Effect of in Cylinder Parameters on Performance and Emission of Diesel Engine: A Review

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Abstract--- The diesel engine is currently the most efficient powertrain for vehicle propulsion. Unfortunately it suffers from rather high particulate and NOx emissions that are directly related to its combustion mechanism. Future emission legislation requires drastic reduction of NOx and particulate matter compared to present values. Engine manufacturers in their effort to meet these limits propose two solutions: reduction of pollutants inside the combustion chamber using internal measures and reduction at the tailpipe using after treatment technology. NOx and PM are combined effect of injection pressure and timing. We know that NOx and PM are inversely proportional to each other so PM-NOx trade off study is important. Here effect of in cylinder parameters on engine emission and performance is reviewed.

Keywords: Diesel Engine, NOx, PM, emission legislation

I. INTRODUCTION

Today's diesel engines are well established as a serious and very promising powertrain solution in the world market. A few years ago it would be difficult to believe that in the beginning of the 21st century more than one third of passenger cars entering the European market would be powered by diesel engines. Furthermore, in the area of transportation, diesels are the dominating power source especially for heavy trucks and buses. This is due to the significant improvements of these engines, especially the DI ones, in combination with the absence of reliable and economic alternative solutions that would cover partially the demand in these areas. Moreover today's technological status reveals clearly (with the aid of any comprehensive cost analysis) that diesel engines (and especially the heavy duty DI ones) will remain the dominating power source in the transportation sector for the short- and mid-term future. Diesel engines are well established as a serious and very promising powertrain solution in the world market.

The introduction and consequent application of a series of strict regulations concerning heavy duty diesel emissions has forced engine manufacturers to focus their research into a series of innovative technologies which belong to two different categories: those aiming at pollutant formation reduction inside the combustion chamber and those seeking reduction using after treatment systems at the tail-pipe Under this framework various research efforts have been conducted on the above subjects. It is widely recognized that the basic mechanism involved in the formation of pollutants inside the DI diesel combustion chamber, is the mixing and combustion of injected fuel. It is also reported in the literature that any effort that results in the reduction of either NO or Soot has a negative effect on the other (and sometimes also on the value of specific fuel consumption). Some of these measures that have already been under extensive research and discussion include advanced injection strategies, increased injection pressure, application of EGR at high rates as well as after treatment systems. Although these technologies have shown a significant potential towards emission reduction, more research is required so that they can be adopted as mainstream approaches in today's commercial heavy-duty diesel engines.

II. IN-CYLINDER PARAMETERS

The in cylinder parameters which affect the performance and emission of diesel engine are piston bowl geometry, swirl induction in cylinder head, number of valves in cylinder head, intake air temperature and pressure, injection timing, number of holes of injector, hydraulic through flow of injector, type of injector i.e. DSLA or DLLA, nozzle tip protrusion etc. All of these parameters affect the performance and emission of diesel engine in different ways. Optimum combination of some of these parameters results into best performance and emission.

III. LITERATURE SURVEY

D. T. Hountalas and G. C. Mavropoulos [1] investigated possibilities to achieve future emission limits for HD DI diesel engine using internal measures. For this purpose, a multi zone phenomenological combustion model was used to examine the effect of number of parameters on heavy duty DI diesel engine performance and emission at various operating condition. As a result of study, it is revealed that, combination of internal measures examined can result in a significant reduction of engine out emissions. Four different emission reduction strategies were examined. In the first two, use was made of advanced injection timing and combination of advanced injection timing and increased injection pressure. From this investigation it was revealed that both strategies result in significant soot reduction but on the other hand to significant increase of NO emissions. Therefore it was necessary to use A/T to reduce NO emissions.

F. Millo and E. Pautasso [6] investigated a DOE analysis on the effects of compression ratio, injection timing, injector nozzle hole size and number on performance and emissions in a diesel marine engine. 6 cylinder, 100 litre displacement, inline, turbocharged diesel engine is used for the study. A DoE analysis was carried out to investigate the effects of the compression ratio, injection timing, injector nozzle hole size and number on performance and emissions in a diesel engine, aiming to find out the optimal combination between all the above mentioned parameters. A preliminary detailed validation process, based on an extensive experimental data set, was carried out on the engine model concerning, in particular, the predicted heat release rate, the in-cylinder pressure trace and NOx emissions for several operating points of a propeller load curve. After a detailed validation process, the engine model was used to select through a full factorial DoE the more promising configurations, and a potential for BSFC reductions up to more than 2.5%, while complying with NOx emissions and peak firing pressures constraints, was demonstrated.

Avinash Kumar Agarwal, Dhananjay Kumar Srivastava et al. [5] investigated effect of fuel injection timing and pressure on combustion, emissions and performance characteristics of a single cylinder diesel engine. A single cylinder research engine was used to experimentally determine the effects of fuel injection strategies and injection timings on engine combustion, performance and emission characteristics. The experiments were conducted at constant speed (2500 rpm) with two FIPs (500 and 1000 bars respectively) and different start of injection (SOI) timings. Cylinder pressure and rate of heat release (ROHR) were found to be higher for lower FIPs however advanced injection timings gave higher ROHR in early combustion stages. Brake thermal efficiency (BTE) increased with increased injection pressures while exhaust gas temperature and brake mean effective pressure (BMEP) increased upto 500 bars. Engine performance was superior at low FIPs leading to lower BSFC and higher BTE at all engine loads. These parameters can be further improved by advancing the SOI. Lower mass emission of CO2 CO, HC and NOx was observed at lower FIP. Emission characteristics improved by advancing the SOI. Particulate number concentration in a CI engine increased with increasing engine load. Increasing the FIP reduced the number concentration of particulates of all sizes at all loads. At higher FIP, advancing the injection timings reduced the particulate number concentration because advanced SOI timings provided longer time for fuel–air mixing before the start of combustion. At lower FIP, particulate number concentration first increased and then decreased with retarding SOI timings because mixing at lower FIP was more sensitive to cylinder pressure and temperature along with time available for mixing before the SOC.

B. Jayashankara, V. Ganesan [18] investigated effect of fuel injection timing and intake pressure on the performance of a DI diesel engine. The performance characteristics of the engine are investigated under transient conditions. A single cylinder direct injection diesel engine with two directed intake ports whose outlet is tangential to the wall of the cylinder and two exhaust ports has been taken up for the study. Effect of injection timing (start of injection 16, 12 and 8 CAD bTDC) and intake pressure (1.01, 1.21 and 1.71 bar) on the performance of the engine has been investigated for an engine speed of 1000 rpm. Based on the overall performance and emission characteristics, the following conclusions are drawn from the present investigation: Advanced injection timing results in increase in-cylinder pressure, temperature, heat release rate, cumulative heat release and NOx emissions (6.88%) and retarded injection timing results in reverse trend (NOx emission 6.85%). In case of advanced injection timing the soot emissions show increasing trend up to certain crank angle then reverse trend whereas in case of retarded injection timing soot emissions show the reverse trend. The supercharged with inter-cooled cases show lower peak heat release rate and maximum cumulative heat release, shorter ignition delay, higher NOx (15.03% and 58.69% at 1.21 bar and 1.71 bar respectively) and lower soot emissions (8.82% and 51.47% at 1.21 bar and 1.71 bar respectively). The optimum injection timing (start of injection) is 12_ bTDC. The intake pressure boosting up to 1.21 bar is the best option.

A. Sarvi, R. Zevenhoven [3] investigated large-scale diesel engine emission control parameters. The influence of engine parameters such as compression ratio (CR), start of ignition (SOI) and fuel injection nozzle and its operation on emissions from a large-scale diesel engine are described in the study. Results showed that, retarded SOI retarded reduced NOx, but increases smoke (soot) and HC. As regards to fuel injection pressure (FNOP), higher injection pressures improve SFC and soot formation. It is found that HC emissions are more dependent on mixing during the combustion process than by temperature. Fuel injection timing (SOI) is one of the primary methods to control emissions from diesel engines. Advanced injection timing increases the pre-mixed combustion temperature which results in increased NOx formation. Retarded injection timing decreases NOx emissions, but increases soot (smoke) and HC. The fuel injector nozzle has a strong influence on the performance of the engine and its emissions. Optimized injection nozzle holes number, diameter and spray cone were of great importance for this study. Using a smaller nozzle orifice diameter (and more orifices) gives higher NOx but lower smoke (FSN), CO and HC emissions. As intake manifold air temperature changes in a turbocharger engine under full load, manifold air pressure would change as well and thereby the change-air density, affecting engine efficiency, and CO and soot (smoke) emissions would vary less significantly, besides a relatively significant change in NOx. Cylinder temperature at maximum pressure affects the engine fuel economy, exhaust gas temperature and particularly NOx formation, as higher air initial temperature will lead to higher combustion temperatures.

IV. CONCLUSION

In cylinder parameters are very important for engine performance and emission. Studies showed that optimization of parameters such as increase in peak cylinder pressure, temperature results into increase in NOx whereas, soot is controlled in that case. NOx reduction is controlled by injection timing i.e. by timing retard. Particulate emissions are generally reduced when the amount of fuel burned after the final peak in the heat release is small. Finally, optimum parameters selection is crucial to control NOx and PM.

V. NOMENCLATURE

A. *Abbreviations And Meanings:*

- CO- Carbon Monoxide
- HC- Hydrocarbon
- NOx- Nitrous Oxide
- PM- Particulate Matter
- FSN- Free smoke number
- CR- Compression ration

- SOI- Start of Injection
- SFC- Specific fuel Consumption
- FIP- Fuel Injection Pump
- DoE-Design of Experiment
- BMEP- Brake mean Effective Pressure
- BTU- British Thermal Unit
- ROHR- Rate of Heat Release
- HD- Heavy Duty
- DI- Direct Injection
- bTDC- Before Top Dead Centre

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