"Enhancement of Performance of Catalytic Converter Using Phase Change Material (PCM)"

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Abstract Increased vehicle emission is one of the most important issues that have drawn the attention of policy makers and environment alerts these days. The increasing no's of automobiles playing on roads to day in our country is positioning a serious threat to the ecology, through its harmful pollutants also the fuel economy least maintained and low cost of the fuel have provoked the people to go for diesel vehicle several research has been made in the field of pollution control from automobiles and the research is still going on.

The catalytic converter is a device used to reduce the toxicity of emission from internal combustion engine. The function of catalytic converter is to convert CO, HC and NOx emission into CO_2, H_20, N_2 and O_2. In catalytic converter, we are making a separate chamber for Phase Change Material around the catalytic. To analyze how the reaction can take place in catalytic converter and how it converts the harmful gases to harmless gases. Due to incomplete combustion in the engine there are number of incomplete combustion product.

Under normal operating conditions, catalytic converter appears to be the most effective means of reducing air pollution from internal combustion (IC) engines. The conversion efficiency, however, declines very steeply for temperature below about 350°C and is practically zero during the starting and warming-up period. A phase change material (PCM) with a transition temperature of 352.7°C, which is slightly above the light-off temperature of the metallic catalyst, was specially formulated.

Among the more successful solutions are preheating of the catalyst electrically, warming up of the catalyst in an external combustion chamber, installing of an auxiliary small-capacity catalytic converter, and employment of an absorbing unit between two catalyst. In the present work an investigation was made of a solution based on the exploitation of thermal capacitance to keep the catalyst temperature high during off-operation periods.

Keywords: cold-start emission, catalytic converters, thermal energy storage, phase change material.

1. **INTRODUCTION** Always been disputed among the ecologists over the centuries and recent years is pollution of air. As the technology carry on sprouting and extending, it brings along many unwanted hazardous effects on top of its wide-ranging applications. The vehicle exhaust limit takes a main production part for the emission of polluted gases. As we know that a number of vehicles voyages thousands of miles per year for the purpose of carrying various needs and demands. Subsequently, an increase in the number of vehicles led to the increase of pollutants in air. Various combustion products and by-products are formed due to the partial combustion in the engine. The products formed from incomplete combustion of engine are hydrocarbons (HC), carbon mono-oxide(CO), oxides of nitrogen(NOx) and the byproduct formed from it is ground-level ozone due to reaction with hydrocarbons in the presence of nitrogen oxides and sunlight, which is responsible mainly for smog. Also, ozone is hazardous for our respiratory system. Nitrogen oxides and hydrocarbons have also contribution for the formation of ozone and acid rain. Carbon monoxide creates obstruction for the flow of oxygen in the blood stream and it is very much dangerous for heart patient. Carbon dioxide does not affect human health directly, it goes about as a "Green-house gas" that traps the world's warmth vitality and produces global warming as industrialization and urbanization has assumed an immense part in making work for ordinary individuals. An exhaust system is the most important part of automobile as it takes a vital role in environment. Roughly 1/3 of the contamination the air is from the automobile fleet. So it is the most important to control car contamination to accomplish the objective of cleaner air, which ought to help for lessening of green-house gasses.

A catalytic converter is an exhaust emission control device that converts toxic gases and pollutants in exhaust gas from an internal combustion engine into less-toxic pollutants by catalyzing a redox reaction (an oxidation and a reduction reaction)

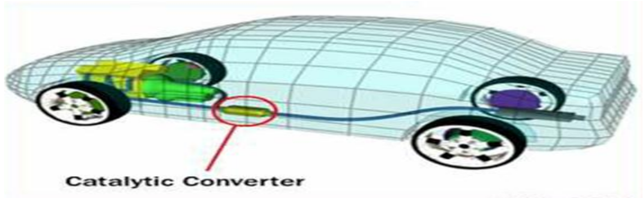

Fig. 1.1: Position of Catalytic Converter

2.DESIGN PROCEDURE

2.1. Design of catalytic converter by using PCM:

Specification in Diesel Engine

- Power = 3.5 KW
- Stroke length = 1100 mm
- Speed = 1500 rpm
- Bore diameter =87.5 mm
- Compression ratio = 1:17.5

Volume flow rate

Volume flow rate = (π/4) * d^2 *l* (N/2) *60

= (π/4) * 0.08752*0.110*(1500/2) *60

= 29.765 m^3/hr.

= 0.008268 m^3/sec

Let's take space velocity = 40000 m/hr.

= 11.11 m /sec

Space velocity = (volume flow rate / converter volume)

Converter volume = (0.008268/ 11.11)

Converter volume = 0.007441944 m3……………………………… (1)

Converter volume = (π/4) *d2*l

= (π/4) *0.1002*.09

= 0.007065 m3…………………………………… (2)

Hence equation 1= equation 2

Space velocity = (volume flow rate / converter volume)

= (0.008268/ 0.0007065)

= 11.7 m/sec

Space velocity = 11.7 m/sec

2.2 Heat stored in PCM

Data: Mass of PCM = 0.5 kg

Room temperature 30°C

M.P(PCM) = 340°C

Heat = m*Cp* ΔT

= .500*715* (340-30)

= 110.825 KJ

Latent heat 0f PCM

= Mass of PCM * 715

= 0.5* 715

Latent heat of PCM = 357.5

Dimensions of Phase Change Material

- Length of catalytic PCM = 90 mm
- Outer diameter of PCM = 120 mm
- Inner diameter of PCM = 100 mm
- Volume of PCM chamber = 28260 mm^3
- Mass of PCM = 500 grams
- Heat produced in PCM = 468.325KJ

3. WORKING:

In the catalytic converter, we made separate chamber for phase change material (PCM) around the catalyst. In this, we used outer surface as an insulating material and inner surface as a conducting material. The PCM is an alloy of Magnesium, Zinc and Aluminum. In that chamber, which is made around the catalyst, we poured PCM in the liquid form.

At the time of starting the engine, temperature in the catalytic converter is low and PCM in the liquid form provides heat to the catalytic converter. Thus, the unburnt gases like CO, NOx, HC gets easily converted into harmless gases. Hence its efficiency and performance get increases.

Due to the heat loss PCM changes from liquid to solid form. After some time span the temperature increases and due to which PCM again changes in the liquid form by absorbing the heat. PCM stores (energy) heat up to 12 to 14 hrs. as we used insulating material at the outer surface of the PCM.

4. RESULT AND DISCUSSION

Exhaust Gas Analyzer: An exhaust gas analyzer or exhaust CO analyzer is an instrument for the measurement of carbon monoxide among other gases in the exhaust, caused by an incorrect combustion, the Lambda coefficient measurement is the most common.

The Lambda coefficient is obtained from the relationship between air and fuel involved in combustion of the mixture.

Fig no. 4.1 Exhaust Gas Analyzer

4.1 RESULT

a) Test on diesel engine

Table no 4.1 Test on diesel engine at speed 1560 rpm

Sr. No.	Gases	Ideal condition	Existing catalytic converter	Catalytic converter with PCM
1.	HC(PPM VOL)	840	762	617
2.	CO(% VOL)	9.893	6.51	.388

b) Test on petrol engine

Table no. 4.2 Carbon mono – oxide (co) (% vol)

Sr. No.	Speed (RPM)	Ideal condition	Existing catalytic converter	Catalytic converter with PCM
1.	1610	.393	.18	.14
2.	2000	.682	.398	.293
3.	2500	.943	.844	.757

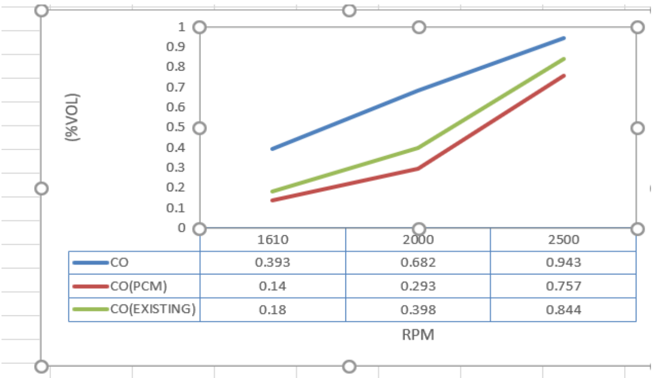

Chart no .4.1 % vol of CO VS Engine Speed(rpm)

Table no. 4.3 Hydrocarbon (HC) PPM(VOL)

Sr. No.	Speed (RPM)	Ideal condition	Existing catalytic converter	Catalytic converter with PCM
1.	1610	861	241	134
2.	2000	937	690	616
3.	2500	2434	2218	1500

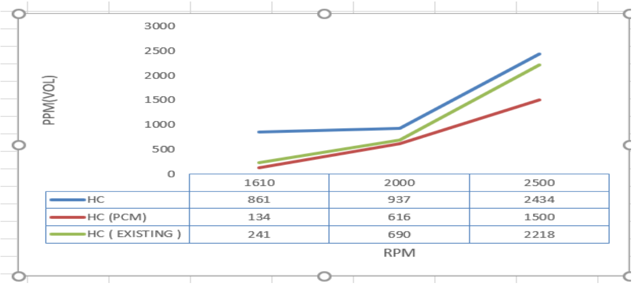

Chart no .4.2 PPM Vol of HC VS Engine Speed(rpm)

4.2 DISCUISSION

1. On Diesel engine - The experiment is carried out on constant engine speed of 1560 rpm The performance and emission are carried with the base engine without catalytic convertor and with existing catalytic converter & catalytic converter with PCM. Table no 5.1 shows that CO and HC emissions are high when the without use of catalytic converter & existing catalytic converter and goes on decreasing when the use of catalytic converter with PCM

2. On Petrol engine - The experiment is carried out on engine speed of 1610 rpm , 2000 rpm and 2500 rpm The performance and emission are carried with the base engine without catalytic convertor and with

existing catalytic converter & catalytic converter with PCM.

Chart no 4.1 shows that variation CO emissions with speed of petrol engine. CO emissions are high when the without use of catalytic converter & existing catalytic converter and goes on decreasing when the use of catalytic converter with PCM

Chart no 4.2 shows that variation HC emissions with speed of petrol engine. HC emission are high when the without use of catalytic converter & existing catalytic converter and goes on decreasing when the use of catalytic converter with PCM

5. CONCLUSIONS

The objective of this project was to test and optimize the catalytic converter on a Petrol and diesel engine which should deliver better performance & emissions. In the experiment the engine was tested without catalytic converter and with existing catalytic converter & with catalytic converter with PCM and results shows that the reduction of the CO and HC are better with catalytic converter with PCM

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