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Study of Noise Reduction in Four -Cylinder Common Rail Direct Injection Diesel Engine at Idle speed

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Abstract— ***The design and development of modern internal combustion engines is marked by a reduction in exhaust gas emissions and increase in specific power and torque. This paper aims at the study of noise reductuion in4-stroke common rail direct injection engine at idle speed. Idle speed is basically a speed of engine when vehicle is not running i.e not in motion . Now a days , this siuation oftenly comes at redlights ,in traffic and in waiting while parked outside a business or residence etc. This paper presents a study about the effects of Fuel Injection Pressure on the combustion process.***

Keywords— CRDI, Idle Speed, Fuel Injection Pressure, ECU.

I. INTRODUCTION

The design and development of modern internal combustion engines is marked by a reduction in exhaust gas emissions and increase in specific power and torque[5]. Correspondingly, combustion noise excitation and fuel consumption also have to be reduced. These objectives can be achieved through the development of advanced combustion systems, the increased flexibility of fuel injection systems and ECUs. However, development of modern combustion systems and vehicle applications has become increasingly complex. Creating an exact, yet straightforward description of combustion noise is a very important task[2]. The customer's subjective impression of the entire vehicle, regarding items such as diesel knock sensitivity, provides evidence to support its value. Countries around the world continue to legislate against the release of specific levels of exhaust gas emissions, such as nitrogen oxide, hydrocarbon, carbon monoxide and smoke[1]. India typically introduces new emission legislation approximately every four years. Since last few years, new vehicles in India have been required to meet the BS4 exhaust emission levels[4]. Additionally, customer requirements for combustion noise need to be met, which can be accomplished through optimization of the combustion system. For a long time now, the reduction of noise and vibration is one of the major concerns of carmakers for their Diesel engines. Cold and idle conditions are considered to be the most critical conditions for both combustion noise and pollutant emissions[3]. These goals can be met through the development of advanced combustion systems and the increased flexibility of fuel injection systems and ECUs. This report presents the results of a study about the effects of Fuel Injection Pressure on the combustion process and on the combustion noise at idle condition in a 4 Cylinder CRDi Engine.

II. OBJECTIVES OF THE STUDY

For a long time now, the reduction of noise and vibration is one of the major concerns of carmakers for their Diesel engines . Idle conditions are considered to be the most critical from combustion noise point of view. It is also the case for the control of pollutant emission. Cold and idle conditions are considered to be the worst conditions in term of pollutant emission control. It is the case for the noise emission too. In such conditions, the piston and the chamber walls are cold, or at most not as hot as it could be in other conditions. The injection and the ignition occur in a cold environment which doesn't contribute positively to the combustion progress. The wall and chamber temperatures are well known to be key parameters for the pollutant emissions. It has also been required recently that diesel engines for passenger cars meet various requirements, such as low noise,
low fuel consumption, low emissions and high power. The key to improve the noise is to reduce a combustion
noise known as "Diesel knock noise". Conventional approaches to reduce the diesel knock are decreasing combustion excitation force due to pilot/pre fuel injection, adding ribs to engine blocks or improving noise transfer characteristics by using insulation covers. However, these approaches have negative effects, such as deterioration in fuel economy and increase in cost/weight. We will try to lower the diesel combustion noise reduction by using this new technology.The aim of the present work is to evaluate the effects of injection parameters on the combustion process in regard to the combustion noise emission.

III. REVIEW OF LITERATURE

M. Gazon et al,[7] studied the results about the effects of engine coolant temperature and injection timings on the combustion process and on the combustion noise at idle condition. A modern direct injection Diesel engine equipped with a common-rail injection system and piezoelectric injectors was used. They found that the combustion noise is very sensitive to both the coolant temperature and the dwell time between the pilot and the main injection, but its evolution did not follow a simple way. When the coolant temperature reached 40◦C, there was a jump of combustion noise. In this case, the combustion of the pilot injection occurs at TDC, creating a high-pressure derivative and consequently a high combustion noise. The same phenomenon was observed with the change of dwell time between the pilot and the main injections. The combustion noise reaches its maximum level when the combustion of the pilot injection occurs at TDC.

Evangelos G. et al,[8] instrumented test bed installation was developed by them in order to study the transient performance and combustion noise emissions of a truck, turbocharged diesel engine. A fast response combustion noise-meter was employed for measuring combustion noise radiation during a variety of acceleration and load increase tests experienced during daily driving conditions.

Ping, W., et al , [9]The sources of the combustion noise of DI (direct injection) diesel engine were investigated in their study. The maximum combustion pressure, maximum pressure rise rate, high frequency pressure oscillation in combustion process and their effects on diesel engine combustion noise were discussed. Fuel pilot injection technology was applied, the effects of fuel pilot injection timing, fuel pilot injection quantity, were analyzed. Main factors affecting the combustion noise were analysed specially. The results showed that pilot injection strategy should consider the pilot injection quantity and the interval time between the pilot injection and main injection under different conditions to optimize the target.

Shibata, G., et al ,[10]In this study, an engine noise analysis was conducted by engine tests and simulations. The engine employed in the experiments was a supercharged single cylinder DI diesel engine with a high pressure common rail fuel injection system. The engine noise was sampled by two microphones and the sampled engine noise was averaged and analysed by an FFT sound analyser. The engine was equipped with a pressure transducer and the combustion noise was calculated from the power spectrum of the FFT analysis of the in-cylinder pressure wave data from the cross power spectrum of the sound pressure of the engine noise. The parameters investigated in the engine tests were the maximum rate of pressure rise, intake pressure by the supercharger, intake oxygen content by EGR, and the fuel injection timing, in all experiments the engine speed was maintained at 1600 rpm. The engine noise and combustion noise were sampled under 69 different test conditions and the data were compared with the results of the simulation. The engine test results show that the maximum rate of pressure rise is most strongly related to combustion noise, and that the combustion duration and the maximum value of the heat release rate (ROHRmax) are the second and third most important parameters in the generated noise. To discuss the results of the simulation, the heat release histories were approximated by Wiebe function, and the simulated combustion noise was calculated from the fitted curves of the heat release and coherent transfer function. To investigate the accuracy of the simulated combustion noise, the simulation data were compared with the engine test data. Further, the simulation makes it possible to determine, for example, changes in the CA50 with the same combustion phases, something that cannot be achieved by actual engine tests. The results of the simulations showed that the combustion noise has a maximum condition for CA50 and is closely related to the degree of constant volume conditions and the thermal efficiency. The simulation also suggests the possibility of reductions in combustion noise with extensions in the combustion duration by EGR. Further, the engine tests showed that a combustion noise of 6.3 dBA at 0.33 MPa IMEP can be achieved.

Jung, I., et al ,[11] The source of the combustion noise of diesel engines was investigated in their study. In the development of exhaust emission and combustion noise, we must optimize the injection parameters at the cell where engine noise cannot be measured. To solve this problem, it is necessary to identify a method for developing combustion noise through in-cylinder pressure measurements. It is known that the combustion noise of a diesel engine is generated mainly in the phase of premixed combustion and depends on the rate at which the pressure increases. The combustion noise was analyzed by measuring the in-cylinder pressure and engine noise. Their results showed that the combustion noise has a low correlation with the maximum rate of pressure increase. For this reason, a new index called the combustion noise index was developed based on the cylinder pressure level.

Jianguang He et al ,[6] investigated the characteristic of combustion noise in a non-road diesel engine, tests with different bio-diesel ratio fuel were conducted. According to the cylinder pressures of 100 consecutive combustion cycles, combustion noise was analyzed. The results showed that, with the increase of blended bio-diesel ratio, both the maximum cylinder pressure and the maximum rate of pressure rise all have increasing trends.The cylinder pressure level at frequency of 1000 Hz increases with blended bio-diesel ratio. In the test with B50 fuel, the biggest value of combustion noise appears and its value is about 0.5 dB(A) bigger than that of diesel at full load. The blending of bio-diesel has a dual effect on combustion noise which contributes to the increase of combustion noise and the reduction of it.

IV EXPERIMENTAL ANALYSIS

This paper aims at the study involved trying various injection pressures with the help of an Open ECU from Laptop in a four cylinder CRDi Diesel Engine. A general layout of the test bed installation, the instrumentation used and the data acquisition system is illustrated below. A brief description of the individual components is provided in the following subsections. The engine used for this experiment is a turbocharged four cylinder water cooled four stroke diesel engine. Diesel fuel is injected directly into the combustion chamber with common-rail fuel injection equipment. The pressure in the rail can be changed online with the help of an Open ECU.

Engine	
No. of Cylinders	4
Application	Automotive (Multispeed)
Volume	1994cc
Bore x Stroke (mm)	84.45 x 88.95
Compression Ratio	17.5:1
No. of Valves/Cyl	2
No. of Strokes	4
Ignition	CI
Camshaft	SOHC
Cooling System	Water Cooled
Max. Torque	260 Nm@1750-2500 rpm
Max. Power	100 bhp@4000 rpm

Fig. 1 Engine Details to be used for the study.

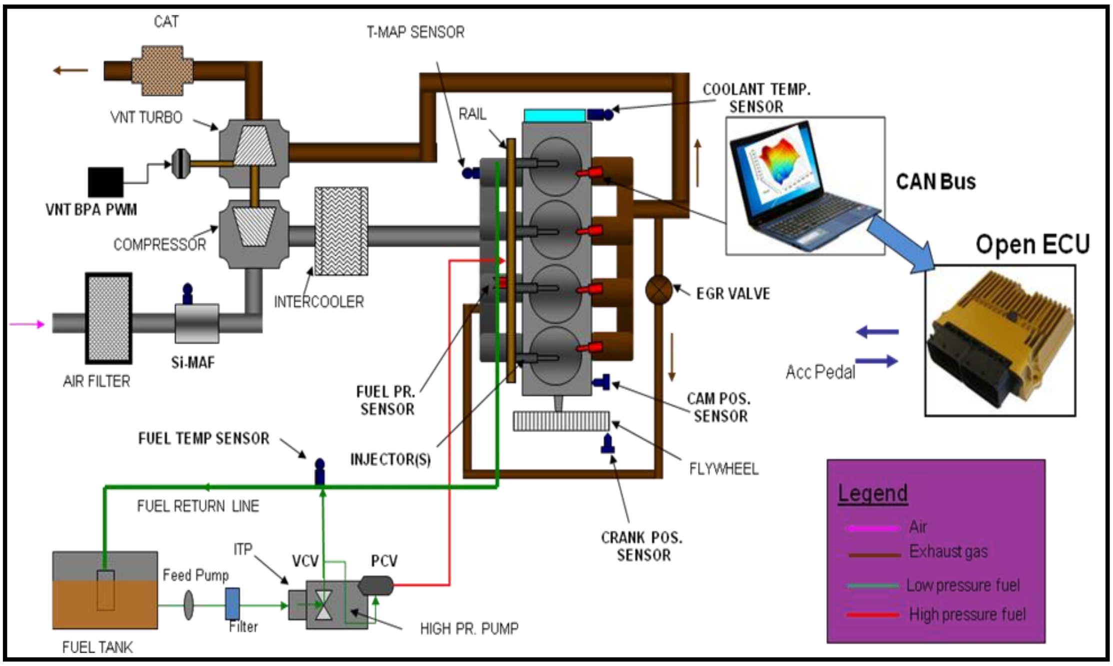

Fig.2 General Layout of Bed Installation.

Experimental Procedure:-

The first task of the test bed installation was the investigation of the steady-state performance and combustion noise characteristics of the examined engine. To this aim, an extended series of base trials will be conducted, covering the whole engine temp range. Between two consecutive measurements, a time interval will be allowed in order for the engine to stabilize at the new conditions. The criterion used here was the stabilization of the Engine Coolant Temperature. The main task of the experimental procedure is to study the engine combustion noise development at idle speed. Since the engine tested is of the automotive type, the main focus was on idle speed. For the experimental investigation, the engine was coupled to an Eddy Current dynamometer, though no load was supposed to be applied at idle.

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