbach S, Su H, Kraft M, Bhave A, Mauss F, Wang Z, et al. Dual injection homogeneous charge compression ignition engine simulation using a stochastic reactor model. Int J Engine Res 2007; 8:41–50.
[14] Kim MY, Lee JH, Lee CS. Combustion characteristics and NOx emissions of a dimethyl-ether-fueled
[15] premixed charge compression ignition engine. Energy Fuel 2008; 22:4206–12.
[16] Azimov UB, Kim KS, Jeong DS, Lee YG. Instantaneous 2-D visualization of spray combustion and flame
[17] Luminosity of GTL and GTL-biodiesel fuel blend under quiescent ambient conditions. Int J Auto Tech-Kor 2011; 12:159–71.
[18] Mancaruso E, Vaglieco BM. Premixed combustion of GTL and RME fuels in a single cylinder research engine. Appl Energy 2012; 91:385–94.
[19] Yoon SH, Lee CS. Experimental investigation on the combustion and exhaust emission characteristics of biogas–biodiesel dual-fuel combustion in a CI engine. Fuel Process Techno 2011; 92:992–1000.

[20] Szybist JP, Song J, Alam M, Boehman AL. Biodiesel combustion, emissions and emission control. Fuel

[21] Process Technol 2007; 88:679–91.

[22] Ishida M, Yamamoto S, Ueki H, Sakaguchi D. Remarkable improvement of NOx- PM trade-off in a diesel

[23] engine by means of biodiesel and EGR. Energy 2010; 35:4572–81.

[24] Barnwal BK, Sharma MP. Prospects of biodiesel production from vegetable oils in India. Renew Sustain

[25] Energy Rev 2004; 9:363–78.

[26] Tsolakis A, Megaritis A. Exhaust gas assisted reforming of rapeseed methyl ester for reduced exhaust

[27] Emission of CI engines. Biomass Bioenergy 2004; 27:493–505.