ABSTRACT

The diesel engine is the versatile prime mover in day-to-day life. The consumption of diesel is six times higher than gasoline in India and it produces large amount of unwanted emissions and also it is fast depleting fossil fuel. Many researchers are currently undertaking experimental studies to substitute diesel by alternate fuels without any modification of the engine.

The research works are very limited in the area of air swirl on diesel engine combustion and emission. This study is an attempt to analyze the effect of swirl with the help of shroud using CFD on diesel engine characteristics for various fuel blends. It is also tried to replace diesel with biodiesel to overcome the energy crises.

An experimental study was carried out on Kirloskar single cylinder direct injection diesel engine with water cooling. A burette and stop watch was used to measure the fuel consumption by volume basis for each test run after the engine attained steady state operation. The chrome-alumel thermocouples were used to measure the exhaust gas temperature, coolant inlet and outlet temperature.

The engine was coupled with a BENZ make eddy current dynamometer and AVL make optical crank angle encoder. A piezoelectric pressure transducer with a charge amplifier connected to a PC based data acquisition system was used to record cylinder pressure data for each crank angle. In cylinder data were used to identify the combustion parameters such as peak pressure, heat release rate, delay period and combustion duration for each fuel blend. An exhaust gas analyzer (AVL Di-Gas 4000) was used to measure carbon monoxide (CO), unburned hydrocarbon (UBHC) and oxides
of nitrogen (NO\textsubscript{x}) emissions. Smoke emission was measured with the help of a continuous flow smoke meter (AVL 437) working on Hatridge principle.

The model for the cylinder head, hemispherical piston bowl and valve with 15 mm height was generated with the aid of Rapitform software. A steady state approach was followed in order to investigate the influence of swirl with inlet velocity as a boundary condition. The analysis was carried out with shroud (WS) and without shroud (WOS) for the two positions namely starts of opening and end of closing position of the valve during suction. The CFD analysis was carried out for 180\textdegree, 60\textdegree and 90\textdegree angle of shroud for both positions and the results compared with that of base engine. The flow pattern was observed better in 90\textdegree compared to 180\textdegree and 60\textdegree angle of shroud. The swirl strength was better very near TDC at start opening of valve than start of valve closing. The distance increased in the combustion chamber during suction from the bottom of the valve laterally or longitudinally the swirl strength diminished.

In this experimental study, the inlet valve was fabricated with 15 mm height with 180\textdegree, 60\textdegree and 90\textdegree angle of shroud to conduct the test runs. The groove was made-up in rocker arm to seat the bridge fabricated in inlet valve stem to prevent rotation while carrying out the test runs. The inlet valve with shroud and exhaust valve were lapped before positioning it into the cylinder head to prevent decompression.

This research work investigated the performance, combustion and emission characteristics of diesel and pongamia pinnata methyl ester blends and Biodiesel-Diesel-Ethanol blends in base engine and shrouded inlet valve engine. The tests were conducted initially by positioning the inlet valve opposite to the air entry with 180\textdegree angle of shroud. The brake thermal efficiency decreased for biodiesel blends with 180\textdegree angle of shroud and there was a decrease in NO\textsubscript{x} along with increase in smoke emission as compared to
base engine. Further test runs were conducted with 60° and 90° angle of shroud by positioning the inlet valve to the side of air entry with necessary modifications in valve and rocker arm to prevent rotation of valve during engine operation.

The performance, combustion and emission characteristics of diesel, biodiesel-diesel (BD) and biodiesel-diesel-ethanol blends (BDE) were discussed for base engine configuration and also compared with the results obtained from shrouded inlet valve engine configurations. The brake thermal efficiency for the blend B30 indicates better performance over diesel for base engine as well as shroud engine configuration. The brake thermal efficiency was higher at 90° angle of shroud for the blends B30, B30D60E10, B30D55E15 than base engine as well as 60° angle of shroud. A marginal increment is noticed at full load for the blend B30D60E10 with 10% and 15% exhaust gas recirculation as compared to diesel.

The oxides of nitrogen was observed higher at full load with the use of 60° as well as 90° angle of shroud for the blends B30, B30D60E10, B30D55E15 than diesel. The smoke, CO and HC emissions decreased considerably at 90° as compared to 60° angle of shroud for all blends but higher reduction was observed for the blends B30, B30D60E10, B30D55E15. A slight increment in oxides of nitrogen was observed with the use of EGR induction but there was a slight reduction in smoke level observed for biodiesel-diesel-ethanol blends.

The peak pressure and heat release rate were slightly increased at 60° angle of shroud for the blends B30, B30D60E10 and B30D55E15 than that of base engine. Further increment observed for both the combustion parameters at 90° angle of shroud as compared to 60° angle of shroud that may be due to enhanced air swirl. The peak pressure and heat release rate
were observed slightly lesser for biodiesel-diesel-ethanol blends with EGR as compared with same blends without EGR.

The test results indicated that 60° and 90° angle of shroud showed improved performance, combustion and reduction in emission characteristics for fuel blends than the base engine.

The experimental results proved that the pongamia pinnata methyl ester blends can be used as a viable alternative to diesel engines. Finally it is concluded that B30, B30D60E10 and B30D55E15 blends are better substitute fuel blends for fossil diesel to obtain better performance, combustion as well as reduction in emission.