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The Effect of Turbocharging on Volumetric Efficiency in Low Heat Rejection C.I. Engine fueled with Jatrophafor Improved Performance

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Abstract:- **The world's rapidly dwindling petroleum supplies, their raising cost and the growing danger of environmental pollution from these fuel, have some substitute of conventional fuels, vegetable oils has been considered as one of the feasible substitute to conventional fuel. Among all the fuels, tested Jatropha oil properties are almost closer to diesel, particularly cetane rating and heat value. In present work experiments are conducted with Brass Crown Aluminium piston with air gap, an air gap liner and PSZ coated head and valve have been used in the present study, which generates higher temperature in the combustion chamber decreases the ignition delay and aids combustion but drops the volumetric efficiency. The degree of degradation of volumetric efficiency depends on the temperatures in the combustion chamber and it further increases the frictional horsepower due to thinning of lubricant. Therefore, for improving the thermal efficiency of low heat rejection (LHR) engine, the volumetric efficiency drop is compensated by turbocharging in the present experimental work. This gave the better performance with reduction in smoke. With the turbocharging the intake boost pressure is raised and its effect on the engine performance is also studied.**

Key Words:Low Heat Rejection, Jatropha, PSZ and Turbocharger.

I. INTRODUCTION

In the diesel engines for about 30% of the total energy is lost to the cooling water. This lost energy can be recovered in the form of useful energy by expanding gases in the turbines. But due to lower temperature in the combustion chambers, the fuels whichhave lowcalorific valuecannot be burned. This can be achieved with an LHR engine dueto the availability of higher temperature at the time of fuel injection. The heat available due to insulation can be effectively used for vaporizing alternative fuel. Some important advantages of the LHR engines are improved fuel economy, reduced HC and CO emission, reduced noise due to lower rate of pressure rise and higher energy in the exhaust gases [2 & 3]. However, one of the main problems in the LHR engines is the drop in volumetric efficiency. This further decrease the density of air entering the cylinder because of high wall temperatures of the LHR engine. The degree of degradation of volumetric efficiency depends on the degree of insulation. In the present work for compensating the decrease in volumetric efficiency a single cylinder 4-stroke Low heat rejection C.I. engine is turbocharged to different inlet pressures depending upon the load and the performance of the insulated engine under turbocharging condition is investigated.

II. EXPERIMENTAL DETAILS

The single cylinder, four strokes 5.2kW Kirloskar, water-cooled DI diesel engine with a bore of 87.5 mm and stroke of 110 mm and a compression ratio of 17:1 is used for the experiment. The engine load is applied with eddy current dynamometer. For the reduction of heat to the cooling water, with Brass Crown Aluminium piston with air gap, an air gap liner and PSZ coated head and valve is used for this experimental investigation. The emissions are measured with exhaust analyzer. TheAluminium piston with brass crown air gap insulation and the experimental set up used for the experiment is as shown in the Fig.1 & 2 respectively

Fig. 1 Photo Graphic View of Aluminium Piston with Brass Crown and Air Insulation

Fig 2. Experimental setup of LHR Engine Test rig

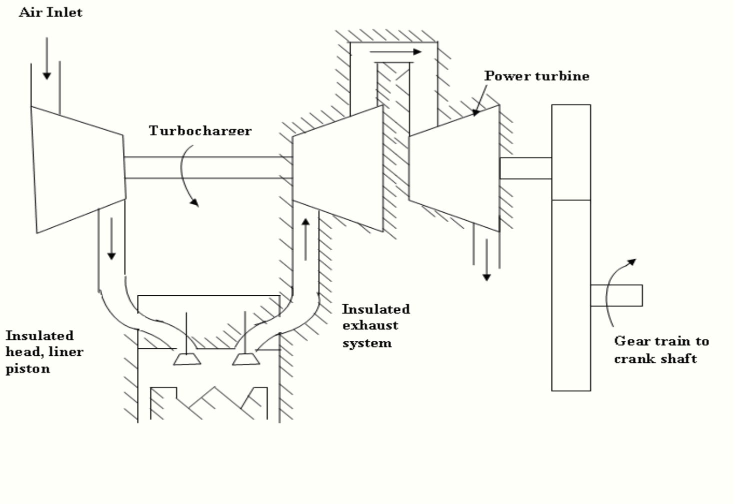

Fig. 3 Turbocharged Insulated Diesel Engine

III. TURBOCHARGING EQUIPMENT

To pressurize the inlet air, internally powered turbocharging equipment with closed loop lubrication is fabricated. The schematic diagram of the turbocharging equipment is shown in Fig: 3. in the turbocharging the high temperature exhaust gases are expanded in a low-pressure turbine for the power generation and this is further coupled to motor of the compressor [4, 5]. This compressor compresses the inlet air and supplies to the engine at slightly higher pressure. By controlling the inlet air, the engine is turbocharged at different inlet pressures.

IV. RESULTS AND DISCUSSIONS

Initially the tests are performed at a constant speed of 1500 rpm with constant injection timing (29^0bTDC) in anormal diesel engine(BASE). All the performance parameters and emissions are measured. For the LHR engine, due to higheroperating temperatures and further lower ignition delays with insulation in the combustion chamber, the injection timing of27^0bTDC is found to give the optimum performance. So all the tests are performed in the LHR engine with Jatropha asfuel at the above optimum injection timing. For testing the engine under turbocharging conditions, the specially fabricatedturbocharging equipment is used.

A.Effect of Insulation on the Volumetric Efficiency

The volumetric efficiency drop mainly depends on the cylinder temperatures in an insulated engine, which in turnsdepends upon the type and degree of insulation employed. In the present work air-gap insulation both for the piston and linerand PSZ coating for the cylinder head and valve have been incorporated. Fig: 4 shows the variation of the volumetricefficiency drop of the LHR Jatropha engine compared with normal diesel engine (BASE). The volumetric efficiency drop ofan insulated engine is about 10% compared to normal engine at rated load.

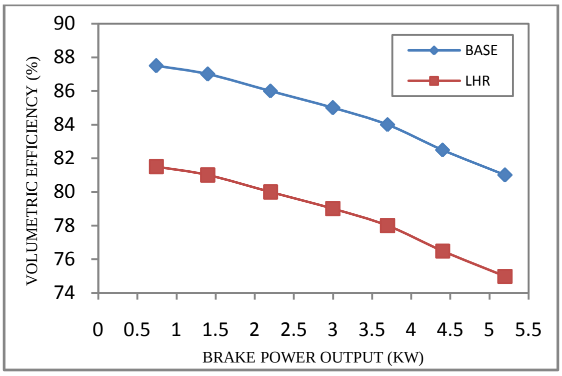

Fig. 4.Comparison of Volumetric efficiency with power output for standard and LHR engines.

B.Effect of Turbocharging on the Volumetric Efficiency

The variation of volumetric efficiency with power output with intake boost pressure is shown in Fig: 5. With theincrease of boost pressure more air is available for the combustion which further increases the combustion efficiency. Athigher boost pressures excess air doesn't improve the combustion efficiency [5].

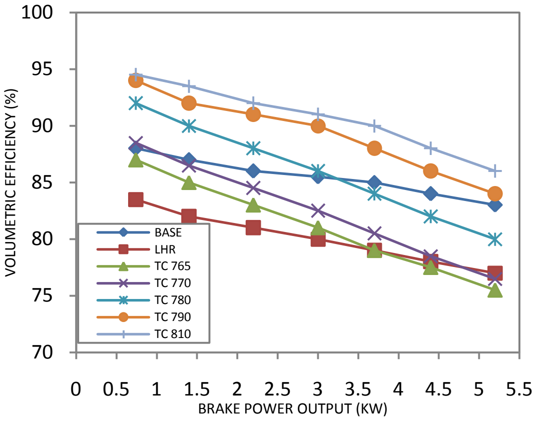

Fig.5. Comparison of Volumetric efficiency with power output for different Turbocharging pressures.

So it is concluded that 780 mm of Hg is the optimum boost pressure at which the drop in volumetric efficiency is compensated with turbocharger. Because of the increased backpressurewith turbocharging conditions, the inlet boost pressures are higher for compensating the volumetric efficiency drop in normalengine. It requires nearly 6% of intake boost pressure underturbocharging conditions for compensating the maximum efficiency drop of 12% in the normal engine. Comparison of percentage of boost pressure required for volumetric efficiency compensation with power output is shown in Fig: 6.

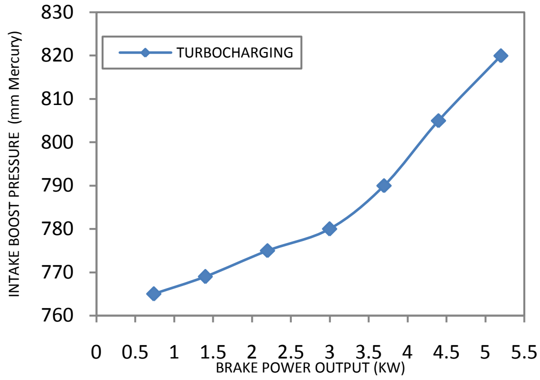

Fig. 6.Comparison of Intake boost pressure required for volumetric efficiency compensation with power output.

C.Brake Thermal Efficiency

The variation of brake thermal efficiency with power output for turbocharged condition is shown in Fig:7. When theengine is turbocharged with volumetric efficiency compensation thermal efficiency is improved continuously with load. Themaximum improvement is about 4 % over LHR engine. Still higher efficiencies are possible with further increase in turbo-charging pressures. The reasons for restricting turbo-charging pressures in the present investigations are due to (i) The intake boost pressures are selected only to compensate volumetric efficiency drop, (ii) The engine had stability problem at higher intake pressures.

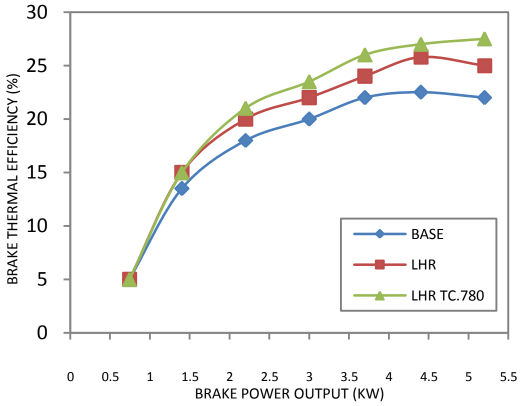

Fig.7. Comparison of Brake thermal efficiency with power output for volumetric efficiency compensation with turbocharging

V. COMBUSTION PARAMETERS

With the turbo charging more air will be available for the combustion and this will change the combustionparameters. The effect of turbocharging on the engine performance is shown in the following figures.

A.Peak Pressure

The peak pressure variationof turbochargingwith power output is shown in Fig.8. Peak pressures required for base engine, LHR engine and turbocharged LHR engines are compared in the same figure. It is observed that the peak pressures are higher with turbocharged engine and is about 84bar at the rated load. At higher turbo-charging pressures, these peak pressures are lower at part load operation of the engine.

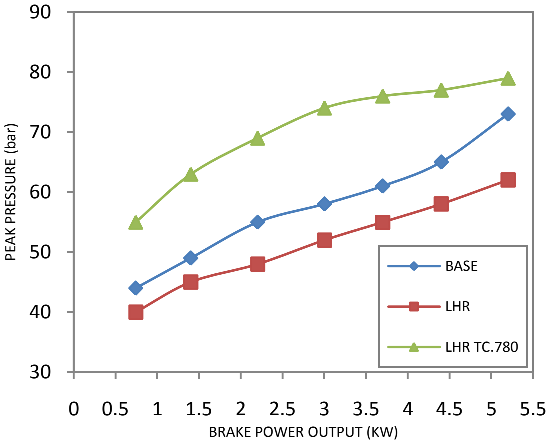

Fig. 8. Comparison of Peak Pressure with power output for Volumetric Efficiency Compensation with turbocharging

B. Ignition Delay

The variation of ignition delay with power output for turbocharging conditions is shown in Fig: 9. There is a reduction of 8° CA for the LHR engine compared to base engine at full load. It will be beneficial to increase the turbocharging pressures in order to have a shorter ignition delay[6].

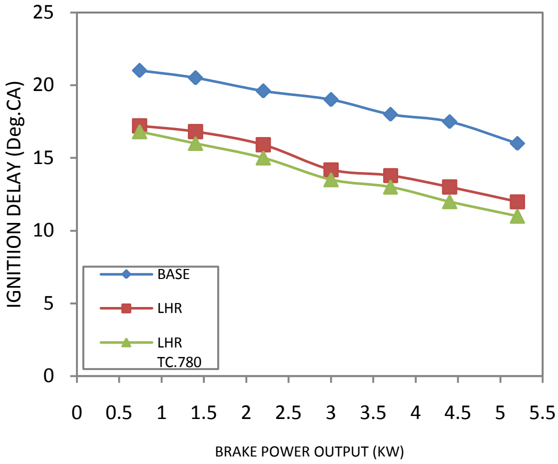

Fig. 9.Comparison of Ignition delay with power output for compensation with turbocharging

C. Exhaust Temperature and Emissions

Exhaust temperatures are marginally lower with simulated turbocharging conditions. Its variation against power output is shown in fig.10. Exhaust temperatures are not affected because of turbocharging at lower engine loads. This is due to the increase of mass flow rate of air, reduction in the ignition delayand hotter combustion chamber which further increases the combustion process.

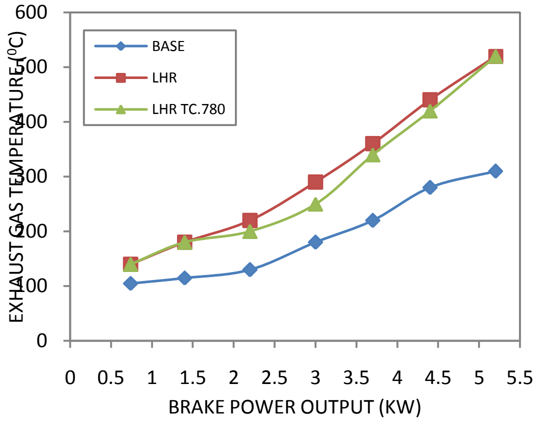

Fig. 10.Comparison of Exhaust gas temperature with power output for Volumetric Efficiency Compensation with turbocharging

Fig: 11& 12 shows variation of opacity and absorptivity with brake power output for turbocharging condition. It can be understood from the same figure that there is a significant reduction in smoke level in turbocharged engine compared to naturally aspirated engine at full load condition. Hotter combustion chamber surfaces availability of excess air may have assisted in complete combustion of the fuel.

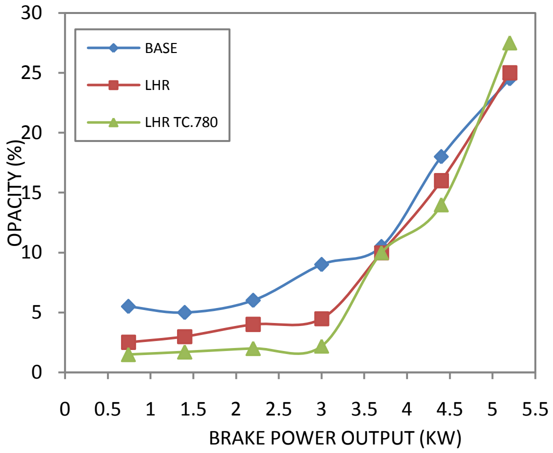

Fig. 11. Comparison of Opacity with power output for Volumetric Efficiency Compensation with turbocharging

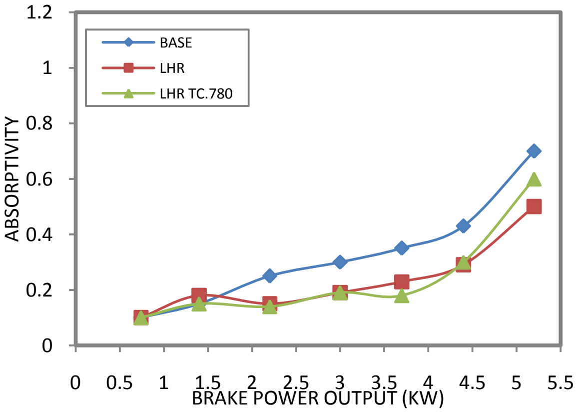

Fig.12. Comparison of Absorptivity with power output for Volumetric Efficiency Compensation with turbocharging

VI. CONCLUSIONS

The following conclusions are drawn based on the experimental investigations on an LHR diesel engine underturbocharging conditions:

1. The increase in the intake boost pressure improves the brake thermal efficiency of the engine.

2.For the compensation of drop in volumetric efficiency of the insulated engine 4% intake boost pressure is required forturbocharging.

3.Volumetric efficiency compensation with simulated turbocharging reduces smoke emission by 30 to 40% compared to naturally aspirated LHR engine.

4.Exhaust temperatures reduced with simulated Turbocharging compared to naturally aspirated LHR engine.

5.Due to the complete combustion of Jatropha at higher temperatures the smoke emissions are also marginal.

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R. Ganapathi, working as a Lecturer in the department of Mechanical Engineering, JNTUA College of engineering, Anantapuramu, Andhra Pradesh, INDIA. I completed my M.Tech in Energy systems from JNT University, Anantapur, Andhra Pradesh. At present I am doing my P.hD work in the area of internal combustion engines under the guidance of Dr. B. Durga Prasad, Professor&Head of Mechanical Engineering dept., JNT University, Anantapuramu. I published 2 articles in various national and international conferences and 5 research papers in various national and international journals.

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