ABSTRACT

The aim of this experimental investigation is to arrive at an alternative fuel for the existing direct injection diesel engines considering a few factors that have been given as the limitations in the previous researches. The investigation reports of biodiesel fuel research revealed that there was reduction in the brake thermal efficiency and increase in the oxides of nitrogen (NO\textsubscript{x}) emission.

In this experimental investigation the ceramic coating was applied to the top surface of the piston, bottom surface of the cylinder head and valve facings. The material used for the ceramic coating was partially stabilized zirconia (PSZ). The coating was applied by plasma arc spraying process. The coated engine may be termed as Low Heat Rejection (LHR) engine or Thermal Barrier Coated (TBC) engine. The reason for applying the ceramic coating was to retain the heat produced during combustion, and accelerate the micro-explosion process taking place in case of emulsified fuels. The heat retained in the combustion chamber might lead to an improvement in the brake thermal efficiency and reduced emissions.

Biodiesel might emit more NO\textsubscript{x} than diesel due to its oxygen content and ceramic coating which increases the in-cylinder temperature. It has been already proved in previous research works that almost all the biodiesel fuel produces more NO\textsubscript{x} emission in uncoated engine (conventional) itself. Hence in this experimental investigation, diesel – water emulsion and biodiesel-water emulsion have been used as the fuels in the coated engine, focusing on reduction in smoke and NO\textsubscript{x}. All the experiments have been carried out without altering engine parameters such as injection timing, injection pressure, and compression ratio.

A single cylinder Kirloskar brand naturally aspirated engine has been used for this experimental work. For analyzing the engine performance and emission parameters, various highly calibrated measuring instruments have been
used. A data acquisition system with windows based powerful software has been used for tracing out pressure crank angle graph and heat release rate curve. It also measures other parameters such as maximum pressure developed, maximum heat release, ignition delay, combustion start angle etc. A smoke meter has been used to measure smoke opacity emission in HSU (Hatridge Smoke Units). A gas analyzer has been used to measure unburnt hydrocarbon (HC) emission, carbon monoxide (CO) emission, carbon dioxide (CO₂) emission and oxides of nitrogen (NOₓ) emission. Crank angle decoder, pressure pick up sensor and signal conditioner have given the feedback to the data acquisition system for generating pressure crank angle graph and heat release rate curve.

In the first phase of experimental work the performance, combustion, and emission parameters of diesel and various other biodiesel blends were analyzed. The aim of this phase was to find the best biodiesel blend to prepare the emulsified fuel and to proceed with the future experimental work. The findings of this phase revealed that Nerium biodiesel 20% by volume with diesel (N20) was best blend among all other biodiesel blends with other compositions. It has been chosen based on the results of performance, combustion and emission parameters. The N20 biodiesel produced a brake thermal efficiency almost close to diesel and more than other biodiesel blends. The emission parameters were also found to be lesser than other biodiesel blends, except the oxides of nitrogen (NOₓ) emission. Since the aim of this investigation is to overcome the limitations in using the biodiesel as an alternative fuel, N20 has been chosen for further testing.

During the second phase of experimental work diesel has been used as the reference fuel and N20 biodiesel, diesel-water emulsion were chosen as the test fuels. Experiments have been carried out in a conventional engine (uncoated) without altering any manufacturer’s settings. Diesel-water emulsion with various compositions were taken to compare its performance, combustion, and emission characteristics with diesel and N20 biodiesel. The DWM1 has the content of 94% diesel, 5% water, and 1% surfactants. DWM2 has a composition of 89% diesel, 10% water, and 1% surfactants. DWM3 has a composition of 84% diesel, 15%
water, and 1% surfactants. The results showed an appreciable increase in the brake thermal efficiency and considerable reduction in all emission parameters when engine was fuelled with DWM3.

During the third phase of experiments the performance, combustion, and emission parameters of diesel, N20 biodiesel, and diesel-water emulsions were analyzed in Low Heat Rejection (LHR) engine. It was found that there was a marginal increase of brake thermal efficiency for both reference and test fuels when compared to conventional engine. Also there was more reduction in emission parameters for emulsified fuels than conventional fuel (diesel) and N20 biodiesel. DWM3 gave out the best results among all other fuels.

During the fourth phase of experimental work diesel, N20 biodiesel, and nerium water emulsion were tested in a conventional engine. Diesel was considered as reference fuel and N20 biodiesel, nerium-water emulsion were considered as test fuels. The results revealed that nerium-water emulsion showed a less brake thermal efficiency than diesel-water emulsion fuels. However emission parameters were found to be considerably lesser than diesel water emulsion except oxides of nitrogen emission. When compared to N20 biodiesel, oxides of nitrogen emission was found to be appreciably lesser for nerium water emulsion.

During final phase of experimental work diesel, N20 biodiesel, and nerium water emulsion were used as fuel in LHR engine. Diesel was considered as the reference fuel, whereas N20 biodiesel, nerium-water emulsions were chosen as test fuels. Brake thermal efficiency of all the fuels tested were found be more than that of conventional engine. Brake thermal efficiency of nerium-water emulsion was found to be better in LHR engine and closer to diesel-water emulsion. There was appreciable reduction in NOx emission though there was biodiesel content of 20% by volume with diesel.

It was concluded that the performance, combustion, and emission parameters of emulsified fuels were found to be better than diesel and N20 biodiesel. Diesel-water emulsion with 15% content of water was found to be the
best among emulsified fuels of diesel. Nerium-water emulsion with 20% of nerium biodiesel and 15% water content was found to be the best among the biodiesel emulsified fuels tested.

Further it was suggested that research might be extended with higher proportions of water and secondary biodiesel fuels with water content. To study the engine wear and tear, endurance test also might be carried out as a continual work of this experimental investigation.