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OPTIMAZATION OF ENGINE PERFORMANCE AND EMISSION REDUCTION IN SINGLE CYCLINDER DI DIESEL ENGINE BY USING SCR TECHNOLOGY

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ABSTRACT

Emission control is one of the biggest challenges in today's automotive industry. Emission control can be achieved either by controlling combustion or by treating the exhaust gas. The latter is comparatively easier since there is less or no need to modify the engine itself. One such after treatment method is the use of catalytic converter. But, the 3-way converter is expensive due to use of both platinum and palladium/rhodium. One of the alternative is the use of selective catalytic reduction, i.e., reduction of a particular mission based on the type of the engine used. For example, the major emissions in case of CI engines are NOX and PM. This project aims at reduction of NOX using SCR and its optimization.This project presents a modelling approach to the design optimization of Selective Catalytic Reduction (SCR) systems. The present study is concerned with ammonia slip and conversion efficiency of oxides of nitrogen (NOx), which are two major issues of SCR technologies. The physical processes including urea spray atomization, droplet evaporation, urea decomposition and turbulent mixing are accounted for in the modelling method. In addition, the velocity distribution and pressure drop in the SCR converter are analyzed with the consideration of flow resistances of the catalyst substrates and perforated plates.

KEYWORDS: SCR, NOx, PM, Urea, catalytic converter.

I. INTRODUCTION

The SCR technology with urea as reducing agent has already been applied successfully to stationary applications and to mobile Diesel engines in applications such as ships and locomotives. Though, the SCR technology is three decades old, it is still an establishing technology. This method shows an excellent reduction in emissions and the reduction in efficiency of the engine is negligible. This paper reports a fully developed after-treatment process based on injection of urea in the upstream of the exhaust gas. The Urea-SCR system was developed to meet the demand for low NOx emissions without compromising the engine efficiency from the existing diesel vehicles. In this study, amounts of aqueous urea solution injected to front pipe of catalytic converter were controlled

from the temperature of catalyst and engine RPM.

II. EXPERIMENTAL SETUP

The engine used for the investigation is kirloskar SV1, single cylinder, four stroke, constant speed, vertical, water cooled, high speed compression ignition diesel engine. The kirloskar Engine is mounted on the ground. The test engine was directly coupled to an eddy current dynamometer with suitable switching and control facility for loading the engine. The liquid fuel flow rate was measured on the volumetric basis using a burette and a stopwatch. AVL smoke meter was used to measure the CO and HC emissions from the engine. The NOX emission from the test engine was measured by chemical luminescent detector type NOX analyser. For the measurement of cylinder pressure, a pressure transducer was fitted on engine cylinder head and a crank angle encoder was used for the measurement of crank angle. The sound from the engine was measured by Rion sound level meter. The experimental setup is shown in the FIG.1

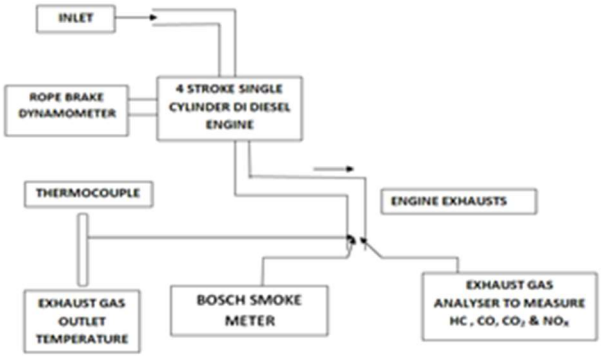

Fig.1

III. RESULTS & DISCUSSION

A. Brake thermal efficiency

It is noted from the FIG.2, as the brake power increases, combustion efficiency increases. The delay period decrease with increasing load because the operating temperature of the engine increases, leading to better combustion.

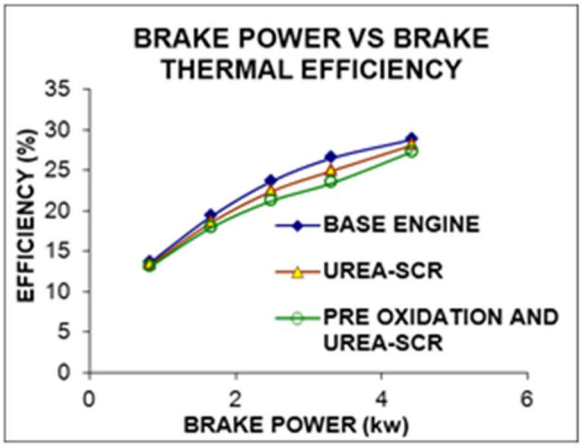

Fig.2 Effects of Efficiency with brake power

For a particular Brake power of the engine, it is observed that, the efficiency of diesel engine Urea-SCR is higher when compared to Urea-SCR with pre-oxidized engine. For instance for 4.14 Kw of

the engine, the efficiency is 28.12% whereas the efficiency of pre-oxidized Urea-SCR diesel engine is 27.3%.

B. Nox emissions

The removal of NOx is especially difficult because of the excess oxygen associated in the diesel engine operation. In this project, a single cylinder constant speed diesel engine was experimented with after treatment such as pre-oxidation to analyze the performance, NOX and other emissions like HC, CO, CO2. It is noted from the FIG.3 that increasing brake power, oxides of nitrogen is also increased due to more oxygen content of fuel chemistry and better combustion quality of the fuel. Also resulting from the oxidation of atmospheric nitrogen at high temperature inside the combustion chamber of the engine. For the maximum Brake power of 4.14 Kw, the NOx emission of diesel engine without pre-oxidized Urea-SCR set up is 310 PPM whereas it is 238 PPM for pre-oxidized Urea-SCR set up.

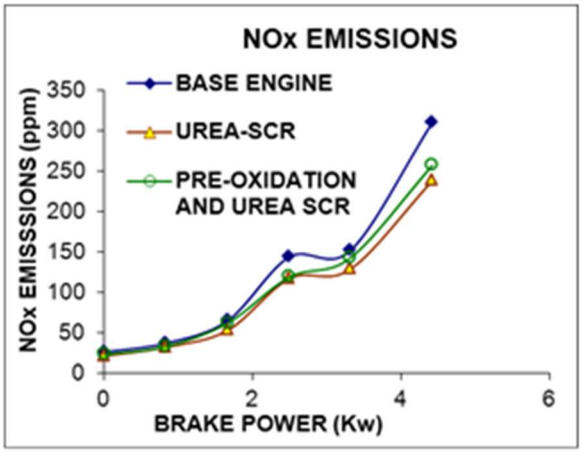

Fig.3 Effects of engine brake power on Nox emissions

C. HC emissions

It is noted from the FIG.4, when brake power is increased, the hydrocarbon emission also increased due to heterogeneous combustion of diesel engine. When the urea is injected the HC slightly increases because urea being a reducing agent removes the oxygen radical or adds the hydrogen radical in the gas coming from the exhaust. After pre-oxidation of the exhaust the HC emission reduces considerably. For the maximum Brake power of 4.14 kW, the HC emission of diesel engine without pre-oxidized Urea-SCR setup is 714 PPM on the other hand 653 PPM for diesel engine with pre-oxidized Urea-SCR setup.

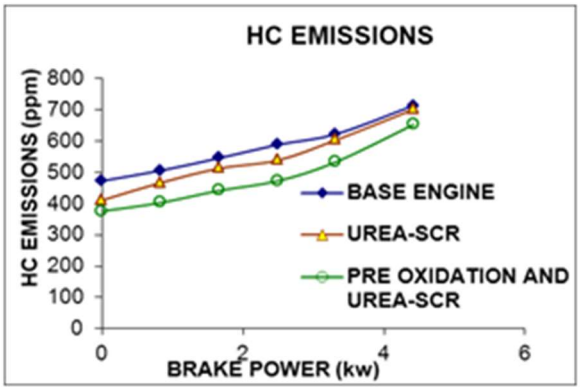

Fig.4 Effects of engine brake power on HC emissions

D. CO emissions

It is noted from the FIG.5, when brake power is increased, the carbon mono oxide emission also increased due to heterogeneous combustion of diesel engine. This will lead to incomplete combustion of the fuel. When urea is injected the oxygen atom is removed from the reaction casing the exhaust gases without proper oxygen atom. For the maximum Brake power of 4.14 Kw, It is observed that the CO emission of diesel engine without pre-oxidized Urea-SCR setup is 0.05 (%by vol) whereas it is 0.04 (%by vol) for diesel engine with pre-oxidized Urea-SCR setup.

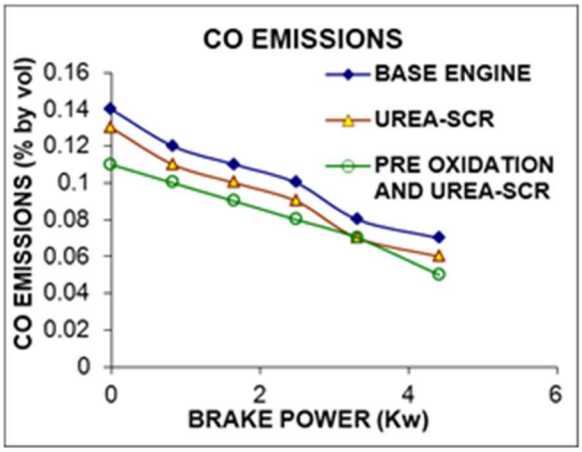

Fig.5 Effects of engine brake power on CO emissions

IV. CONCLUSIONS

Due to the global environmental pollution level and their rapid increase has forced environmental agencies of various countries to enforce very stringent emission norms. The after treatment device like EGR, SNR, NCR, SCR & particulate trap are required to achieve these emission norms. In this project the improved SCR technology (Pre-oxidation and Urea-SCR) is used to carry out the experimentation. The conclusions are summarized as follows.

It is concluded that there is decrease in the NOX emission by 23.22%. The reduction in the HC percentage, when the diesel engine with Pre-oxidation Urea-SCR setup is used is nearly 10%. There is also a reduction in the CO emission of Pre-oxidized Urea-SCR setup diesel engine is used the CO emission is decreased by 40%. Because of the complete oxidation when the exhaust is oxidized, the CO2 emission in diesel engine with pre-oxidation Urea-SCR setup is increased by 8.3%.

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