

Design And Analysis Of Catalytic Converter Model With Shape Change For Overall Improvement In Fluid Flow

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Abstract: Catalytic Converter plays a important role in emission control from the vehicles reducing harmful pollutants to the atmosphere. However, the presence of catalytic converter in the exhaust system has an impact in the flow of exhaust gases from the internal combustion engines. The proposal is an improved design of the monolith present in the catalytic converter which caters to better flow rate of fluids than the conventional design. The conventional and improved models are created in CAD and analyzed in ANSYS with solver FLUENT. The flow results are provided with comparisons between conventional design and new improved design. The proposed new design with shape change provides improved fluid flow than the conventional model.

Keywords: Engine, Catalytic Converter, CAD, ANSYS, FLUENT.

1. INTRODUCTION

Internal combustion engines employed in vehicles obviously emits harmful exhaust gases after its combustion cycles and current major problem due to this is the resulting air pollution [8-10]. Many researches are going on in various dimensions to achieve a minimum air pollutants to the atmosphere from the internal combustion engines by improved fuel quality, vehicle aerodynamics, electronic fuel injection systems, better heat transfer in engines and its components, vehicle tyre tread design, usage of catalytic converter etc., The catalytic converter comes as a last stage of preventive method in emission control as it is employed in the exhaust system of an vehicle. Current vehicles are achieving a better fuel efficiency, high quality fuels and other improvements than the vehicles used in the last decade. However, the burning of fuels will definitely emit considerable amount of the exhaust gases and hence many researchers are into designing better catalytic converters, finding new materials which has high absorption and conversion rate of pollutants [1-3]. As a monolith is used in the catalytic converter, researchers intent to experiment with alternative material of monolith which is currently made with ceramic combined material. The introduction of catalytic converter had a major improvement in emission control of the vehicles and has become a mandatory component is major small passenger vehicles [4-7].

2. CATALYTIC CONVERTER

Catalytic converter is an exhaust release control unit that changes toxic emission from engines into low-toxic emission by catalyzing a redox reaction. For automotive converters, the core is typically a ceramic megalith that has a honeycomb configuration. Metallic foil megaliths made of FeCrAl are utilized in applications where mainly higher heat resistance is obligatory. The substrate is organized to yield a big surface area. A washcoat is a transporter for the catalytic resources and is utilized to scatter the supplies over a huge surface area. Aluminium oxide, silicon dioxide, titanium dioxide, or a mixture of silica and alumina can be used. Platinum is the utmost dynamic catalyst and is extensively used, but not appropriate for all uses since of undesirable added responses and higher cost. Rhodium and Palladium are two added precious metals utilized. Rhodium is utilized as a reduction catalyst, palladium is utilized as an oxidation catalyst, and platinum is utilized together for reduction and oxidation.

3. METHODOLOGY

The main objective is to improve the fluid flow through the catalytic converter there by increasing the overall efficiency of its working. Based on this concept we intend to propose a new shape for the monolith present commonly in a catalytic converter.

- Current Model with Conventional Monolith shape.
- Proposed Model with New Monolith shape - Aero Filter.
- Proposed Model with New Monolith shape - Updated Aero Filter

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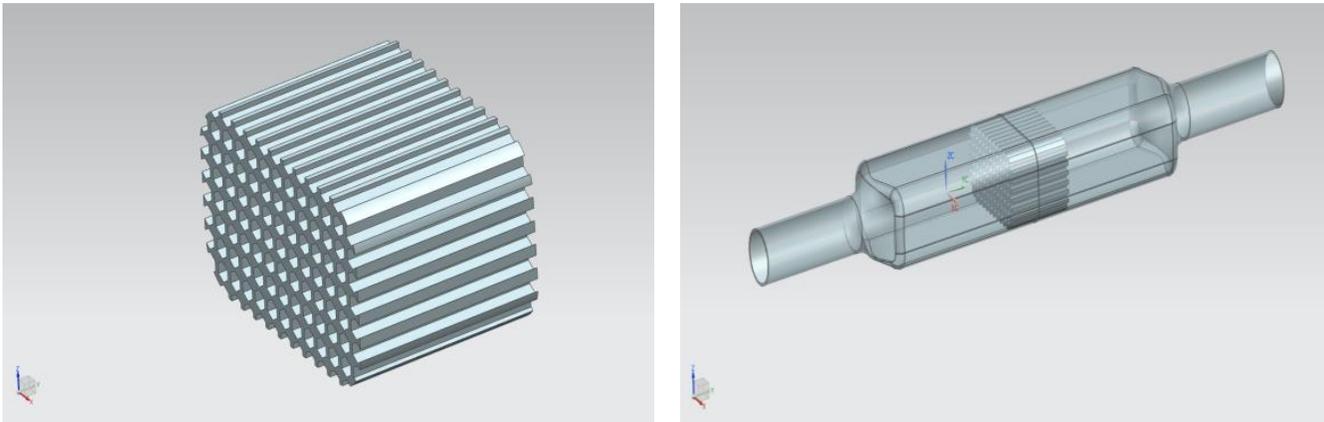


Fig 3.1 Current Model with Conventional Monolith Shape

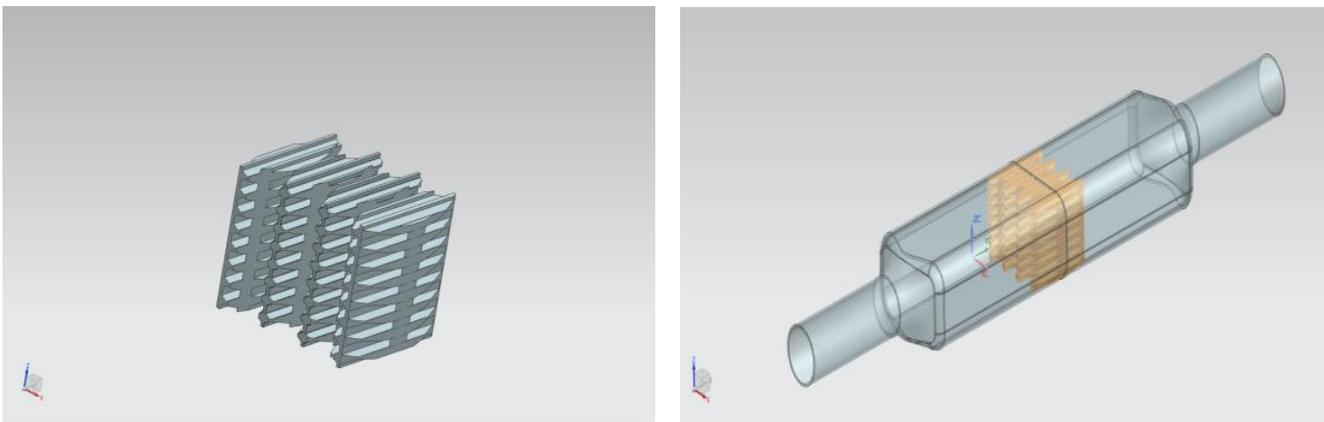


Fig 3.2 Proposed Model with New Monolith shape – Aero Filter

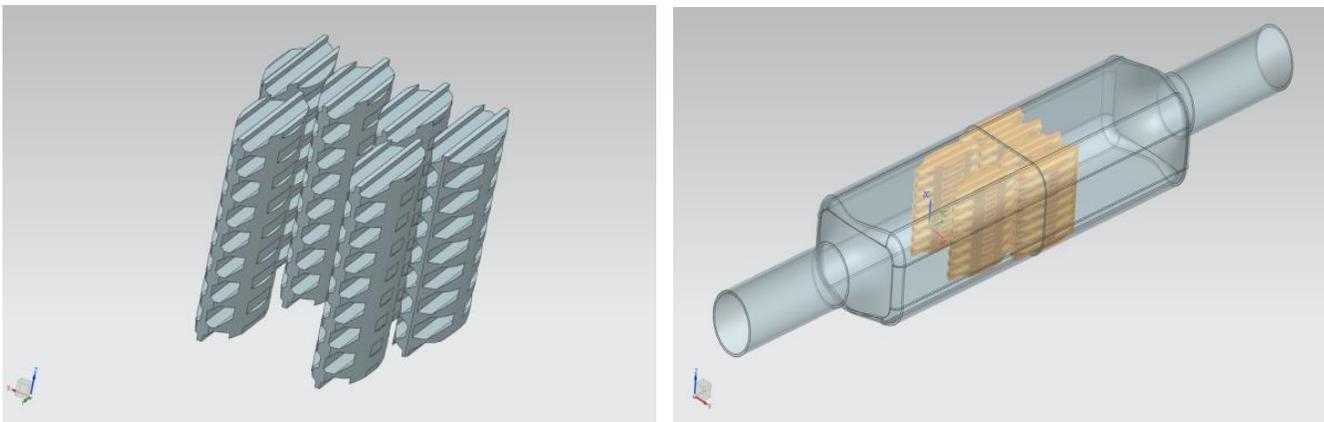


Fig 3.3 Proposed Model with New Monolith Shape – Updated Aero Filter

4. ANALYSIS

TABLE 1. FLOW CONDITIONS

OUTER CASE MATERIAL	ALUMINIUM 6061
MONOLITH MATERIAL	CALCIUM CARBIDE
INLET CONDITION	50 M/S

OUTLET CONDITION	No Back Pressure
OUTSIDE OPERATING TEMPERATURE	300K
FLUID CONSIDERATION	Carbon-di-Oxide (CO ₂)
CAD SOFTWARE	NXCAD
MESH & ANALYSIS	ANSYS
SOLVER	FLUENT

TABLE 2. MODEL

MESH DETAIL	Domain	Nodes	Elements
CURRENT MODEL	Cats	13434	40289
	Filter	6030	4048
	Fluid	6888	5368
	All Domains	26352	49705
AERO FILTER MODEL	Cats	13434	40289
	Filter	3924	12718
	Fluid	6888	5368
	All Domains	24246	58375
UPDATED AERO FILTER MODEL	Cats	13434	40289
	Filter	5115	16036
	Fluid	6888	5368
	All Domains	25437	61693

The models are designed and assembled in NXCAD. The assembled component is imported to ANSYS. Using the inbuilt meshing option the entire model is meshed with fluid consideration, inlet & outlet named sections. Using the FLUENT solver embedded in ANSYS the CFD analysis is performed with boundary conditions and inlet flow parameters. The velocity distribution, dynamic pressure distribution, turbulent intensity was measured for all the models.

5. RESULT AND DISCUSSION

The figures 5.1, 5.2, 5.3 are the velocity, dynamic pressure & turbulent contour representation generated after the CFD analysis using the solver FLUENT in ANSYS. Similarly figure 5.4 to figure 5.9 represents the contour results of respective models designed. The velocity contour of the new proposed shape has an uniform distribution when compared with the conventional model. The dynamic pressure contour of the conventional model has more pressure distribution after the inlet neck section and greatly reduced near the outlet section. However, the new shape's pressure contour has a smooth transition due to its design paving way a uniform pressure distribution. Similarly the turbulent intensity is more in the conventional model whereas in the proposed model the distribution is uniform

CURRENT MODEL

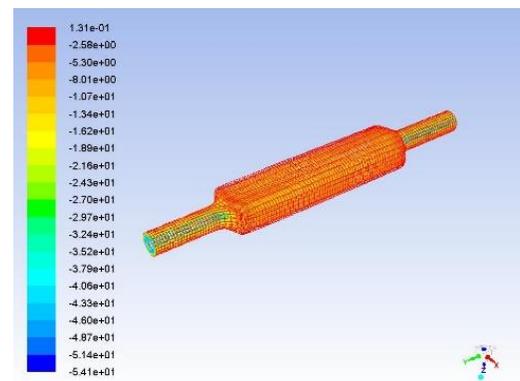


Fig 5.1 Velocity Contour

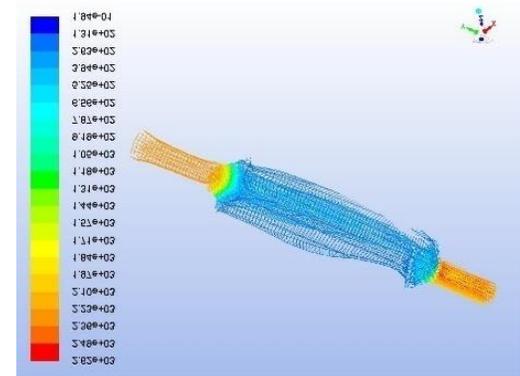


Fig 5.2 Dynamic Pressure

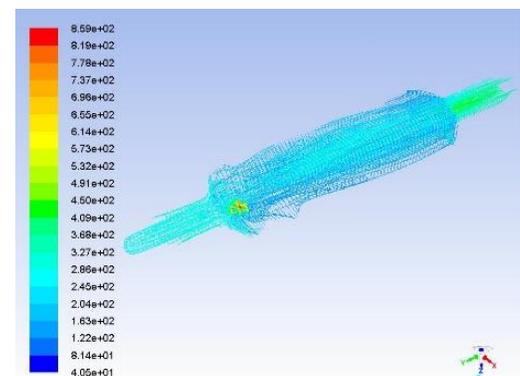


Fig 5.3 Turbulent Intensity

MODEL WITH NEW FILTER SHAPE

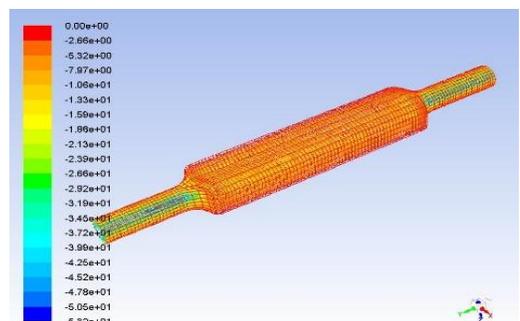


Fig 5.4 Velocity Contour

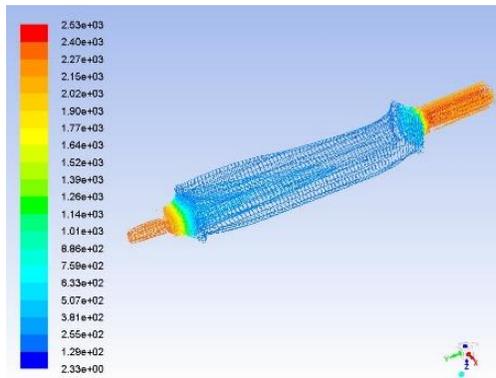


Fig 5.5 Dynamic Pressure

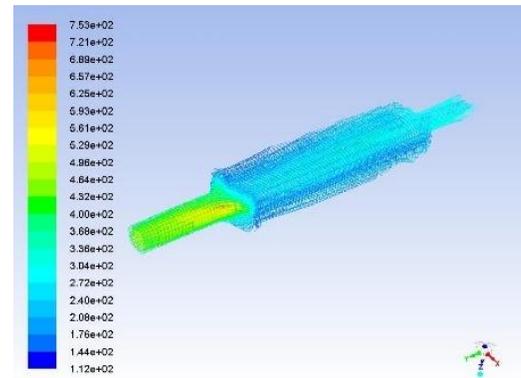


Fig 5.9 Turbulent Intensity Contour

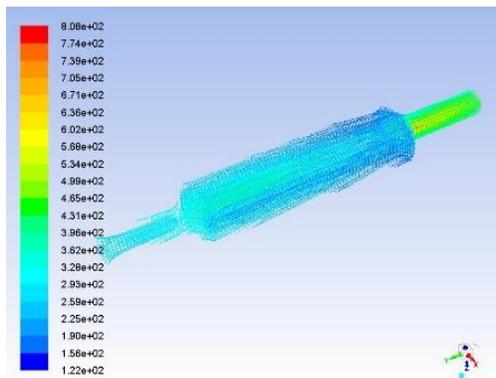


Fig 5.6 Turbulent Intensity Contour

MODEL WITH UPDATED NEW FILTER SHAPE

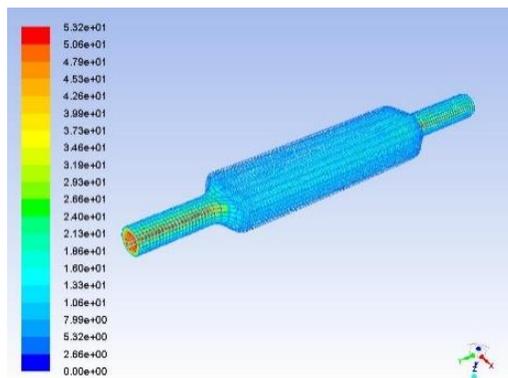


Fig 5.7 Velocity Contour

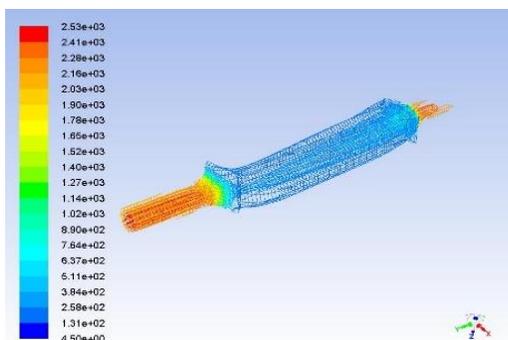


Fig 5.8 Dynamic Pressure

6. CONCLUSION

In analyzing the fluid flow in current conventional design and proposed design, the velocity, dynamic pressure, turbulent intensity contour gives better results for the proposed design. The distribution is uniform and has less turbulence when the fluid enters the catalytic converter. The back pressure is less and is more uniformly distributed with high dissipation rate than the current model. The proposed shape with some update gives more promising results than the current model as it is compared as well.

REFERENCES

- [1] Pontikakis, G.N., Konstantas, G.S. and Stamatelos, A.M., 2004. Three-way catalytic converter modeling as a modern engineering design tool. *Journal of engineering for gas turbines and power*, 126(4), pp.906-923
- [2] Lai, M.C., Kim, J.Y., Cheng, C.Y., Li, P., Chui, G. and Pakko, J.D., 1991. Three-dimensional simulations of automotive catalytic converter internal flow. *SAE transactions*, pp.241-250
- [3] Shamim, T., Shen, H., Sengupta, S., Son, S. and Adamczyk, A.A., 2002. A comprehensive model to predict three-way catalytic converter performance. *Journal of engineering for gas turbines and power*, 124(2), pp.421-428.
- [4] Kim, Y.D., Jeong, S.J. and Kim, W.S., 2009. Optimal design of axial noble metal distribution for improving dual monolithic catalytic converter performance. *Chemical engineering science*, 64(7), pp.1373-1383.
- [5] Braun, J., Hauber, T., Többen, H., Windmann, J., Zacke, P., Chatterjee, D., Correa, C., Deutschmann, O., Maier, L., Tischer, S. and Warnatz, J., 2002. Three-dimensional simulation of the transient behavior of a three-way catalytic converter (No. 2002-01-0065). *SAE Technical Paper*.
- [6] Tronci, S., Baratti, R. and Gavriilidis, A., 1999. Catalytic converter design for minimisation of cold-start emissions. *Chemical Engineering Communications*, 173(1), pp.53-77.
- [7] Lai, M.C., Kim, J.Y., Cheng, C.Y., Li, P., Chui, G. and Pakko, J.D., 1991. Three-dimensional simulations of automotive catalytic converter internal flow. *SAE transactions*, pp.241-250.

- [8] Karikalan, L., Chandrasekran, M., Ramasubramanian, S. and Baskar, S., 2017. Hybridization of composites using natural and synthetic fibers for automotive application. *International Journal of Scientific Research in Science and Technology*, 7, pp.916-920.
- [9] Ramasubramanian, S., Manavalan, S., Gnanavel, C. and Balakrishnan, G., 2017, March. Processing Of Neem And Jatropha Methyl Esters—Alternative Fuels From Vegetable Oil. In *IOP Conference Series: Materials Science and Engineering*(Vol. 183, No. 1, p. 012036). IOP Publishing.
- [10] Karikalan, L., Venugopal, S., Ramasubramanian, S. and Jacob, S., 2019. Experimental Analysis of Performance and Pollutants of CI Engine using Jatropha Biodiesel with Exhaust Gas Recirculation. *International Journal of Vehicle Structures & Systems (IJVSS)*, 11(2).