

Experimental Investigation on LHR Extended Expansion DI Diesel Engine Performance Controlling Injection Timing

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Abstract— Transportation industry is one of the largest industry in using diesel vehicles. Continuously decreased in reserves of fossils fuels, foreign exchange expenditure for import of crude petroleum, the unsteadiness of their prices and the increasingly stricter exhaust emission legislation, put forward in the innovations of advanced technologies to adopt in the engines. It is a known factor that, these engines loses a part of its energy developed during combustion and in other thermodynamic processes. To minimize these losses, an attempt is made to study a Low Heat Rejection (LHR) concept as one of the measures. In LHR engines the effective utilization of generated heat takes place due to insulation of both piston and cylinder. The inlet cam design has modified for late closing of intake valve, to overcome blow-down losses. In addition to this, the extended expansion concept has also incorporated to improve the thermal efficiency. The ignition delay will vary as the injection timing of the engine is varied. The variation in the injection timing is very much influencing the performance of engine. The experimental results of the effects of variation in injection timings on the performance of LHR extended expansion engine is presented and analyzed.

Keywords— Injection Timing, LHR, Performance and Extended Expansion Engine.

I. INTRODUCTION

THE thermal efficiency of the engine can be increased by reducing heat rejection to coolant, according to second law of thermo-dynamics. LHR Engines aim to reduce this heat energy transfer to the coolant [1]. This energy could be recovered to promote a slight power increase at the flywheel. This LHR engine concept proved to be a viable means of recovering thermal energy normally rejected by the diesel

engine to the coolant. The diesel engine with its combustion chamber walls insulated by ceramics is referred to as LHR engine. The LHR engine has been conceived basically to improve fuel economy by improving the conventional cooling system and converting part of the wasting exhaust energy into useful thermal energy [2-3].

Normally diesel engines have higher compression ratios and their expansion ratios are some what lower than the compression ratios. The extended expansion cycle with a short compression stroke is one of the few remaining engine concepts that are available for improving engine performance and reducing fuel consumption. The complete operation is based on having high expansion ratios and the low effective compression ratio [4-5]. The decrease in the compression ratio can be achieved by closing the inlet valve either before the BDC or after the BDC.

The timings of the inlet/exhaust valve are controlled by cam and cam shaft action it can be pre opened or it can be closed lately. But in LHR engines the late valve closing displays an advantage over early valve closing (inlet) which affects its volumetric efficiency. This is basically a part of the gas dynamic, where gas is filled and emptied based on the breathing process of the LHR engines. Better heat transfer is also achieved with late intake valve closing (LIVC). These engines with extended expansion stroke and short compression stroke are known as the Extended Expansion cycle [6-7].

The advantages of Extended Expansion cycle are many aside from more power and efficiency over the conventional engine such as, lower compression temperature for lower cylinder component stress, fuel knock deterrent, lower peak pressure, lower exhaust pressure, lower compression work and greater expansion work.

The net result of extended expansion alone is an improvement in fuel consumption and efficiency. It is further improved by making the Extended Expansion Engine a Low Heat Rejection type. The Extended Expansion cycle concept was achieved, in this case by closing the valve late. In the Extended Expansion cycle the inlet valve closes at 60° after BDC whereas in the conventional engine inlet valve closes at 45° after BDC. It has been chosen to achieve an effective compression ratio of at least 15:1 and a ratio of ER to compression ratio is of about 1.2 [8-10].

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In this paper the investigations made on test engine at different injection timings for various performance parameters are presented and analyzed.

II. EXPERIMENTAL SETUP

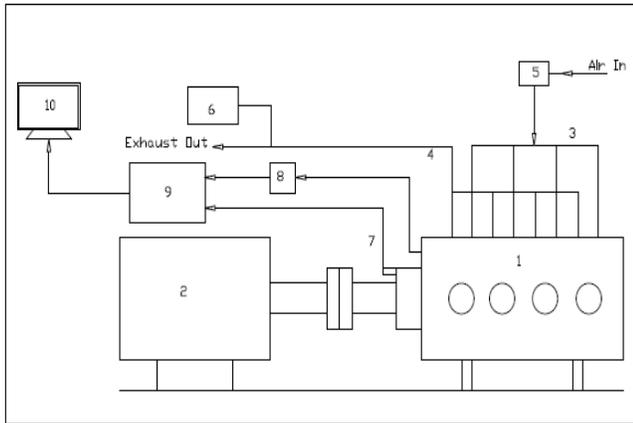


Fig. 1 Experimental Set up Layout

1. Engine 2. Eddy current dynamometer 3. Inlet line 4. Exhaust line 5. Air surge tank
6. Exhaust gas analyzer 7. Crank angle encoder 8. Charge Amplifier 9. CRO 10. Computer

An experimental set-up is developed to conduct tests on a four cylinder, four stroke water cooled DI Diesel engine. The test engine is coupled with eddy current dynamometer. In addition to this, fuel measuring burette, air flow measuring U-tube manometer are also fitted to the test engine set up. A provision is also made to mount a piezoelectric pressure transducer flush with the cylinder head surface to measure the cylinder pressure. The experimental set-up layout is shown in Fig. 1. The equipment and instrumentation used in this work is briefly described below.

TABLE I
SPECIFICATIONS OF THE TEST ENGINE

| | |
|----------------------------|----------|
| Bore, mm | 111 |
| Stroke length, mm | 127 |
| Connecting rod length, mm | 251 |
| Compression ratio | 15:1 |
| Displacement volume, liter | 4.9134 |
| Maximum power, HP | 75 |
| Injection pressure, bar | 200 |
| Inlet Valve Open(IVO) | 8° bTDC |
| Inlet Valve Closing(IVC) | 45° aBDC |
| Exhaust Valve Open(EVO) | 45° bBDC |
| Exhaust Valve Closing(EVC) | 12° aTDC |
| Injection timings, degrees | 8° bTDC |

III. RESULTS AND DISCUSSIONS

A. Brake Power

Brake power of the engine is little affected by change in injection timing. It increases slightly on advancing the injection timing up to 6° bTDC and then drop slightly for further advance in injection timing. It is observed from the Fig 2 that the LHR (EEE) engine is developing a higher brake power for all the injection timings approximately 8.33% than LHR engine and it is also noted that the LHR (EEE) engine is developing a higher brake power for all the injection timings approximately 16.66% than conventional engine.

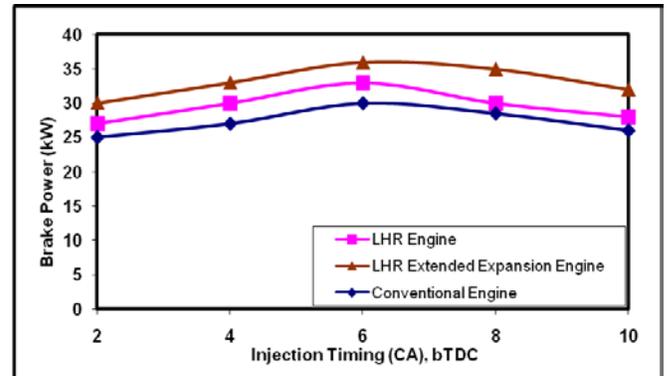


Fig. 2 Comparison of Brake Power for Conventional, LHR and LHR (EEE) engines for different injection timing.

B. Brake Mean Effective Pressure

The effect of injection timing on BMEP is shown in Fig 3. It is observed that on advancing the injection timing the mean effective pressure increases till 6° bTDC and further decreases in advancing the injection timing. As the combustion efficiency in turn thermal efficiency increases in advancing the injection timing leading to increase in BMEP. It is observed from the figure that the LHR (EEE) engine maintained higher BMEP for the entire injection timings approximately 12.5% than LHR and it is also observed that the LHR (EEE) engine maintained higher BMEP for all the injection timings approximately 25% than conventional engine.

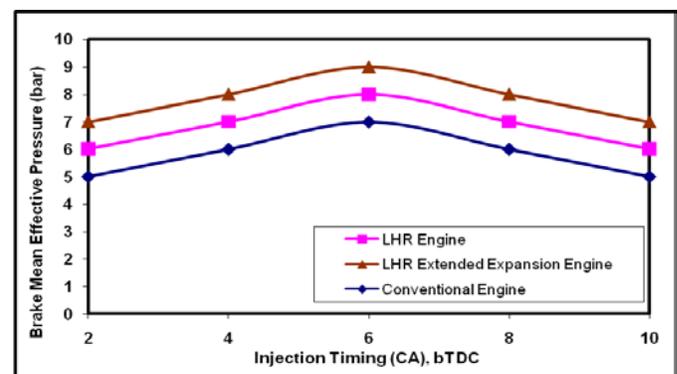


Fig. 3 Comparison of Brake Mean Effective Pressure for Conventional, LHR and LHR (EEE) engines for different injection timing.

C. Brake Thermal Efficiency

Brake thermal efficiency indicates the ability of the engine how efficiently the energy in the fuel is converted to mechanical output. The coating of low thermal conductivity material will act as barrier for the heat transfer to the surroundings from the engine combustion chamber and thus reduces the heat loss from the engine. The reduction in heat loss will ultimately increase the thermal efficiency of the engine. From the Fig 4, it is observed that the BTE of the conventional, LHR and LHR (EEE) engine are shown increasing as the injection timing increases till 6° bTDC and then reducing slightly for further increase in injection timing. BTE is always higher in LHR (EEE) engine than conventional and LHR engines for all the injection timings. It is noted that the LHR (EEE) engine is approximately 5.40% higher than LHR engine and it is also noted that the LHR (EEE) engine is approximately 10.81% higher than conventional engine.

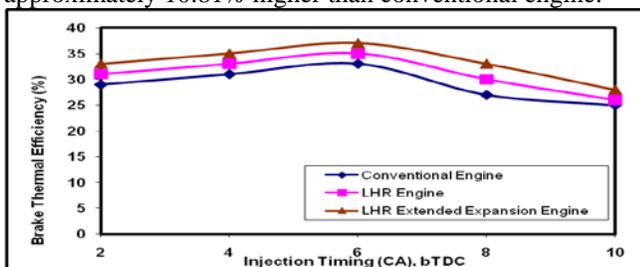


Fig. 4 Comparison of Break Thermal Efficiency for Conventional, LHR and LHR (EEE) engines for different injection timing.

D. Brake Specific Fuel Consumption

Brake specific fuel consumption is an important parameter to judge how efficiently the engine is performing. The increased temperature in the combustion chamber results in better mixing of vaporized fuel with air and increasing the combustion efficiency. The thermal barrier coatings keeps cylinder operating temperature high which leads to better combustion efficiency in turn lower BSFC of the engine. Fig 5 shown variation of BSFC with different injection timings for conventional, LHR and LHR (EEE) engines. It is observed that the LHR (EEE) engine performing with lower BSFC at all the injection timings than conventional and LHR engines. It is observed that the LHR (EEE) engine is approximately 4.898 % lower than LHR engine and it is also noted that the LHR (EEE) engine is approximately 13.06% lower than conventional engine.

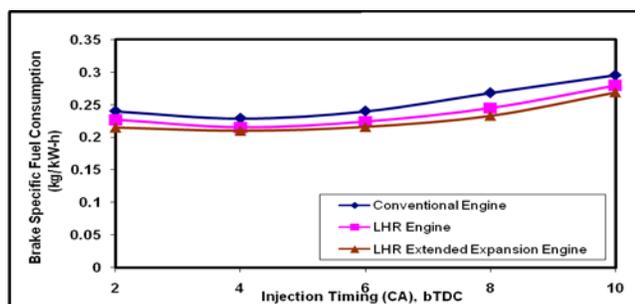


Fig: 5 Comparison of Break Specific Fuel Consumption for Conventional, LHR and LHR (EEE) engines for different injection timing.

IV. CONCLUSIONS

The experiments are conducted on conventional diesel engine in the beginning, later which is converted into LHR engine. The experimentation procedure is repeated on LHR engine. Then LHR engine is operated on Extended Expansion cycle by modifying the inlet cam. All the results of experiments mentioned above are reported and discussed below.

- LHR Extended Expansion Engine develops higher brake power for all the injection timings than LHR and conventional engines. Brake power of the engine is little affected by changing injection timing.
- LHR Extended Expansion Engine maintains higher BMEP for all the injection timings than LHR and conventional engine. The combustion efficiency leads to increase the thermal efficiency by advancing injection timing resulted in increasing BMEP.
- The reduced heat loss from the engine due to coating of low thermal conductivity of material will ultimately increase thermal efficiency of the engine. Brake thermal efficiency is always higher in LHR Extended Expansion Engine than conventional engine and LHR engines for all the injection timings.

The LHR Extended Expansion Engine performs well with lower BSFC for all the injection timings than conventional and LHR engines. The thermal barrier coatings which keep higher operating temperatures in the cylinder resulted in better mixing of vaporized fuel with air which improved the combustion efficiency leading to lower BSFC.

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