ABSTRACT

The function of an engine is to produce mechanical power. When the fuel is burnt, heat is released. This heat energy is converted into useful work. The details of the engine design are varying significantly over the size of diesel engine. In particular, different combustion chamber geometries and fuel-injection characteristics are required to deal effectively with a major diesel engine design problem, achieving sufficiently rapid fuel-air mixing rates to complete the fuel-burning process in the time available. A wide variety of inlet port geometries, cylinder head and piston shapes, and fuel-injection patterns are used to accomplish this over the size of diesel engine. Combustion chamber profile changes are considered technologically important because of their ability to further increase in diesel engine working temperatures and reduce cooling requirements, thus achieving higher engine efficiency, lower emission and increased performance.

The vibration of engine also depends on the combustion phenomena and then the piston profile. The force acting on piston is varying depends on the piston profile area for the same pressure inside the cylinder. By this way combustion chamber profile otherwise the piston crown profile is very important to get a favourable performance in terms of thermal and vibration aspects. The combination of thermal performance, simulation of in-cylinder flow and vibration data are not available for use. A new design approach adapted for compromising the thermal performance and
vibration behaviour of the engine. Four different piston profiles were selected for the experimental work as well as the simulation work. All pistons were fitted in engine and the performance parameters along with emission parameter were recorded. The specific fuel consumption, thermal efficiency, mechanical efficiency and NO\textsubscript{x} were obtained from the experiment. At the same time the vibration signal was collected and stored in the computer.

Normally EGR have an effect in engine performance and emissions. The effect of piston profile and EGR were identified from the performance test by supplying exhaust gas to the inlet manifold side. The performance parameters and emission parameter were investigated for better combination. Flow simulation was used to investigate the effect of piston profile inside the combustion chamber in the flow patterns. The intake and compression stroke are the most important processes which influences the pattern of air comes inside the cylinder during intake stroke and generates the favourable conditions at the end of compression stroke. This enhances the mixing of air and fuel and results in higher combustion efficiency. To identify the in-cylinder flow structure, transient simulation was performed using commercial CFD software for four combustion chambers. The thermodynamic properties and velocity contour of different piston profiles were analysed. The experimental data of vibration was analysed using MCME software. The engine block displacement, time-domain frequency, wave form and auto correlation were examined for the analysis for all the piston profile.

A theoretical two degree mathematical modelling was developed to investigate the engine block displacement of an internal combustion engine in the radial direction due to combustion force and inertia forces. The
combustion force produced in in-cylinder is a substantial function of angular displacement and then correlated with pressure and temperature. Other than the substantial function, combustion force depends on chamber design, injection parameters, flow patterns and fuels. But inertia is a function of angular displacement and mass of reciprocating parts. Speed is directly related to combustion by means of indicated pressure and the indicated torque respectively. The dynamics of piston secondary motion across the clearance between piston and cylinder inner wall of reciprocating machines are analyzed. The impact point between piston and cylinder inner wall is modelled on a two degree of freedom vibratory system to represents its planar motion. For different profile the theoretical simulation was performed and the results were correlated in terms of combustion force, side thrust force and displacement. Finally the identification of different vibration signature was done using MATLAB. The vibration signals obtained in experiment were divided into four levels and justified the each level contribution factors. FFT energy level for different signal were generated and compared with each group. The results provide uncertainty in combustion processes, nonlinear vibration of the engine block and vibration spectra. The piston profiles have an impact on the engine performance. From the thermal and vibration analysis, the streamlined Rankine types of profile pistons have a better performance and reduced vibration than other piston profiles. An Ellipsoid and Elliptical type of piston profile is suitable for combustion chamber of internal combustion engine.