International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 6, June - 2014

A Computational Flow Analysis for Optimising the Inlet Diffuser Design in Automotive Catalytic Converter

S SRI Vaishnav
Department of Mechanical Engineering
University of Petroleum & Energy Studies
Dehradun, IND

V Vignesh
Department of Mechanical Engineering
University of Petroleum & Energy Studies
Dehradun, IND

***Abstract*--In trendy fuel vehicle, several automobile producing industries are mistreatment multilateral converter for reducing the emission pollution and thence reducing the fuel prices. Most generally used sort of device converters in business is barely multilateral chemical process converter. It's recently that business individuals and researchers are getting additional conscious of the advantage of mistreatment multilateral chemical process converters for scale back toxicity of engine emissions. Platinum and rhodium are the two channels with which chemical reaction of oxidation and reduction takes place which creates three – way catalytic converter. Fluid flow path of channel throughout cross sectional area is kept constant by not gap between the catalysts. The catalytic converter will distribute the uniform air flow by double cone tubes kept in the inlet diffuser of the catalyst. Between two catalyst domain the flow potency will decrease and constant because of porous concentration. Throughout the flow of air does not have the physical change then this pattern can be used.**

In this work, flow pattern and porous concentration in an exceedingly multilateral converter are analysed victimisation counter flow model pure mathematics. The results obtained for the effective uniform fluid flow over all the portion of the catalyst and porous concentration provides a concept concerning however we will optimize the flow path of the fluids so increasing the potency of the catalyst.

Keywords: Catalytic Converter, Inlet Diffuser Design Optimization, Pollutant, Conversion Efficiency, Flow Distribution.

I. INTRODUCTION

In Earlier days, it absolutely was notional that a pollution from the automotive automobile was disturbed the surroundings, that they know as it as 'emission'. Later it absolutely was found that, it's the IC engine exhaust combustion emission fluid that's flowing from piping. There's continually the flow of pollution that require to be reduces permanently condition.

Heat transfer happens in each medium. The all energies during which of the universe ought to be unbroken constant. The warmth transferred can continuously within the sort of contact. The two-way convertor performs oxidization tasks whereas triangular convertor to boot reduces chemical element oxides

Oxidations that are in the main concentrating the transformation of warmth is taken into account through species reaction and reaction concentration. Catalyst flow in fluid for abundant dimensional reaction transfer is given by somebody. Reactions during which two-way and trilateral convertor are represented as

$$2CO + O_2 \rightarrow 2CO_2 \quad (1)$$

$$2C_3H_6 + 9O_2 \rightarrow 6CO_2 + 6HO \quad (2)$$

$$2H_2 + O_2 \rightarrow 2H_2O \quad (3)$$

It was the very fact as – oxidization reaction is directly proportional to practical gradient of the flow direction. The operation constant and quotient is known as species concentration of the merchandise. Species concentration has no unit. This includes the first course of the positive species is heat transfer analysis from low flow temperature operate to a high flow temperature operate. Species concentration is taken into account as reaction property of materials that is generally obtained from experiments. Species concentration constant temperature remains for a selected price of substance.

In exhaust flow with axial direction that area unit insulated with the 2 faces of the elements and spending the species reaction solely in practical direction. This following figure shows one.1 in reduction happens here with Platinum and metallic element and oxidization happens here with Platinum and metallic element. And waste product enters at recess and within the outlet detoxified fumes area unit target-hunting to the pip age and out of the automobile.

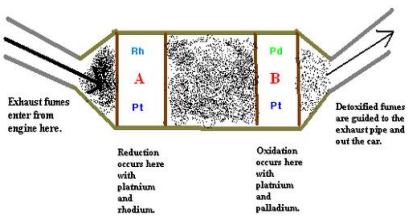


Fig. 1. Basic Catalytic converter

Based on form and porous channel of the fluid material, species concentration constant calculates the constant reaction. On assumptive 2 fluid streams of the catalyst between that the reaction happens essentially calculated the mean temperature difference: contour flow, vector flow, temperature flow area unit the common form of flow pattern and 2 fluid streams of flow pattern area unit absolutely depends on mean temperature distinction. A species concentration constant of fluids dimensions of solids and thermal physical phenomenon calculates the reaction constant. for each system overall species concentration varies supported fouling factors of the fluids, kinds of the fabric and form of the fabric that lies between 2 fluid streams.

The second sort in catalyst reaction concentration fluids principally happens in oxidization mode. Catalysts area unit the mix of noble metal and metallic element, the reaction during which the porous channel happens by the fluid property that the molecules area unit moving in conjunction with the fluid. the foremost vital style of temperature distinction that comes with the warmth transfer. The engines can manufacture the warmth from the combustion.

A. Three-way catalytic converter (TWCC)

It isshortly referred to as current Advanced catalytic converter contains two porous channels bonded honey comb shape for the first production of flow channel (oxidation/reduction) and secondary (oxidation/reduction) property of fluids used for catalytic converter. The separated fluid channels that can be manipulate metallic surface and effective coefficient of temperature that can be in the fluid channel of the domain.

The fine metal surface for honey comb that are equally spaced and distances using spacer on both sides to the sheets for uniform cross sectional area channel fluid flow. They had been gathered together and executed. The fabrication itself was honey comb type catalytic converter turned towards the one marked for the effective form of fluid function.

Three-way catalytic converter (TWCC) that has more advantages while compare with the common ordinary type – simple domain catalytic converter.

Main advantages in honey comb shape catalyst as follows:

- Honey comb catalyst is compact in size.
- Less maintenance costs.
- Three-way catalytic converters are easy to clean compare with the ordinary type of catalyst.
- Three-way catalytic converters are more effective and taken for catalyst. The flow pattern in the catalysts are having double porous channel thus reducing the pollution.
- Effective flow functions that exerts formation of pattern on fluids that helps decreasing emission level.

Disadvantages of catalytic converter are:

- The catalytic converters are more expensive.
- Operating pressure and operating temperature are more
- Methods of fabrication for three-way catalytic converter are not standardized as ordinary type catalyst.

This formula is the base for formation of catalytic converter. The following is a typical equation that is used for different types of experimental values.

$K1 = 6.802 \times 10^{16} \exp(-13{,}108/T)$ $(cm^4 / mol.s)$ (4)

$K2 = 1.416 \times 10^{18} \exp(-15{,}109/T)$ $(cm^4 / mol.s)$ (5)

K3 = k1 since H2 oxidation inhibited by CO (6)

Where,

K1, K2, K3 = Constant
T = temperature
Cm = Centimetre

These are the main type of flow patterns are used in three-way catalytic converter. Fluid channels are shown in picture. The optimised form of catalytic converter has a direction of flow by which it should be in order to maintain the separation of fluid channel for the metal sheet.

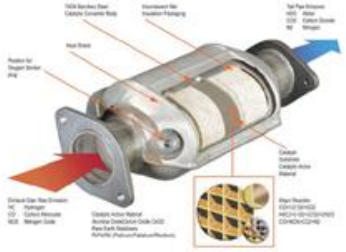


Fig. 2.Three-way catalytic converter

The major type of fluids flow in species reaction from the catalyst body to the species fluid flows was the main production turning towards the catalytic converter.

In this catalytic converter it was late into the first hour of the fourth time step. It had been decided that the catalyst would set up the base of domain. Catalytic converter properties take direction formation of straight. The most important type of reaction concentration is chosen for good pollution control.

In this species reaction takes place and flow that can be simulated in the fluid domain of the constrain direction of catalyst. This flow channel describes sub emission control of the effective environment. Data type of three-way catalytic converter is complex for calculation of catalyst length and porous channel for good phase change material.

Engine emission – Reduce toxicity
Honeycomb design catalytic converter – Two-way & Three-way

B. Purpose of the thesis

Flow pattern in the Catalytic diffuser region for the present study is in which porous medium in the catalyst first flow pattern region.

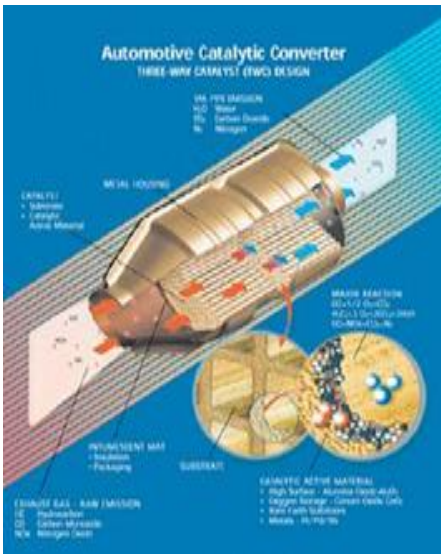


Fig. 3.Flow Pattern in normal catalytic converter

This project main objective is to distribute the flow of fluid equally inside the catalytic converter and execute an effective fluid flow in maximum regions of the porous medium domain. Calculations are done for both Platinum and Rhodium porous medium region. The flow conditions that are evaluated for log temperature mean. The final results consider are then analysed and simulations of the catalytic converter are mainly for the design optimization parameters.

Table IGas species properties

Gas Species	Range	Resolution	Accuracy
HC	0-20,000 ppm	1 ppm	6 ppm or 5% of reading
CO	0-10%	0.01%	0.06 ppm or 5% of reading
CO2	0-20%	0.1%	0.5 ppm or 5% of reading
O2	0-25%	0.01%	0.01 ppm or 5% of reading
NOx	0-4000 ppm	1 ppm	32 ppm between 0-1000 ppm 60 ppm between 1001 and 2000 ppm 120 ppm between 2001 and 4000 ppm

Fig. 4.Flow Pattern in modified Catalytic converter

C. *Hypothesis*

This catalytic converter provides the optimum conditions to obtain methodology which the operation increasing the industries life. The automotive catalytic converter future work provides the detailed study analysis on contour flow coordinate that improves arrangement on it. The analysed property of methodology provides flow types in two different coordinate functions for including the unsteady analysis. The automobile industry most widely uses the computer aided engineering for fluid dynamics and thermal engineering.

II. LITERATURE REVIEW

A. *History*

Catalytic converter is a crucial invention employed in most of the auto industries and different applications during which reaction combustion from one medium transfers to a different medium. A converter is often porous concentration and relies upon the number of warmth to be transferred from the fluid domain. From hand-held electronic devices to reaction field applications catalyst plays a crucial role within the individual application.

Cowley A. Platinum [8] Three-way converter in industries has developed lots. With the increasing relevancy of converter in field of high viscous fluids, fouling of metal sheets was inflicting several issues operating and maintenance of warmth reaction exchanging instrumentation. Then converter was unreal within the early 1930's in FRG to resolve this drawback of fouling, that reduces and controls the pollution. Converter became the most effective replacement for cone and tube kind Catalyst, wherever reaction fluids were concerned.

B. *Previous Work*

From past several decades, work administered on style of converter, analysis of catalyst, some patents on model modification gave the inspiration to figure on the present topic of alternative.

M. C. Lai, T. Lee, J. Y. Kim [2] Catalytic converter was getting used within the early eighteenth century. It's within the nineteenth century, that the car industrial applications and importance of catalyst were recognized. Converter helped in ill heat in several fields and this recovery helped them in reducing vast investments on heat generation mistreatment fuels.

H. Weltens, H. Bressler, F. Terres [3] Several advancements in convertor were seen throughout 1940's to 1990's. The different modifications inside the diffuser shapes and diffuser positioning were developed to satisfy the wants of the numerous industries

Three-way converter served the aim of compactness besides providing giant temperature space. These converter have higher pressure drop compared to round shape sort catalyst.

Fig. 5. A schematic view of catalyst

C. *Three - way catalytic converter*

D. W. Wendland, W. R. Matthes 1986 [1]performed analytically studies on distribution of temperature in porous sort catalyst. They developed formulae for power Mean Temperature distinction and potency for style calculations of the converter. Calculations were created for power Mean Temperature distinction correction factors. These were premeditated against associate degree expression fashioned mistreatment variety the amount the quantity of transfer units and number of turns for the porous channel catalyst, used for the numerical calculations. From these calculations correction issue was modelled to estimate thepotency of the converter.

W. Taylor III 1993 [4] found a shortcut approach for style of tripartite convertor. The thought behind their study is to provide fewer inputs like external catalyst diameter and plate thickness as initial values and to search out the quantity of turns supported the specified pressure drop for the fluid flow channel. It shows the scale for a tripartite convertor range of turns or the inner diameter was modified consequently to induce the planning parameters. This method takes the approach of repetitious procedure to converge at the specified resolution to match the warmth duty and pressuredrop across the catalyst style.

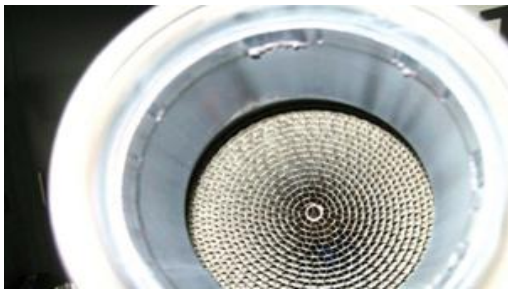


Fig. 6.Spiral Plate species porous medium

III. MODELLING WITH POROUS CONCENTRATION OF THREE-WAY CATALYTIC CONVERTER

A. Mathematical Modelling

The design approach determines the three-way catalytic converter for several flow variables like pressure drops, velocity magnitude which are equivalent diameters of both porous domain and exhaust gas fluids that calculates with Reynolds number equation in the catalyst process.

Following design approach for TWCC are shown:

a) The area in which the oxidation and reduction can be select in the first step of the catalyst. The different application that needed to be select. In the research type pattern, the industries that will use fluid as flow properties in the functions of catalytic converter.

b) The mass flow rates in the inlet area need to be noted in the fluid properties. This can be utilising for energy calculations and mass conservation. The amount of transferred energy depends on the fluid flow velocity channel and estimates the mass flow rate value.

c) In the inlet and outlet exhaust gas fluids, calculation of volume fraction need to be done for the mean displacement for the system using in the catalyst functions in cell zone boundary conditions.

Volume Fraction in m^3/s = (Displacement in $cm^3/100000$)x(Rpm max/60/4) (7)

d) In the previous literature review, overall catalyst coefficient area that needs to be calculated initially.

e) The coefficient of different values that need to be assumed as three-way catalytic converter is calculated.

f) For three-way catalytic converter, the area in which it is modified as effective flow rate in the form of manufacturing. The calculated equation that need to be simulated for the porous medium

$$A = 2xLxH \quad (8)$$

Where,
A = Area inm^2
L = catalyst length in m

This method of fabricating the porous domain is fixed with the manufacturing industries. According to the calculation sheet

$$L = A/(2xH) \quad (9)$$

g) The below formula shows the calculation of mass flow rate from the density and inlet area of the catalyst.

Mass flow rate in kg/s = (Gas density in kg/m^3) x (Inlet area in m^2) x (Velocity in m/s) (10)

h) Calculation of velocity and gas density is applied for mass flow rate calculation and following equations are given below.

Velocity in m/s = (Volume flow rate m^3/s)x(Inlet area in m^2) (11)

Gas Density in kg/m^2 = (353 Exhaust gas temperature^0c) (12)

Space Velocity = 80.64 x Mass flow rate/(0.028966xtotal volume in m^2) (13)

i) Reynolds number calculation is needed for all flow simulation problems for inertial and also viscous force equations.

$$Re = 2m/H \quad (14)$$

Where,

m = Mass flow rate of fluid in kg/s

j) The velocity in the Reynolds number calculation gives the fluid flow idea that should be critical path in the following turbulent flow problems. Thus the nature of the Reynolds number is more critical than the normal calculation for three-way catalytic converter is done.

k) Now three-way catalytic converter flow property deals with the proper Reynolds number which the grid size are calculated using the method

Laminar flow: $Re < R_e$
Turbulent flow: $Re > Re_c$

l) Calculation of porous concentration by following equation

Velocity in m/s for 100% = Total flow rate m^2/s/Area m^2 (15)

Inertial resistance coefficient (□L) = Pressure drop/ (0.5x1.225x100%) (16)

Inertial resistance factor (C2) = □L thickness (17)

m) The another important role plays here is pressure drop equation in which the catalytic converter needs to check the static pressure value in the following equation.

$$Re < 100 \quad (18)$$

Where,

P = Pressure drop in Pa

The above geometry modelling steps deal with the following equation as solved in the form of porous concentration. The theoretical calculations in which the standard design calculated using Reynolds number for fluid flow properties. In the present project, the work done with above parameters and equations are calculated using space velocity and mass flow rate also static pressure.

B. Flow Setup for Simulation

Three-way catalytic converter CFD and methodology of simulation in different steps are shown in below flow chart. Pre-processing, Post-Processing and solver are the method of CFD process. The following steps are described in below flow chart.

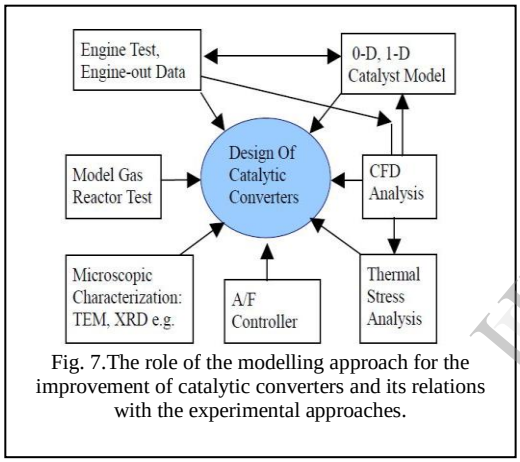


Fig. 7.The role of the modelling approach for the improvement of catalytic converters and its relations with the experimental approaches.

C. Geometry Modelling

Auto cad has been used in modelling the 3 way catalytic converter. Geometry creation plays a very critical role in this type of simulations. Changes of small magnitude in the geometry may have a lot of impact on the results expected. The Current Work Geometry has been created using non-standard values of parameters. These results with CFD analysis on a TWCC involves the future comparison of created using standard parameters. Following steps describe briefly the manner in which complex Three-way catalytic converter geometry modelled using Auto cad.

- The catalytic converter is created in the initial stages. This stage is where the dimensions of the three-way catalytic converter such as thickness of the two porous channels, inner diameter of the catalyst, length of the porous channel are decided upon. Hence these steps need to be performed in a proper manner. Catalysts were created using the species creation. The porous domain thickness of the channels must also include the thickness of the phase metal sheet.
- The open catalyst created has been done we extrude profile shape using key option. This is the option where we define the porous type catalytic width and height of converter. The extrusion is carried out in both the directions with full of the required of catalytic converter.
- While fabricating the catalytic converter extrude the profile we also follow thickness of the sheet metal. Metal thickness consider for the present study is 3 mm with the constraints.
- Note the following parameters for TWCC.
- The metal sheet in the present need to be closed. This is done using following option by projecting the closing profile. The porous channel needs to be defining in the functions of all the parametric value.

The catalytic converter need to be closed in the sides of the catalyst profile. These are carried out by projecting the inner and outer edges and extrude the profile for a dimension equal to the thickness of the catalyst.

- One inlet and one output of three-way catalytic converter body require providing the opening.

The parameters of the catalytic converter: cone radius 20mm is done by creating the catalyst.

Fig. 8.Geometry model of catalytic converter

The catalytic converter geometry is formatted as IGES file. The Boundary conditions and continuum conditions for mesh setting software.

- In Three-way catalytic converter, following zones are created.

Table II. Zone properties For TWCC

Volume	Continuum Type
Catalyst – 1 (Platinum)	Fluid
Catalyst – 2 (Rhodium)	Fluid
Wall	Wall

- The automatic creation of continuum flow type's reaction concentration interfaces. This property of flowing fluid between the proper zones which contact with each other in the catalytic converter.
- Exhaust air which comes from IC engine is taken as inlet condition of the body catalyst to reduce pollution.
- Inlet and outlet of the exhaust air in the core side for pollution reduction. The catalyst inner body will reduce the flow for better catalyst in the reduction process. Boundaries will be maintaining the simulation system.
- Completion of geometry design and model.

D. Meshing

- Import the geometry into GAMBIT for grid generation.
- Catalyst zones are named as fluid and rest other area is named as wall shown in below figure.
- The boundaries of the catalytic converter is as inlet _velocity, Cat-1_Porous, Cat-2_Porous is as fluid and outlet pressure respectively with the properties that combine with the wall

Fig. 9.Geometry into Gambit

- The grid and mesh size given in interval size as 0.02m and the base reference value for separation of mesh zone continuum.
- Structured mesh interval size ratio 0.02m that will be the consideration of maximum cell layers.
- The following number of cells in the catalytic geometry model.
- The properties of simulation that which the internal form of flow separation will be advised as to perform the mesh analysis function is independent. The work in the mesh is structured with examine the quality.

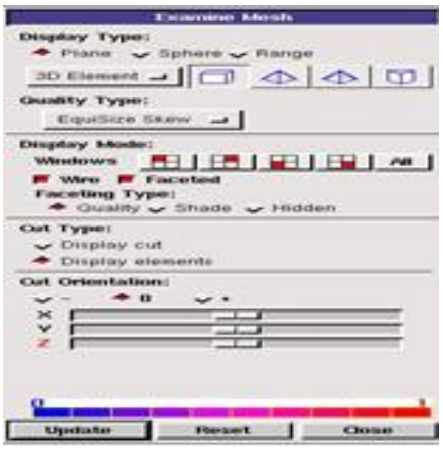


Fig. 10.Examine Mesh Accuracy

- The mesh mode windows setting up the formalities in the above meshing parameters. The continua change in mesh will be remains same.

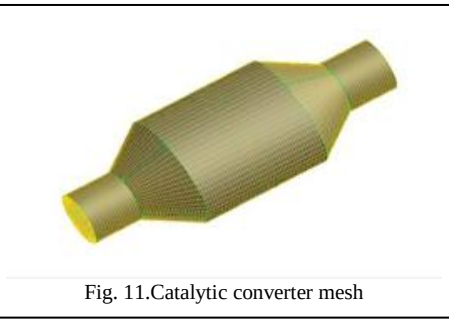


Fig. 11.Catalytic converter mesh

- Compute mesh generation

Initialize Meshing
→ Generate Surface Mesh
→ Generate Volume Mesh

- Mesh generation shown in figure.
- The mesh system analyse for structured type of cross sectional refined scene can be further analyse.
- Fluid zone created for mesh is as perfect quality of analysis.
- The temperature variation profile which will be in fluid channel for analyse more number of

cell thickness layer in the structured mesh elements that is added to the flow profile and contains 2 million.

The huge mesh size file will take more computational time for simulation process and gives accurate result in the present study. Hence analyse the reaction changes in the porous region for catalyst domain.

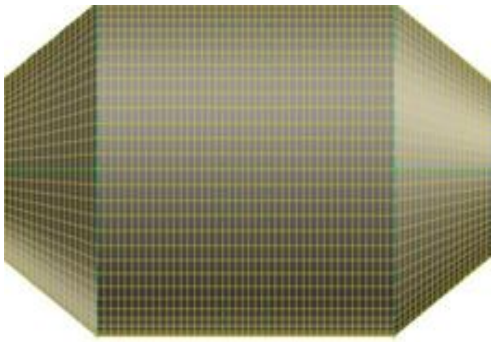


Fig. 12.Mesh section of TWCC

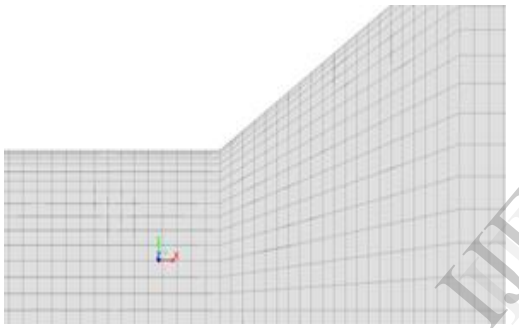


Fig. 13.Mesh side view of TWCC

Isometric view is shown in the below

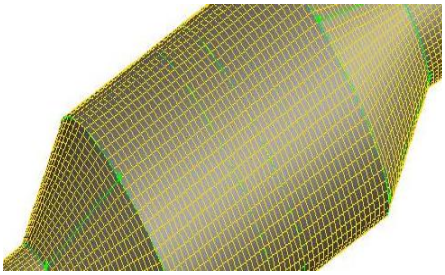


Fig. 14. Isometric view regions of TWCC

- The three-way catalytic converter is ready.
- The conditions to solve simulation process for flow channel model setting up the geometry.
- Initial condition, boundary condition continuum conditions includes the step function for geometry

E. Physical property Setup

- We have to select the physical properties setting up different region setup for fluid wall.
- All fluid properties can be select by creating the continuum region.
- The different region properties can be done in the geometry formation of structured mesh.
- Now physics will generate flow boundary medium for the properties of original theme of mesh generation

All specify continuum type medium seen below

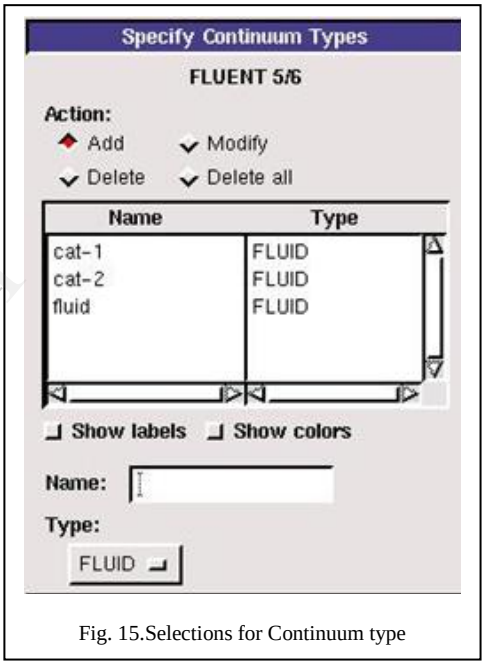


Fig. 15.Selections for Continuum type

Fluid Continuum medium:

- Metallic is chosen for platinum and rhodium.
- Continuum zone enables the catalytic properties.
- Properties of boundary layer domain can be set by flow parameter condition for fluid medium.
- The continuum fluid medium can be included the interfaces region.
- Cell zone properties for Fluid Zone are as shown in above figure.
- Fluid: Air
  - Now the inlet condition was velocity and outlet was pressure chosen as

reference value.
- Inlet temperature for the fluid properties carried out as 400kas a physical continuum.

- Fluid porosity: Catalyst.
  - The fluid region in the continuous velocity condition that are to be taken as reference frame.

Inlet temperature is taken from the exhaust air temperature of IC engines that are calculated and described.

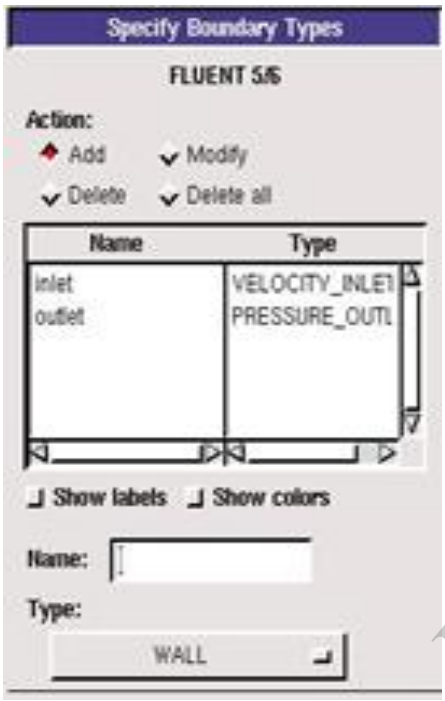


Fig. 16.Specify boundary for Fluid Zones

Boundary conditions are done for simulations.

Boundary conditions: fluids and wall

$$Regions \rightarrow Continuum \rightarrow Boundaries$$

Table. III Steady state Boundary conditions

Boundary name	Specify Type	Value	Units
Inlet cond	Velocity magnitude	13.65	m/s
Outlet cond	Pressure Outlet	0.0 (relative)	Pa
Cat – 1 (Porous)	Fluid	0.267	
Cat – 2 (Porous)	Fluid	0.267	

Solving the flow equation in the boundary layer theory enables the flow equations over the domain.

Condition: Initial

The three-way catalytic converter initial conditions are fluid zones temperatures and average values in the system.

Table.IV Conditions for Fluid Streams

Condition name	Value	Units
Fluid Temperature	400	K

Initialise the solution for standard condition and set the residual value plot for running the simulation.

F. Analysis of Three-way catalytic converter

Three-way catalytic converter is designed with the constrain parameters and also with calculated dimensions from the equation modelled in previous chapter. All the design parameters that are fabricated in the following form of porous concentration catalyst domain can be done.

The present study in which the catalyst type porous region fluid flows with the various functions of turbulent problem and the cell zone conditions in the following flow in nature. The study of this project involves the velocity magnitude that is more effective in the form of nature using computer aided design.

Computational fluid dynamics simulation of any kind of flow problem, physics of the problem setup should be well known and well defined. In current study includes, Turbulence Model of energy transfer is done. The functions of software which allows performing calculations and other means of fluid dynamics based on the values and by using the boundary conditions of the catalyst.

The two-equation models in Turbulence flow problem can be simulated using different models like, four and seven equation models, LES and eddy detached simulation. Current project deals with the turbulence model. The model which is chosen for present study was K-epsilon model type in turbulent simulation of three-way catalytic converter.

k-epsilon turbulence model used in the current study based on Reynolds Averaged Navier Stokes. The velocity fluctuation in the time averaged function. This enables to discrete the model for

Model Name			**Skoda**		
Engine Specifications			***Catalytic Convertor Specifications***		
Engine Type	4 stroke	SI	Inlet Area	0.002560	m^2
Displacement	1598	cm^3	Velocity	13.655	m/s
RPM (Max)	5250	rpm	Substrate	Metallic	
Exhaust Gas Temperature	400	K	Total Volume	0.000549	m^3
Volume Flow Rate	0.034956	m^3/s			
Mass Flow Rate	0.030849	kg/s			

flow simulation. Reynolds transport theorem gives the better calculations of conservation, momentum and energy. k-epsilon equations are described in the below functions.
Coefficient constants are

Alpha = 5/9, Beta=3/40, gamma =9/100, σ = ½, σ^* = ½, $\varepsilon = \beta^* \omega k$ (19)

This k-epsilon model shows better result. The modifications of calculations were done and simulated the constant coefficients. Below it was shown:

Alpha = 13/25, Beta = 9/125, σ = ½, σ^* = ½, β_o^* = 9/100 (20)

The two-equation models in Turbulence flow problem can be simulated using different models like, four and seven equation models, LES and eddy detached simulation. Current project deals with the turbulence model. In this model second-order upwind is chosen. The velocity fluctuation in the time averaged function. This enables to discrete the model for flow simulation. Reynolds transport theorem gives the better calculations of conservation, momentum and energy. The reduction of truncation error was done by difference equation formula.

The temperature takes time to solve the variables and equation of state and it calculates the enthalpy equation.

The above equation is solved for catalytic converter and transferred to reaction concentration of fluid. Oxidation and reduction takes place in the reaction concentration to reduction pollution.

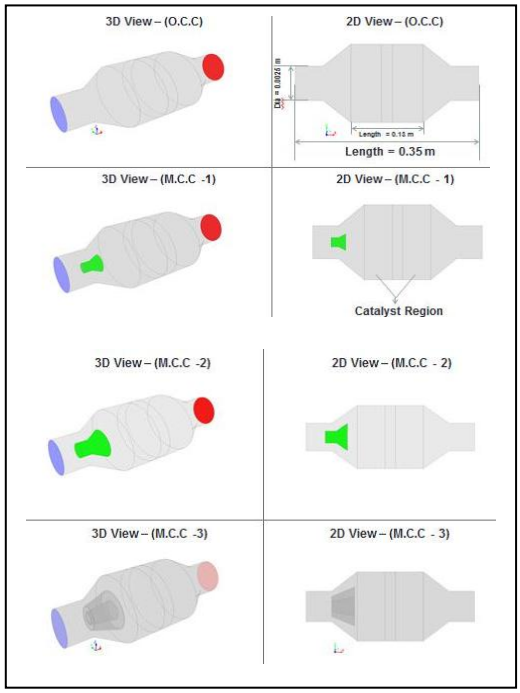
G. Engine Specification:

S. H. Shuai [7] These are engine specifications calculated using equation which discussed mathematical modelling chapter and taken for analysing and setup the boundary conditions for three – way catalytic converter.

Table. V Engine Specifications

IV. RESULTS AND DISCUSSION

- Fluent CFD software used for Simulation of Three-way catalytic converter for automotive car.
- The problem of catalytic converter simulation gets converged to X-axis parallel considered in residual plot.
- The simulation results are taken in the CFD post that creates the contours of velocity XY plot.
- This study consists of one ordinary catalytic converter and seven modified catalytic converter effective flow problem with porous concentration.
- Inlet velocity of engine exhaust air is 13.65 m/s. The velocity flow in the catalytic converter can be seen in the following contour plots.
- Velocity and pressure contour profile at the inlet of the catalytic converter.
- The list of below figures shows the velocity magnitude and static pressure contours of the catalytic converter.
- The contours plots in which plane distance along x = 0.1, y & z = 0 axis



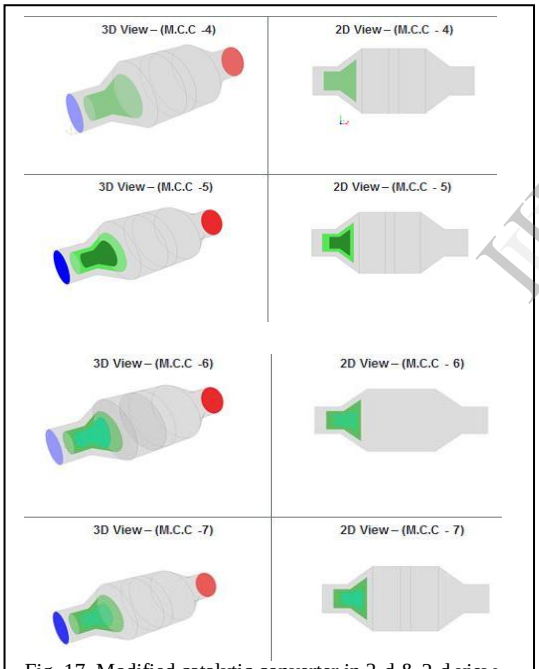


Fig. 17. Modified catalytic converter in 3-d & 2-d view

- Velocity contours or velocity scalars on plane created at X – axis is created for each 0.1m distance from inlet.

- The functions in which the catalytic converter realistic form of flow velocity estimation.

- The contour velocity magnitude profile shows the result in the flow plane that develops normally and straight to the outlet.

- The catalytic converter width is to be taken perpendicular for different planes of flow distance development.

- The porous region is to reduce the emission control the flow pattern of catalyst that has low velocity profile at the center.

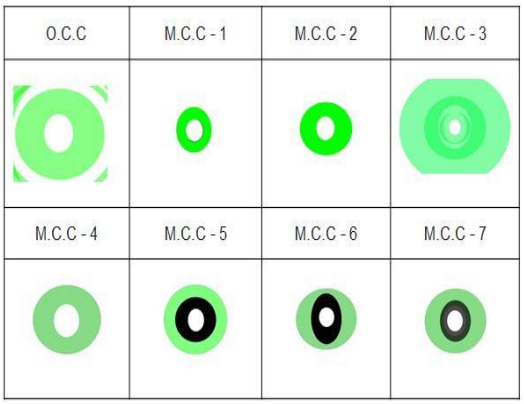


Fig. 18. Schematic of Diffuser Front view for all models

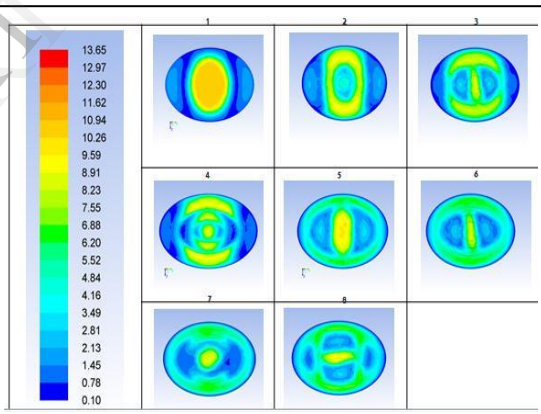


Fig. 19 Schematic of X-Coordinate Diffuser Front view for all models

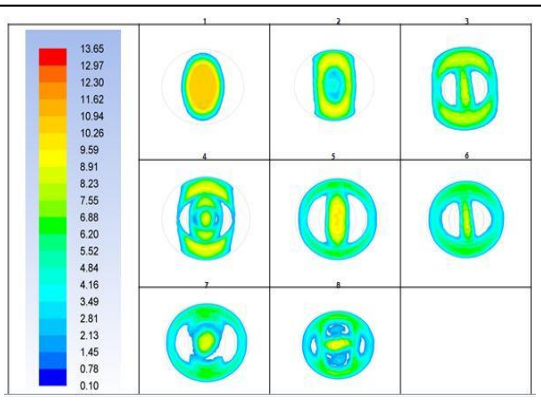


Fig. 20. Schematic of X-Coordinate Diffuser Front view for all models

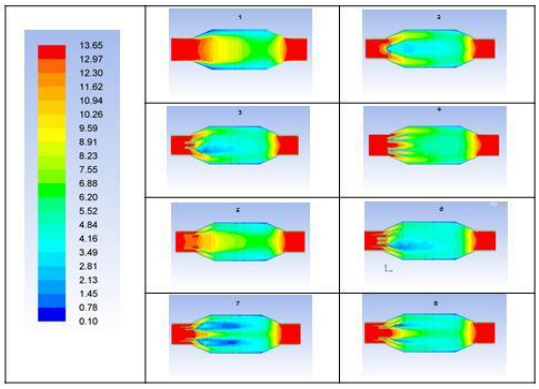


Fig. 21. Schematic of Catalytic Converter Y-Coordinate (Y=0)

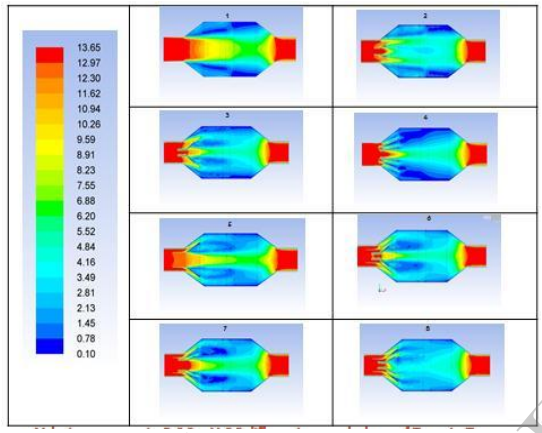


Fig. 22. Schematic of Catalytic Converter Z-Coordinate (Z=0)

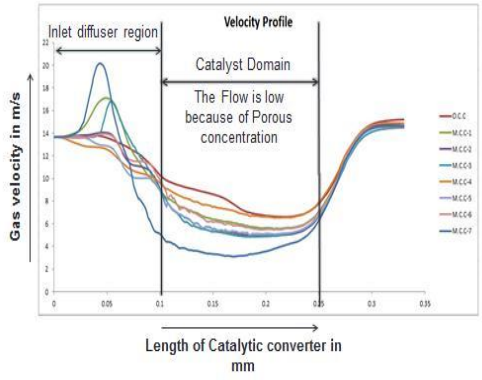


Fig. 23. The gas velocity profile at the inlet surface of catalyst for inlet gas velocity of 13.65 m/s

V. CONCLUSIONS AND RECOMMENDATIONS

In this work, three-way catalytic converter is analysed and simulated with species porous concentration consider with two catalyst separated by metallic sheet of platinum and rhodium. Early stage, the catalytic converter design optimisation to model with better diffuser splitter for effective flow with computer aided engineering. The design for future modelling part that understands and helps to improve design function. In the analyse part initially carried out for normal catalytic converter diffuser design .i.e. for fluid will flow straight parallel to the porous region and analyse how the effective compare with other catalyst surface. In Future work, modelling and simulation is done for muffler along with three-way catalytic converter. In present study, all new seven modified catalytic converter shows the better concentration of flow compare with initial case.

Models	Actual area	Covererd area	%
1	0.0106	0.0053	50
2	0.0106	0.0067	63.20755
3	0.0106	0.0074	69.81132
4	0.0106	0.0074	69.81132
5	0.0106	0.008	75.4717
6	0.0106	0.0084	79.24528
7	0.0106	0.0084	79.24528
8	0.0106	0.0088	83.01887

Fig. 24. Specially last two cases shows covers 85% of effective flow in the catalyst area and it is recommended for automobile industry.

Early 1905's, there was not much modification in the three-way catalytic converter design. Latter many research carried out for better life and emission control in the TWCC and decided to optimise the diffuser design which is evenly distribute to all catalytic passage. Work can also be done on splitter diffuser to increase the flow which is effective by cone shaped diffuser design. All the new design research analysis gives a variety of three-way catalytic converter.

Computer aided engineering with fluid dynamics gives the better structure of fluid flow interaction and the increase life-cycle of three-way catalytic converter. The automobile industries provides the time period for optimise the design and material availability for manufacturing the three-way catalytic converter.

REFERENCES

[1] D. W. Wendland, W. R. Matthes, "Visualization of Automotive Catalytic Converter Internal Flows", SAE Paper 861554, 1986.
[2] M. C. Lai, T. Lee, J. Y. Kim., "Numerical and Experimental Characterization of Automotive Catalytic Converter Internal Flow, J. Flu-ids Structure. 1992.
[3] H. Weltens, H. Bressler, F. Terres,, "Optimization of Catalytic Converter Gas Flow Distribution by CFD Prediction," SAE Paper 930780, 1993.
[4] W. Taylor III, "CFD Prediction and Experimental Validation of High-Temperature Thermal Behaviour in Catalytic Converters," SAE Paper 1999-01-0454, 1999.
[5] E. Karvounis, D. N. Assanis, "The Effect of Inlet Flow Distribution on Catalytic Conversion Efficiency", Int. J. Heat Mass Transfer, Vol. 36, No. 6, pp. 1495-1504, 1993.
[6] G. Bella, "A Study of Inlet Flow Distortion Effects on Automotive Catalytic Converters," J. of Engineering for Gas Turbines and Power, Vol. 113/419, 1991.
[7] S. H. Shuai., "Unsteady Temperature Field of Monoliths in Catalytic Converter," Chemical Engineering Journal 100, pp. 95-107, 2004.
[8] Cowley A. Platinum 1998. London (England): Johnson Matthey, 1998.