ABSTRACT

Key Words: Direct Injection Diesel Engines, In-Cylinder Turbulence, Bluff Bodies, Internal Jets, Fuel Additives, Emission.

Owing to direct injection (DI) diesel engines becoming acceptable choice as prime movers in many applications, it has become imperative to improve their fuel consumption and emission characteristics. For this purpose, several attempts are ongoing to improve the emission characteristics of DI diesel engines without having to sacrifice their fuel consumption advantage. In diesel engines, fuel is injected near compression top dead center and hence the requirements of fuel-air mixing are quite stringent. The fuel-air mixing process therefore remains at the core of the diesel engine combustion and emission problems. Beside better fuel-air mixing, the improvements in diesel engines are also possible through changes in fuel.

In the present work, the changes in fuel and fuel-air mixing process are tested independently and together to improve diesel engine performance and emission characteristics. A simpler method of producing in-cylinder turbulence has been arrived at and investigated. The same has been combined with the best of the additives tested to attain a significant decrease in fuel consumption and exhaust smoke concentration.

Six polymer based additives of varying properties are mixed in different proportions in diesel fuel and their experimental results compared. Beside, comparing the measured performance and the exhaust emissions (exhaust smoke and oxides of nitrogen) of various fuel-additive combinations, a detailed and systematic combustion analysis of the acquired cylinder pressure histories on these samples has been attempted for understanding the effect of the additives on the engine combustion characteristics. From
In this analysis, it is observed that the engine combustion has become smoother in presence of certain additives proportions used here. The maximum improvements in BSFC and exhaust smoke level are found to be 13% and 37.5% respectively in case of Additive 6 (at 2% by volume) fuel-additive combinations as compared to that of the base diesel fuel. The optimum choice in terms of additive cost is found to be Additive 1 (at 0.5% by volume) with an improvement of 7.6% in BSFC and 36.8% in the exhaust smoke level.

In the second stage of the work, the effects of inducing in-cylinder turbulence through bluff bodies or internal jets on the diesel engine are investigated. In the work carried out here, the bluff bodies are placed horizontally across the piston cavity in the form of rods or rods wound with thin wire in different orientations with respect to the piston pin axis. The jet turbulence is introduced by holes on the piston crown, allowing a tangential entry of the working fluid into the piston cavity along the direction of swirl. The effect of size, position and number of jets has been investigated. In general, horizontal bluff bodies do not result in significant advantage in fuel economy and smoke levels, but some reduction in NO\textsubscript{x} concentration is observed. More importantly, it is observed that the internal jets introduced through the tangential holes showed improvement in the engine brake thermal efficiency and exhaust smoke level with only a marginal increase in NO\textsubscript{x} concentration.

An attempt to predict mixing effects of internal jets through an available commercial CFD package STAR-CD reveals that the turbulent kinetic energy and the eddy dissipation rate is maximum in the case of the internal jets with 3 mm diameter. The experimental results concerning performance, combustion and emissions of the engine corroborates with this mixing predictions.
Finally, a representative study on the combined effects of the best fuel additive combination and the best internal jet configuration suggests superior performance in terms of fuel consumption and even better exhaust smoke emission to the independent changes. In the combined case there is a decrease of 9.8% in BSFC and about 38.5% decrease in the exhaust smoke level with a marginal increase of about 4.5% in of NO level vis-à-vis the base engine.