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Investigation of exhaust emission and optimization of cell shape catalytic converter using Ag, Au and SS 304 on IC engine

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Abstract *— Catalytic converter used in automobile to reduce exhaust emission by converting high toxic gases into less toxic gases. The main pollutant gases in the automobile are HC, CO and NOX. These gases are treated in catalytic converter and converted into water vapor and CO2 which is less toxic. Noble metal based Catalytic converter face some problem like; poisoning, melting and higher cost these leads to application of non-noble metal based material such as copper, silver, gold or combination of these material as catalysts. In present work the catalytic converter is developed using gold coating wire mesh, silver coating wire mesh and SS coating wire mesh. It is found that silver coated and gold coated material gives better results.*

Keywords- *Diesel engine, Engine performance, Emission, Catalytic Converter, IC Engine..*

I. INTRODUCTION

A catalytic converter is used to control the emission of a vehicle by converting the highly toxic gases to less pollutant gases by reduction (or oxidation) reaction process. Existing catalytic converters suffers from various problems like; poisoning, fracture, melting & higher cost. These factors leads to the application of non-noble metal based material such as copper, nickel, manganese Gold, Silver, SS-304 based alloy, or combination as a catalyst. So to develop cost effective catalytic converter like Gold, Silver, and SS-304 Substrate based catalytic converter.

Two-way catalytic converter:

A two-way catalytic converter contains two beds. The first conversation of NOx and In the second part conversation of hydrocarbons (HC) to water and carbon dioxide (CO_2) and carbon monoxide (CO) to CO_2 by oxidation takes place. The secondary air supply between the two bodies leads to transform a part of NH to NO_X. The system is not optimal, but it can be used in the case of engines with carburetors without electronic control.

Three-way catalytic converter:

A "Three-way catalytic converter" has the capability to control efficiently the three main pollutants CO, NO_X and HC. As the three-way catalytic converter removes three pollutants in the exhaust gases like NO_X, HC, and CO at the same time by reducing NO_X, and oxidizing HC.

Most commonly application of Catalytic converters are in exhaust systems of automobiles; also used in electrical generators, mining equipment, forklifts, trucks, buses, locomotives. They also can be used on some wood stoves to control emissions

Design of catalytic converter

Catalyst and substrate preparation

Material selection for Catalyst: Silver, Gold and SS-304 is used as the oxidizing agent. Its non poisonous nature, lower economy, and availability makes it preferred carrier in oxidation from the stationary pollution sources. It can be seen in below figures.

Properties of SS 304

Its good corrosion and heat resisting properties. SS 304 being extremely tough and ductile. And Maximum Recommended Service Temperature is 925o .

Chemical composition of SS-304

Ni – 8 to 10.5 % Cr – 18 to 20 % Mn – 2 % Si – 1 % S -- 0.030 % P-- 0.045 %

Properties of gold and Silver as catalyst

- Gold's and silver's catalytic properties - it accelerates the rate of chemical reactions without being consumed.
- Melting point of gold: - 1062 °C.
- Gold is a soft, yellow, corrosion-resistant element.

- Pure silver is nearly white, lustrous, soft, very ductile, and malleable; it is an excellent conductor of Heat and electricity.
- **Catalytic converter Dimension**
- L = 200 mm
- D = 80 mm
- Inlet and outlet cone dia = 40 mm
- Flange: I.D = 80 mm Gasket: I.D = 80 mm
- O.D = 165 mm O.D = 165 mm

Figure 1. catalytic converter

Engine specification

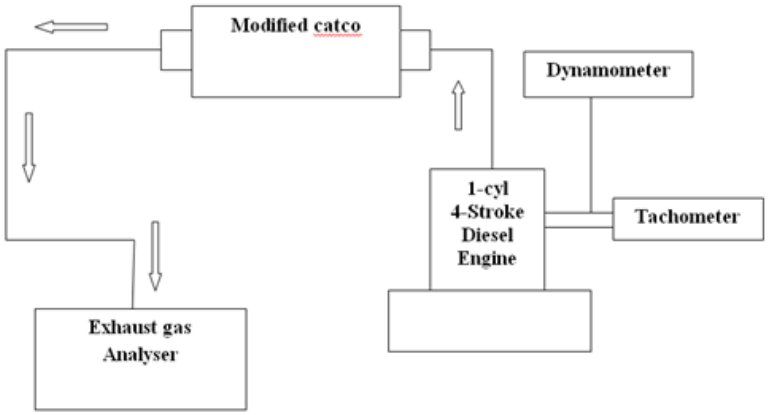

Figure 2 Schematic diagram of experimental set up

For the Diesel engine set up of having power 5 HP @ 1500 rpm which is 1 Cylinder, Constant Speed and water cooled, four stroke experimental examinations were conducted. Diesel engine is engaged with a Rope brake dynamometer. Rope brake with loading screw and spring balances, Brake drum diameter of 0.270 meter, belt thickness of 0.006 meter and effective radius of 0.0138 meter. Separated cooling water lines are fitted .A measuring system for 'fuel consumption' consisting of fuel tank mounted on the stand and provided burette.

No. of cylinder	Single cylinder
No. of stroke	4
Cylinder dia.	87.5 mm
Stroke length	110 mm
C.R. length	234 mm
Orifice dia.	20 mm
Dynamometer arm length	185 mm
Fuel	Diesel
Power	3.5 kw
Speed	1500 rpm
C.R. range	12:1 to 18:1
Inj. Point variation	0 to 25 TDC

Table 1. Engine specification

EMISSION CHARACTERISTICS

First take the reading convention OEM catalytic converter and find the emission characteristics. Then find the emission characteristics with modified catalytic converter. Emission characteristics like NOX, CO, CO2, HC and O2 at different injection pressure with varying load. Diesel fuel is used and emission characteristics are observed.

EMISSION OF HC

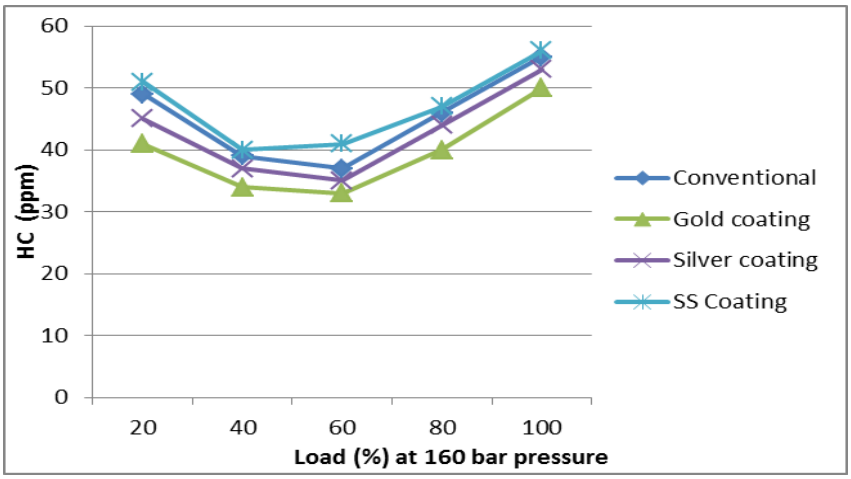

Figure 3.HC vs LOAD

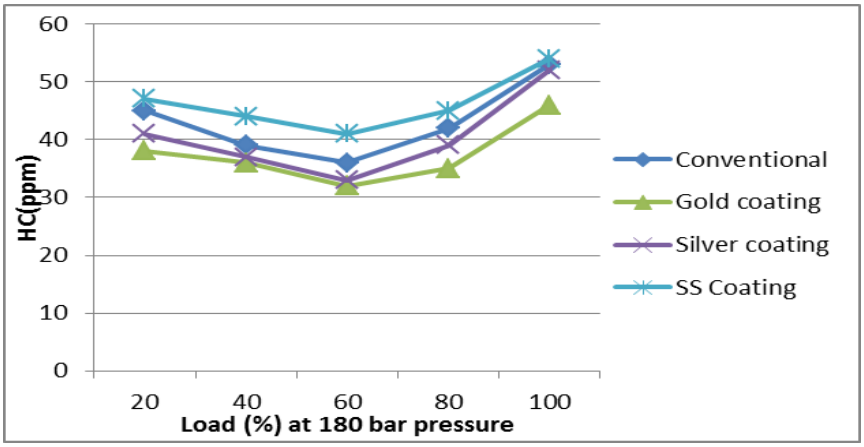

Figure 4.HC vs LOAD

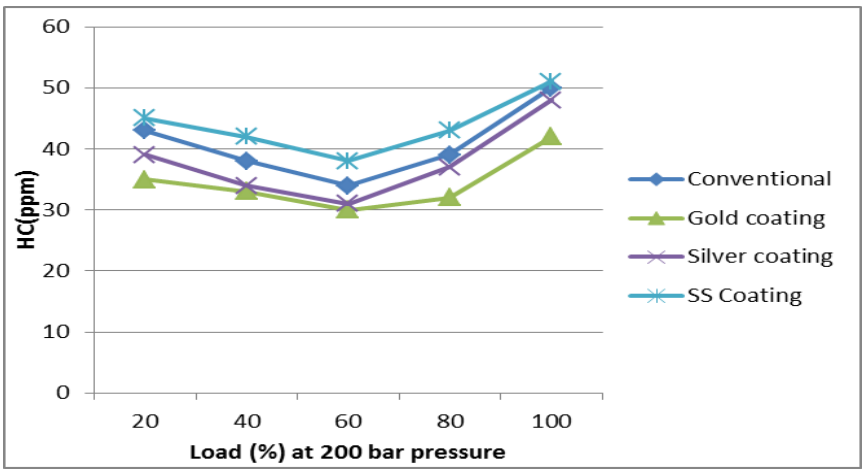

Figure 5.HC vs LOAD

At starting HC content is high due to incomplete combustion as load increase temperature also increase so the HC content decrease. At load further increase, fuel consumption increase that leads to the increase in HC emission. But as injection pressure increase the better combustion takes place so HC emission at 160 bar pressure is higher than 180 bar pressure and vice versa. Among the coating materials the gold coating gives good results than other and stainless steel execute poor performance.

EMISSION OF CO

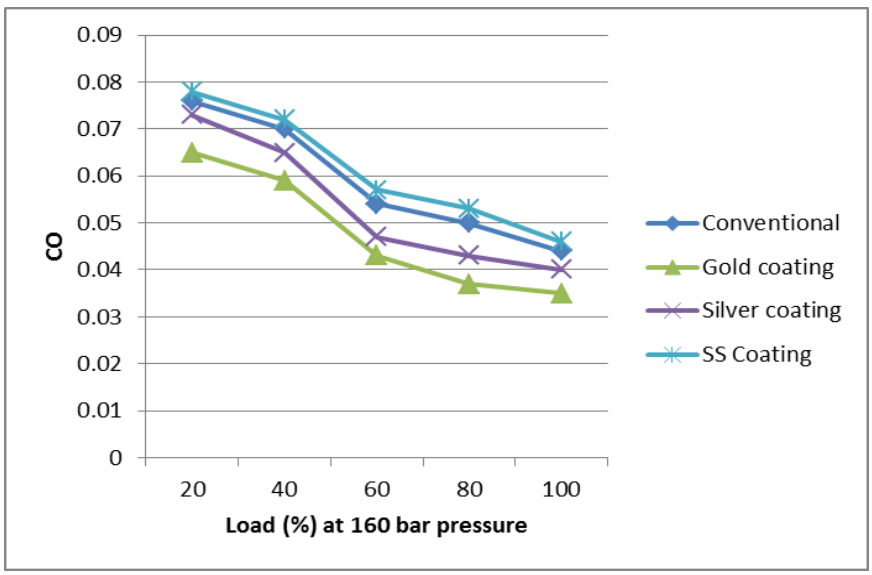

Figure 6. CO vs LOAD

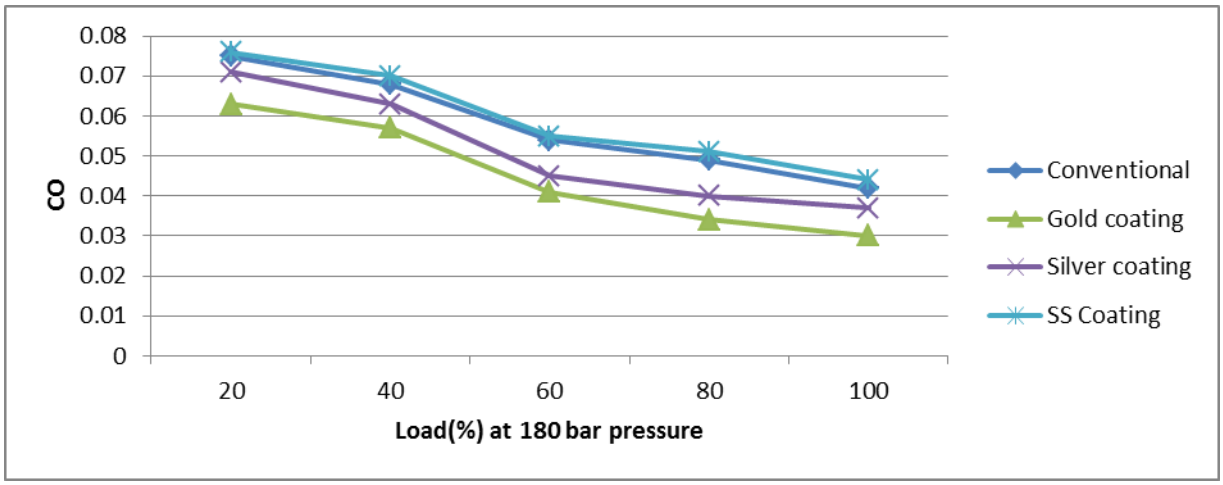

Figure 7.CO vs LOAD

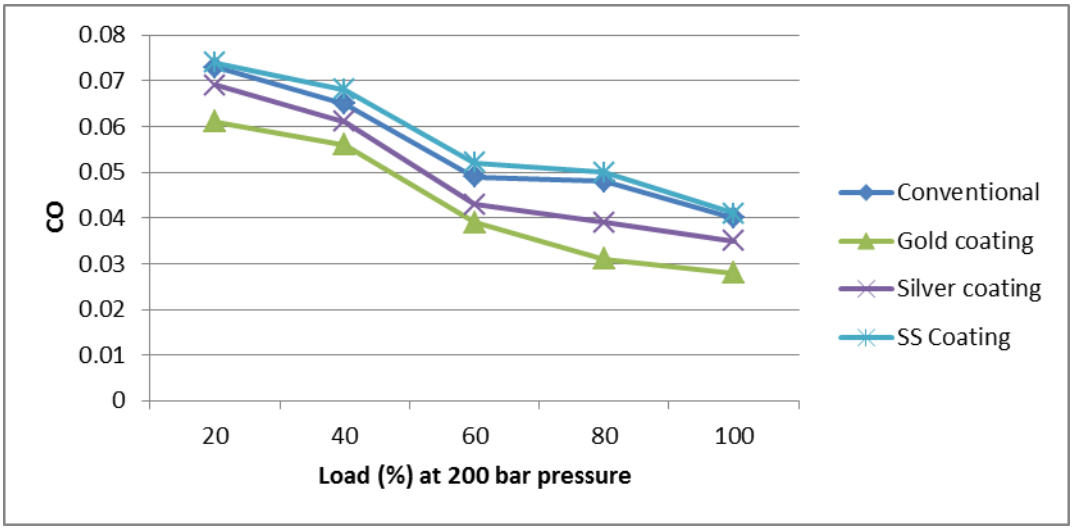

Figure 8.CO vs LOAD

Carbon monoxide emission decreases as load increases on the engine. This happened due to continuously increase in temperature in the engine. Different coated catalytic converter gives different results in which gold coating converter gives lower emission of carbon monoxide compare to other catalytic converter. With rise in injection pressure the better combustion takes place so emission at 200 bar pressure is lower than that of 180 bar and 160 bar pressure.

EMISSION OF CO_2

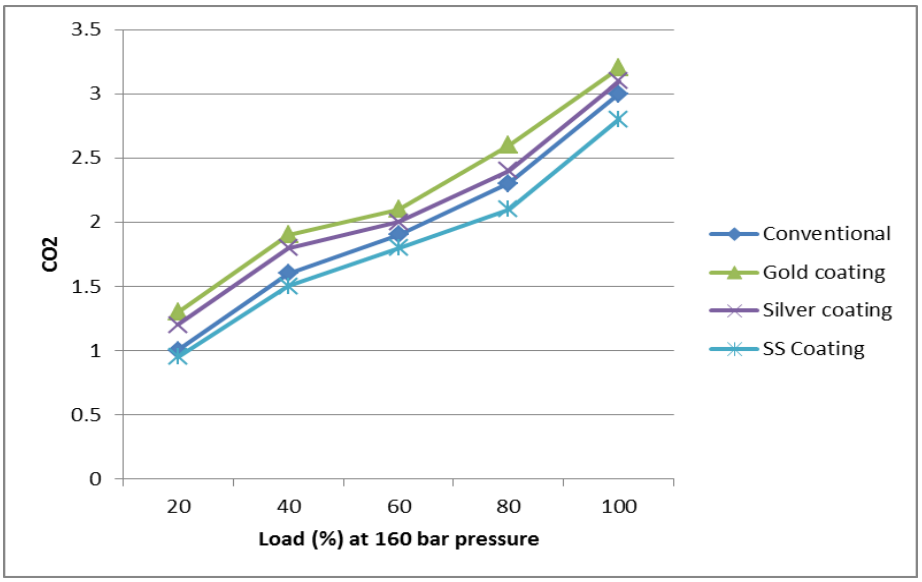

Figure 9.CO_2 vs LOAD

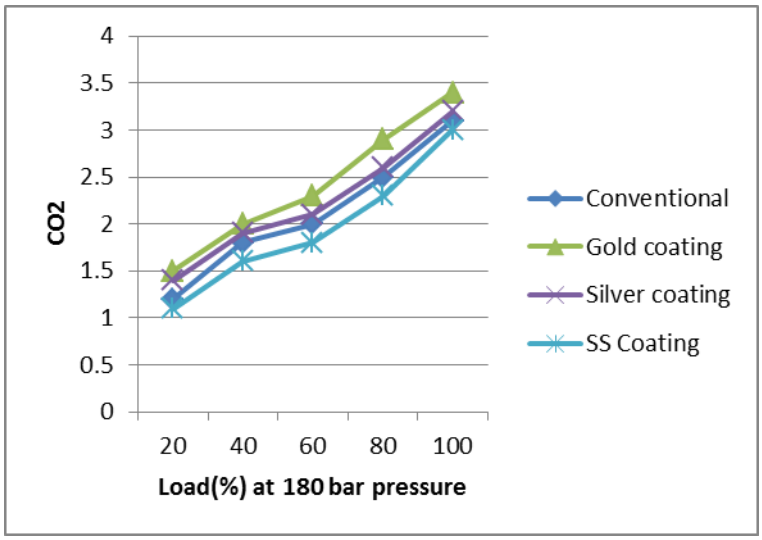

Figure 10.CO_2 vs LOAD

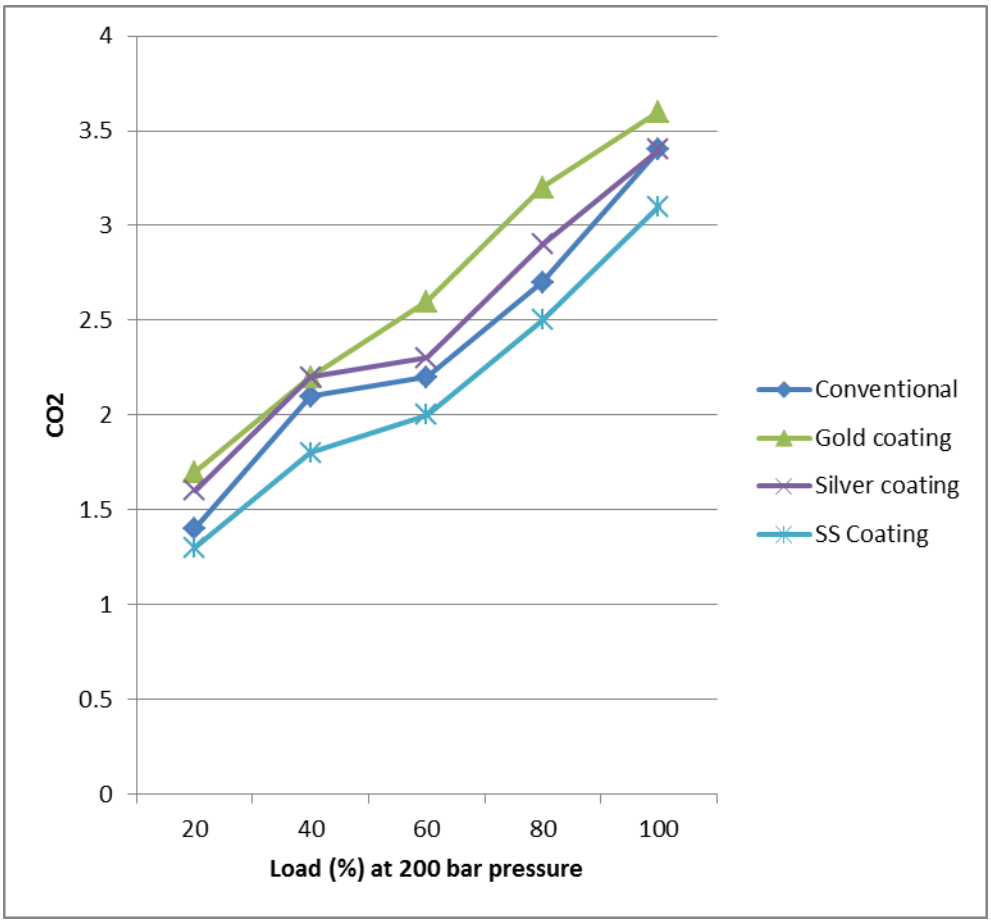

Figure 11. CO_2 vs LOAD

CO2 emission increase as load increase because as load increase on the engine the inside temperature of engine increase that leads to better conversation of CO into co2. As injection pressure increase the emission of co2 increases due to better combustion. So co2 emission at higher injection pressure of 200 bar is higher comparatively higher than that of 160 bar and 180 bar pressure. Here from the graph it can be seen that co2 emission in gold coating converter is higher compared to that of other material converter.

EMISSION OF NO_X

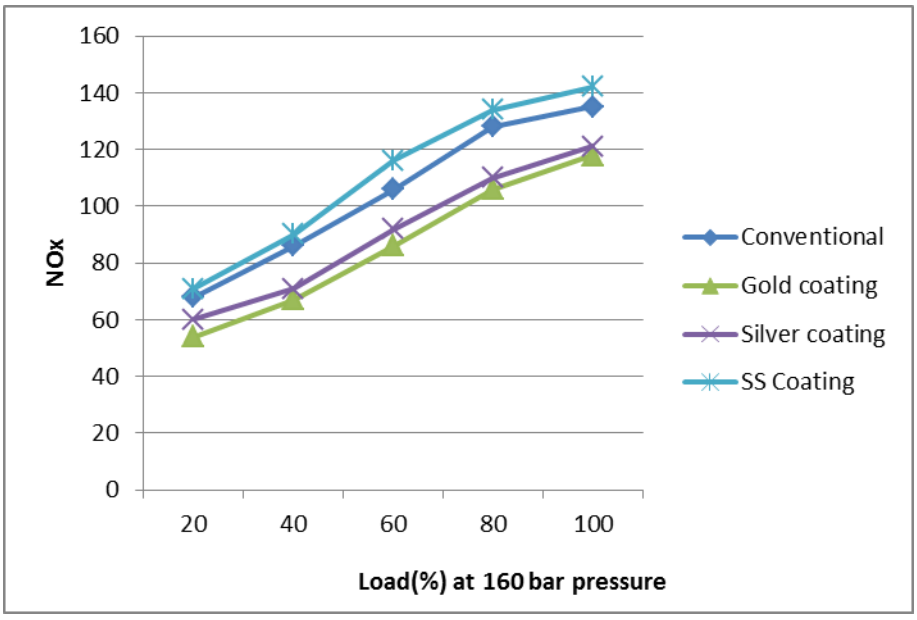

Figure 12.NO_X vs LOAD

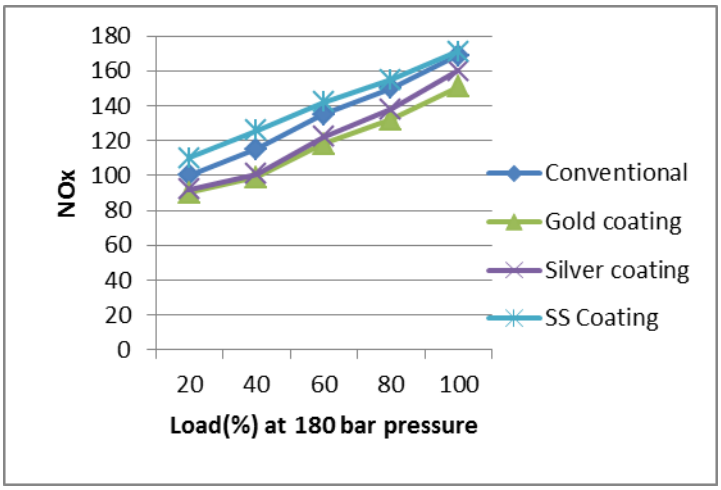

Figure 13.NO_X vs LOAD

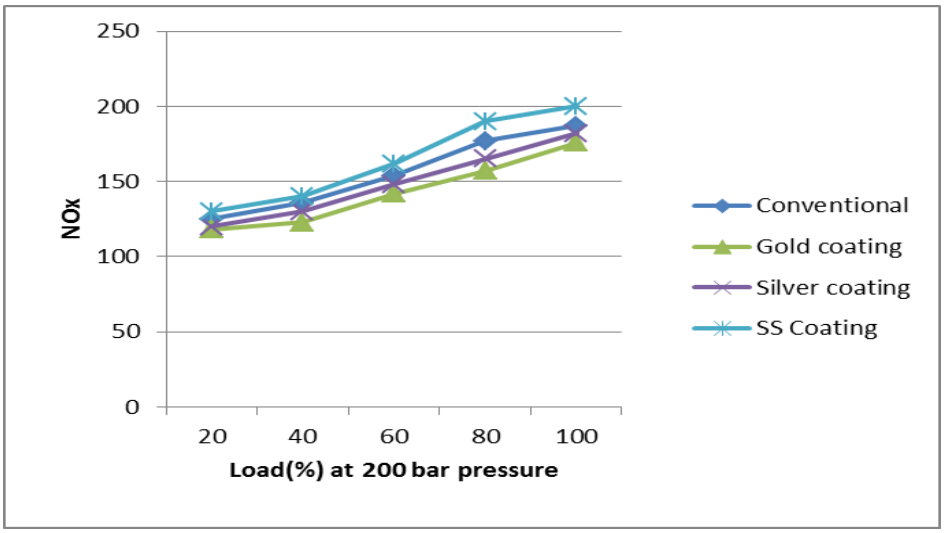

Figure 14 NO_X vs LOAD.

Temperature is one of the major factors that effect the formation of the NOX. As load on the engine increase the temperature inside the cylinder increases that leads to increases the emission of the NOX.

Also as injection pressure increases the temperature of engine increases that cause higher NOx emission. Hence emission at 200 bar pressure is higher than that of 160 bar and 180 bar pressure. Here gold coated catalytic converter is more effective than other catalytic converter.

CONCLUSION

- It has been found that HC, CO, CO_2 and NO_X content increases with increases injection pressure and load.
- It has been observed that by using gold coating wire mesh substrate based catalytic converter, CO reduces, HC reduces and, NO_X content reduces.
- It is therefore concluded that development of SS coating wire mesh substrate based catalytic converter is not practicable since it does not give acceptable result for given working conditions.
- Gold coating wire mesh substrate based catalytic converter can be useful approach in place of copper, Nickel based catalytic converter based catalytic converter. So focusing on emission parameter**,** gold coating wire mesh substrate is proved to have satisfactory results than other catalyst material.
- Silver coating and Gold coating wire mesh substrate based catalytic converter reduces NO_X content emission.

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