International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 05 | May 2020 www.irjet.net p-ISSN: 2395-0072

Design of the Electronically Aided Catalytic-Converter for ATV

Pro. L.B. Diwakar[1], Shantanu Diwakar[2], Ganesh Iyer[3], Mohd.Imran Choudhari[4]

[1]*Head of Department, Automobile Engineering S.E.S.Polytechnic Solapur.*
[2,3,4]*Student, Mechanical Engineering Dr. D.Y.Patil Institute of Technology Pimpri, Pune.*

Abstract - *Air Pollution produced from the Vehicular sources has become a big problem and going to become larger. There are a large number of products such as NOX, CO, HC etc. due to incomplete / improper combustion in engine. These pollutants influence the air quality. A catalytic converter is a device used to reduce the toxicity of emissions from an internal combustion engine. Use of Catalytic Converter however is found to be the most suitable method to control the automotive exhaust emission. This research paper discuss the design alternative and cost efficient catalytic converter for the special purpose off road racing vehicle. To manufacture a robust, cost-effective & a compact cat-con integrated with a simple temperature control unit to enhance the performance of the prototype during cold starts. It seems that general catalytic converter are slightly less effective at cold start condition. Following are the some objectives to design Electronically Aided Catalytic-Converter, and to minimize the cold start pollution.*

Key words: *catalytic converter, off road racing vehicle, cold starts pollution, Electronically Aided Catalytic-Converter*

1. INRODUCTION

A catalytic converter is a device used to reduce the toxicity of emissions from an internal combustion engine. A Catalytic Converter is an emissions regulating means that converts Toxic gases and Pollutants in exhaust gases to less Toxic pollutants. Typical exhaust gas composition at the normal engine operating conditions are: carbon monoxide (CO, 0.5 vol. %), un-burned hydrocarbons (HC, 350 ppm), nitrogen oxides (NO x, 900 ppm) hydrogen (H2, 0.17 vol. %), water (H2O, 10 vol. %), carbon dioxide (CO2, 10 vol. %), oxygen (O2, 0.5 vol. %) [1-3].Various technologies available for automobile exhaust emission control a catalytic converter is found to finest choice to control Carbon monoxide, unburnt hydrocarbon and NO x emissions from petrol/LPG driven vehicles while diesel particulate filter and oxidation catalysts converter have so far been the most prospective option to regulate particulates emissions from diesel driven vehicle.

1.1 Basic over view of catalytic converter

The generally catalytic converter assembly consists most of these components, inlet/outlet pipes/flanges, steel housing, insulation material, seals, inlet/outlet cones, substrate(s), coating and sensor boss.

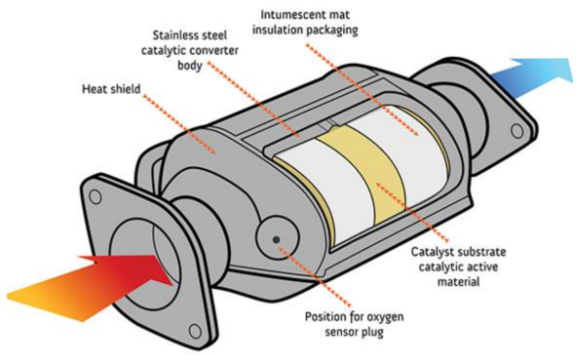

Figure-1 The typical catalytic converter

1. A steel housing provides protection and structure support for substrate; insulation material (mat or wire mesh) provides heat insulation and support between steel housing and substrate; seals are there to protect mat material from been burned by the exhaust gas.
2. The substrate is often called a "catalyst support". It is a ceramic honeycomb or a stainless steel foil honeycomb in modern catalytic converters. The ceramic substrate was invented by Rodney Bagley, Irwin Lachman and Ronald Lewis at Corning, in use to increases the amount of surface area available to support the catalyst.
3. The wash coat is used to make converters more efficient, often as a mixture of silica and alumina. When a wash coat is added to the substrate, it forms a rough, irregular surface, which has a far greater surface area than the flat core surfaces do, which then gives the substrate a larger surface area, providing more sites for active precious metal – the catalytic which is added to the wash coat (in suspension) before being applied to the substrate.
4. The catalyst itself is most often a precious metal. Platinum is the most active catalyst and is widely used. However, because of unwanted additional reactions and/or cost, Palladium and rhodium are two other precious metals that are used. Platinum and rhodium are used as a reduction catalyst, while platinum and palladium are used as an oxidization catalyst. Cerium, iron, manganese and nickel are also used, although each has its own limitations.

The three-way catalytic converters have been used in vehicle emission control systems. A three-way catalytic converter has three simultaneous tasks:

• Oxidation of carbon monoxide to carbon dioxide:

$2CO + O_2$ _ $2CO_2$

• Oxidation of un-burnt hydrocarbons (HC) to carbon dioxide and water:

$C_xH_{2x+2} + [(3x+1)/2]O_2$ _ $xCO_2 + (x+1)H_2O$

• Reduction of nitrogen oxides to nitrogen and oxygen:

$2NO_x$ _ $xO_2 + N_2$

2. PROBLEM STATEMENT

To manufacture a robust, cost-effective & a compact cat-con integrated with a simple temperature control unit to enhance the performance of the prototype during cold starts. It seems that general catalytic converter are slightly less effective at cold start condition. Following are the some objectives to design Electronically Aided Catalytic-Converter, and to minimize the cold start pollution.

2.1Objectives of Electronically Aided Catalytic-Converter

1. Convert toxic exhaust gas emissions into simpler compounds using non-noble metal catalyst.
2. Implementation of non-conventional multi-cored metallic substrate.
3. Use of cost effective secondary chemicals.to minimize the overall cost of the catalytic converter.
4. Use of temperature control unite.
5. To minimize the pollution during cold start condition.
6. To design a catalytic converter for off road racing vehicle.

3. DESIGN OF ELECTRONICALLY AIDED CATALYTIC-CONVERTER.

To design the catalytic converter we select the BAJA DUNE Buggy. Which is rear wheel drive single seater off road sports vehicle. The reason behind the selection of the off road racing vehicle is that the focus of designing of this vehicle is to gain maximum power from the engine. So that time somewhere the emission factor slightly compromised.

Now to begin the actual design of the catalytic converter there is some predesign parameters that we have to consider.

Table -1: Design considerations

Engine Type	**Briggs & Stratton Vanguard 19 Series**
Fuel	**Petrol**
Power	**10 hp**
Swept Volume	**305cc**
Bore*Stroke	**0.08178m*0.05791m**
Engine Speed	**Idle=1800rpm Max=3800rpm**
Exhaust Gas Velocity	**Idle=6.6m/s Max=11.4m/s**

3.1 Design of Split shell.

The selection of the material for the shell is the primary task. The material should have best resistance to corrosion property. Also it has less effect of the heat. So according to this basic parameter we select SS304. The material of the outer shell is SS304 as it has better resistance to rusting at elevated temperatures due to higher concentration of nickel and chromium. This will in turn compensate the reduced performance of a non-noble metal catalyst by a marginal amount.

The dimensions of the shell and the substrate are calculated using the following parameters. Engine Specs (Bore*Stroke), Volume flow rate of exhaust gas (Max RPM), Volume of the catalyst. The ratio Volume flow rate of exhaust gas (Max RPM), Volume of the catalyst determines the value of "Space Velocity". This concept has a major influence on the overall dimensions of the substrate.

Exhaust Gas Volume flow rate = Swept Volume * No. of intake strokes per hour

= 605*10-6*1900*60

= 34.77 m3/hr

Space Velocity = VFR/Catalyst Volume

= 34.77/0.000477

= 72683.43 hr-1

Hence to meet the space velocity criterion we have implemented a dual split shell design.

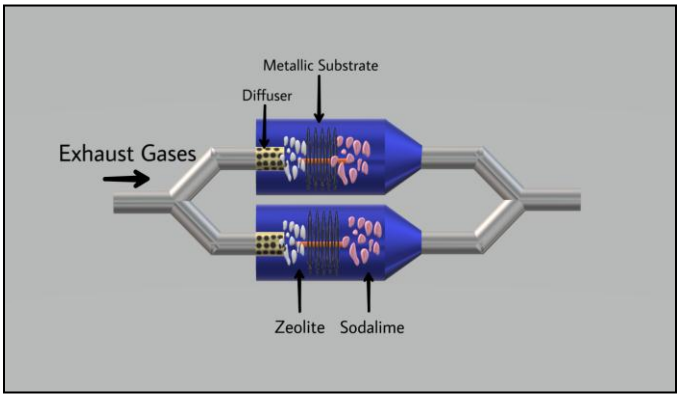

Figure-2: Split Shell Design

3.2 Design of Substrate.

A substrate is the Catalyst-Supporter, which basically has a large number of holes (square/hexagonal) to increase the surface which in-turn increases the reactivity of exhaust gas with the catalyst. Metallic foil monoliths are used in applications where particularly high heat resistance is required & a substrate is structured to produce a large surface area.

A wash-coat is a carrier for the catalytic materials and is used to disperse the materials over a large surface area. The catalytic materials are suspended in the wash-coat prior to applying to the core. Wash-coat materials are selected to form a rough, irregular surface, which greatly increases the surface area compared to the smooth surface of the bare substrate. This in turn maximizes the active surface available to react with the engine exhaust. Hence Al2O3 has been used as a wash-coat.

Non-noble metal catalyst Nickel has been used, having lower activation temperature (180oC). This metallic substrate is designed to hold the heating coil at the center having a cell density of 80 cpsi. Following are the basic considerations for substrate. This parameter are consider according to the shell design.

Diameter = 80mm
Length = 85 mm
Hole Density = 150 cpsi
Catalyst Used = Nickel (Light-Off=185°C)

3.3 Design of Heating Coil & Temperature Control Unit:

An iron rod wound with a copper wire of 0.8mm diameter having 700 turns has been used as a heating coil. The temperature of this coil & substrate is monitored using a LM35 sensor and the heating is turned on and cut-off using a solid state relay. This entire circuit is programmed using an Arduino-Uno Board.

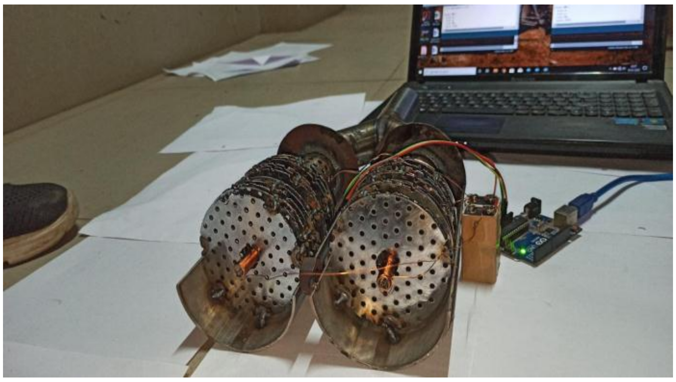

Figure-3: Substrate and temperature unite

3.4 Selection of Secondary Chemicals:

Soda lime & Zeolite have been used as the secondary chemicals to enhance the overall efficiency of the Coil-ON. Soda-sorb a derivative of soda lime has been used in anesthesia machines to absorb the evolved CO2. This grade of soda lime has been used to absorb the excess CO2 coming out as one of the by-products. Zeolites find their applications in boiler treatment and hence due to their desirable properties have been used to adsorb HCs as they have very fine pores in the range of 10A diameter.

3.5 Functioning of the entire system:

The exhaust gases enter the Catalytic converter through the inlet and then spilt into the two chambers. Each chamber has a similar construction. There is a LM35 sensor just at the inlet of each chamber that constantly notes the temperature of the exhaust gas. A diffuser is used to reduce the velocity of exhaust gas to maximize reactivity and pass on to the zeolite chamber. The zeolite chamber adsorbs HCs and heats up the surrounding atmosphere.

Initially the temperature of exhaust gases is less than 80oC hence the circuit is programmed in such a way that the heating coil is turned on. These cold exhaust gases then pass through the metallic substrate and react with the catalyst to form NO x & CO2. The second LM35 sensor then measures the temperature of the substrate and cuts-off the heating once activation temperature is attained. The final chamber contains soda lime that absorbs the excess CO2.

4. RESULT

To validate or to test the product the emission test is carried out by using the gas analyzer setup. Several tests are carried out by using this setup some of the final results are as follows.

The table 2 show s the results of the before and the after use of the catalytic converter.

Table -2: Reading comparison of gas analyzer.

Test	Before Catalytic converter			After Catalytic converter		
	CO (%Vol)	HC (PPM)	CO2 (%Vol)	CO (%Vol)	HC (PPM)	CO2 (%Vol)
Idle	1.875	178	2.03	0.625	112	0.87
Max RPM	2.578	214	2.18	1.326	138	1.06

5. CONCLUSION

Thus the Electronically Aided Catalytic-Converter is a cost-effective, compact & robust prototype that can be used in middle weight category vehicles to reduce emissions. Also this type of prototype is able to minimize the cold start emission. And the successfully used cost effective secondary chemicals.to minimize the overall cost of the catalytic converter and improves the overall efficiency of the catalytic converter.

6. REFERENCES

[1] G. C. Kisku, "Nature and type of pollution from automobiles and strategies for its control", Industrial Toxicology Research Centre, En-vironmental Monitoring Division, Lucknow, pp. 1-16.
[2] R.M. Heck, R.J. Farrauto, Appl. Catal. A 221 (2001) 443.

[3] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

[4] R. Nicole, "Title of paper with only first word capitalized," J. Name Stand. Abbrev., in press.

[5] K. Elissa, "Title of paper if known," unpublished.