ABSTRACT

The expanding requirement for clean air has pushed vehicle makers to contribute more time and money to reduce toxic emissions. Modification in engine design for better combustion, improved fuel properties to reduce emissions and the utilization of catalytic converters are some of the research areas to obtain clean exhaust.The utilization of monolith catalysts is one of the well-known strategies to clean the exhaust in automotive emissions. Catalytic converters oxidize the destructive carbon monoxide, hydrocarbon emissions into harmless carbon dioxide and water vapour. The toxic NO_x exhaust gas components of lean-burn engines cannot be efficiently removed with three-way catalysts, which are effective only under stoichiometric conditions.

In this work, a catalytic converter with combined NO_x storage and reduction (NSR) and Selective Catalytic Reduction (SCR) was developed and effectiveness towards the NO_x reduction from the exhaust of diesel engine was tested.

For NSR catalyser prepared by wash coated the monolith with γ- alumina to increase its surface area. The next step was the incorporation of the active phase (Pt) followed by Barium incorporation for NO_x storage. SCR catalyser was prepared by coating with CU-zeolite and colloidal silica which is used to decompose the NO_x into nitrogen.

The combination of the NSR and SCR filters helps to build an effective catalytic converter by distinguishing the optimal emission processes.The fabricated NSR-SCR catalytic converter was fitted to the exhaust system and the emission rates were measured with the help of gas analyser. The testing was carried out with diesel as fuel in a multi fuel

variable compression ratio Kirloskar engineat a constant speed. The developed prototype with the combination of both NSR and SCR catalyser was fitted to the diesel engine exhaust line with a T-joint to allow a limited amount through the pipe. The testing was completed at different engine operating conditions like different compression ratios ranging from 17.5 to 20 and injection pressures from 180 to 230 bar by applying different load conditions from 0-20 Nm. With the help of the flow regulating valve fitted between the engine exhaust pipe and the prototype exhaust pipe inlet, the flow rate is adjusted. An eddy current dynamometer was utilized to load the engine as per the requirements.

The emission readings were taken without filter, by utilizing the NSR catalyser, and with the combined NSR-SCR catalyser conditions. Twenty tests were completed by using diverse input parameter esteems. The fumes from the diesel engine were associated with the gas analyser and sensors to recognize the percentage of each gas emitted.

From the results, it was observed that the NO_x emission values increased with respect to an increase in the compression ratio by keeping the injection pressure and load as constant. Even though NO_x emission was high at a high compression ratio, the percentage of increase of NO_x without a filter was 132% but it was only 20% with combined NSR and SCR catalyser condition due to the reaction on the developed NSR and SCR catalyser.

The test was also conducted at different injection pressures by keeping the compression ratio and load as constant. Finer atomization and good air fuel mixing which were attained at high injection pressure, lead to better combustion and a rise in the exhaust gas temperature. It simulates NO_x emission which was significantly reduced while using combined NSR and

SCR catalyser developed by this work.

The NO_x emission at different loading conditions by keeping the compression ratio and injection pressure as constant were also conducted. At full load condition, the NO_x emission has been reduced to 214 % when compared with no filter and with combined NSR and SCR catalyser conditions.

From the results, it was concluded that the developed NSR and SCR catalyser performs well for the reduction of NO_x emission at various operating conditions. Minimum of 37.35 % and a maximum of 84.96 % of NO_x reduction was obtained for the engine operating at 19.5 of compression ratio, 190 bar of injection pressure with 10 Nm of loading condition and 18.75 of compression ratio, 230 bar of injection pressure and 10 Nm of loading conditions. The other emissions like CO, HC were also reduced significantly with the help of NSR and SCR catalyser. The O_2 emission was increased significantly indicating NO_x reduction into N_2 and O_2 and in some cases, CO_2 also released O_2 and carbon particles that converted into ash.

A numerical model using MATLAB software was developed to simulate the NO_x reduction with the use of NSR and SCR catalyser. For optimizing the input parameters and improving discharge level in the engine, the test data was taken as a reference. A hybrid invasive weed optimization and particle swarm optimization with a recurrent neural network is utilized for the prediction and the optimization process and input parameters like compression ratio, Injection pressure and load are utilized. The model output was compared with the experimental data.

The results of the experimental work and the numerical modelling were compared. It yields a minimum of 1.50 % and a maximum of 6.60 % error which is an acceptable error range for predictive results.

From the above results, the proposed system shows higher and improved capabilities than the existing exhaust systems. The predicted results show lesser percentages of CO, HC, CO_2 emissions and lesser values in the case of NO_x emissions.