THE OPTIMIZATION ANALYSIS OF EMISSION, REDUCTION, VALIDATION OF CATALYTIC CONVERTER USED IN CFD

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ABSTRACT:

In this article, the development of a catalytic converter for back pressure minimizing and effective reduction in emissions is presented. Dissimilar models of the catalytic converter are being examined based on several factors like cell shapes and sizes, the configuration of CPSI and inlet cone angle. Also, effect of various types of catalysts regarding reducing emission of HC and CO is examined. Findings are presented after carrying out CFD or Computational Fluid Dynamics on the forecasted catalytic converter. Three dissimilar kinds of catalyst coatings are tested to selecting the optimum one, which includes Nickel coated monolith substrate, Copper and TiO2 coated wire mesh. The analyzer of Gas is used to measure emissions. Results suggest that the corrugated cell shape offers larger area of surface when exposed to the emission gases. Also, it is seen that converter size has a significant impact on the performance of the converter. Finally, Nickel coated structure of monolith offers 50% HC decrease and 60% CO decrease through minimum dropping of pressure and extreme turbulence.

Keywords: catalytic converter, backpressure, optimization, CFD.

I. INTRODUCTION

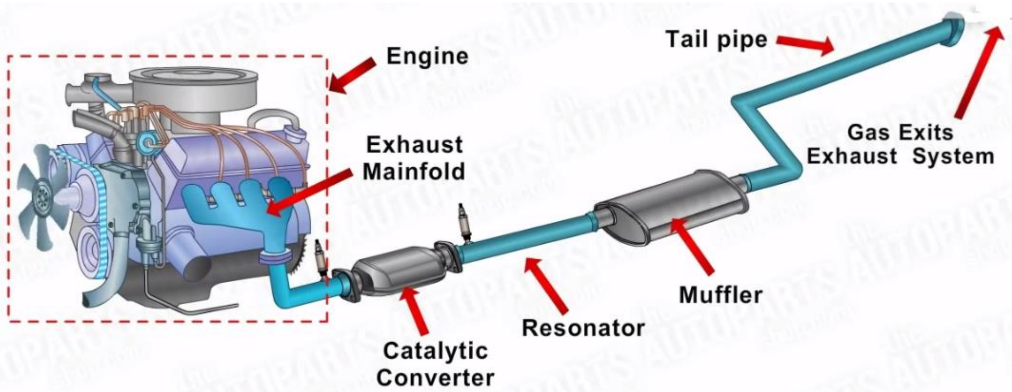

Fig.1 Position of Catalytic Converter

Automobiles throughout the world are the primary consumers of fossil fuels, which release toxic gases when burnt; among them HC, CO, and NOx. Catalytic converters have been designed to purify these gases into less hazardous gases like Co2and H2O. OEM catalytic converters are constructed for utility vehicles and to use noble elements like Pt or Platinum, Pd or Palladium and Rh or Rhodium. In 2003 Joachim Braun[10] at the University of Heidelberg performed research in the catalytic converter. He examined the distribution of temperature along with the help of analysis of CFD immediately after the launch of an engine and after approximately 41seconds. Uniform distribution of temperature has been observed. He observed that time lag was required to activate the catalyst. Rolf Bruck [11] felt that solution for Euro 5 norms and beyond would be to use turbulent flow catalyst. Emitec has introduced two new channel structures that create turbulent like flow condition thus increasing catalytic efficiency. One of the aims of this study is to develop a catalytic converter with available elements other than noble elements, which cost much higher. The catalytic converter has been specifically designed for a Briggs and Stratton 305 CC engine used to power an ATV or All-Terrain Vehicle. The foremost purpose of this study was to observe pressure drop for different converter designs with respect to geometry and structure of the substrate.

II. LITERATURE REVIEW

The use of the catalytic surface to improve chemical reaction is a well-established and common practice. Catalysts are extensively used for exhaust treatment of automobile engines [1, 2, 3]. However, its use in devices of combustion for an increasing rate of combustion is somewhat less common and limited to applications of airplane combustor [4, 5]. Karim and Kibrya [6] have done detailed experimental work to evaluate the catalytic activation of eight dissimilar metals and discovered that Pt and Cu showed superior performance. Ramesh Babu et al. [7] have examined the impact of dissimilar catalytic coatings on the exhaust emissions of a four-stroke engine. The results indicated that Cu as a catalyst was very effective through the significant reduction in emissions of HC and CO with lean combustion in a four-stroke SI engine. In the present study, non-noble metal catalysts such as copper, nickel, and chromium have been used as catalyst and they are coated inside the combustion chamber walls. A detailed experimental study has been carried out to evaluate the catalyst efficiency and its influence on combustion and exhaust emission at different speeds.

III. MODELING OF CONVERTER

The purpose of this study was to describe the impact of the geometry of the inlet cone of the catalytic converter on the dropping of pressure and distribution of heat-mass flow. Dissimilar cell shapes like square, triangular, hexagonal &corrugated [8] and cell sizes of 100 and 200 Cells per square inch (CPSI)[1,2]. CFD analysis enabled to detect the dropping of pressure in each of these shapes and sizes. The chamber of catalytic converter was designed while considering the engine specifications which are as follows:

Engine type Briggs & Stratton	**10 HP**
Swept Volume	**305cc**
Engine Speed (N)	**2800**
Bore Diameter (d)	**0.08178 m**
Stroke (L)	**0.05791**

Space Velocity = $Volume\ Flow\ Rate\ Catalyst\ Volume$ (1)

For Single Cylinder,

Space Velocity = 60,000 hr-1

Volume Flow Rate = Swept Volume × No. of intake strokes

IV. CFD ANALYSIS

The CFD analysis is able to forecast flow fields, even combined with heat transport, because of newly developed mathematical algorithms. The careful choice of physical parameters like inlet and boundary conditions is a pre-condition for reliable simulation results [3]. The CFD analysis was performed on various converter designs integrated with substrates of different CPSI. The considerations for this analysis were the inlet fluid velocity, inlet temperature, and outlet relative pressure. The procedure followed includes setting the boundary conditions i.e. diameters of inlet and outlet, applying the inlet velocity and temperature, providing time step and initializing the run.

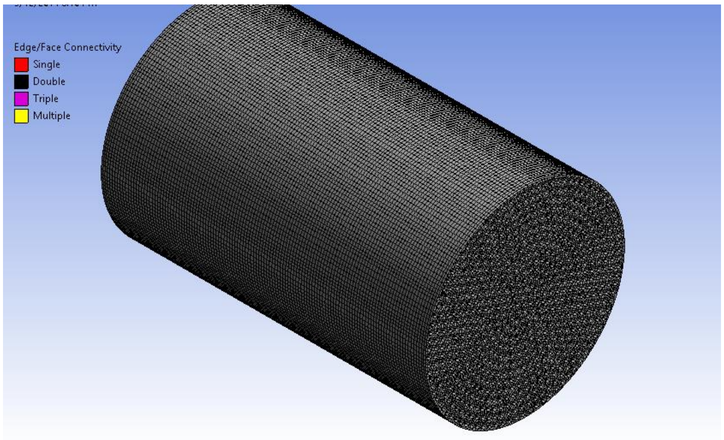

Figure 1 Modeling – CFD Catlytic converter

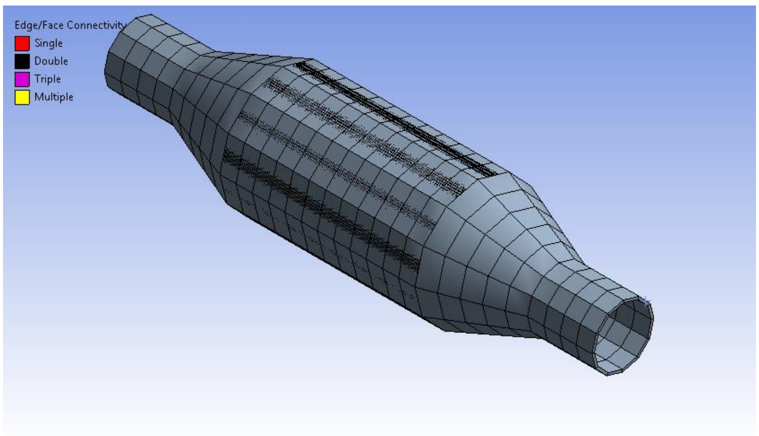

Figure 2 Boundary Conditions

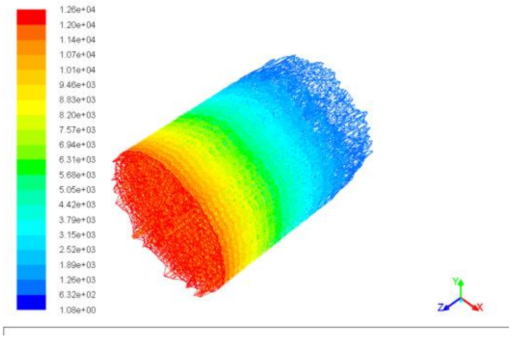

Figure 3 Dynamic Pressure

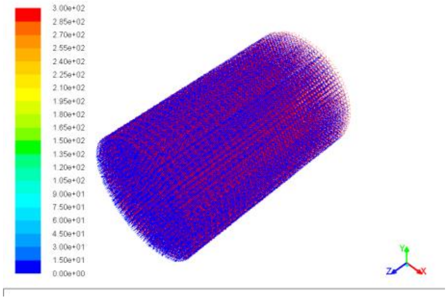

Figure 4 Wall temperature

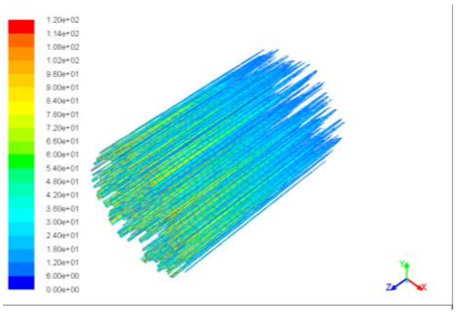

Figure 4 Velocity

Comparing the results of the analysis of CFD, the corrugated shaped substrate provided with 23% less drop of pressure and superior flow distribution. Also, corrugated shape reveals more area of surface for catalyst coating which reduces the light-off period and enables the catalyst at a faster rate, resulting in fewer emissions and stable catalysis [9].

V. CONCLUSION

In cold flow simulation, 100 CPSI with thin walls, showed the lowest drop of pressure. Also, the designed geometry had the lowest eddies occurring in the converter. When compared with Copper and TiO_2, Nickel, which diminishes 51.85 ±5.27 % of HC and 59.17 ±3.49 % of CO, was discovered to be the most suitable catalyst. The angle of the Inlet cone of 15° leads to a drop of pressure of 4 Pa.

VI. FUTURE SCOPE

A structure of double corrugated is forecasted for the monolith. Every single arm of the corrugation will be corrugated, which will result in a tri-corrugated cell. The effective area of the surface will rise through constant CPSI.

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