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Design Optimization of Catalytic Converter to Achieve Limited Back Pressure in Diesel Engine by using CFD

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***Abstract*:** Presently a days the a dangerous atmospheric devation and air contamination are huge issue on the planet. The 70% of air contamination is because of outflows from an inner burning motor. The unsafe gasses like , NOX CO, unburned HC and particulate matter builds the a worldwide temperature alteration, so exhaust system assumes an imperative part in diminishing destructive gasses, however the nearness of exhaust system expands the fumes back weight because of this the volumetric productivity will abatement and fuel utilization is higher. So examination of exhaust system is imperative.

The uncommon earth metals now utilized as impetus to lessen NOX are excessive and infrequently accessible. The lack and popularity of present impetus materials require the requirement for discovering the choices. Among all other particulate channel materials, weaved steel wire network material is chosen as channel materials in this paper. Through Computational Fluid Dynamics (CFD) examination, different models with various wire network lattice size blends were mimicked utilizing the suitable limit conditions. The correlation of back weight of various exhaust system models is made in this paper.

1. INTRODUCTION

Inward Combustion motors produce undesirable discharges amid the ignition procedure, which incorporate, NOX CO, unburned HC, smoke and so on. Aside from these undesirable gasses, it produces Particulate Matter (PM, for example, lead, sediment. Every one of these contaminations are destructive to environment and human wellbeing. They are the primary driver for nursery impact, corrosive downpour, an unnatural weather change and so on. The least complex and the best approach to diminish NOX and PM, is to go for the after treatment of fumes. Gadgets created for after treatment of fumes outflows incorporates warm converters or reactors, traps or channels for particulate matters and exhaust systems. The best after treatment for decreasing motor emanation is the exhaust system found on most cars and other cutting edge motors of medium or expansive size..

It has been seen by (Andreassi, et al, 2004) and examined that the part of channel cross-area shape on mass and warmth exchange forms. The improvement of exhaust system frameworks for car applications is, as it were, identified with stone monument impetus bolster materials and configuration. In this paper upgrades of converter channels liquid elements expecting to improve poison transformation in all the motor working conditions are concentrated on and (Rajadurai, et al, 2006) explored the impact of Knitted wire network substrates with various geometry and channels on the back weight of exhaust system. The essential prerequisites of fumes after treatment frameworks are low back weight, low framework weight, better emanation execution and lower cost. Mixes of these properties give better motor execution and higher framework esteem. Blends of these properties give better motor execution and higher framework esteem (Ekstrom and Andersson, et al, 2002) Investigated the weight drop conduct of exhaust system for various distinctive substrates, reasonable for elite IC-motors, with respect to cell thickness, divider thickness and covering. The estimations have been performed on an exploratory apparatus with room-wind stream and hot-wind current. The information has been utilized to build up an experimental model for weight drop in exhaust systems. (Narasimha Kumar, et al, 2011) Investigations have been done for decreasing toxins from a variable pressure proportion, copper-covered flash ignition motor fitted with exhaust system containing wipe iron impetus keep running with gasohol (mix of 20% ethanol and 80% gas by volume).The significant poisons transmitted from sparkle ignition motor are carbon monoxide (CO) and unburnt hydrocarbons (UHC). (Mohiuddin and Nurhafez, et al, 2007) led a trial to concentrate on the execution and transformation efficiencies of fired stone monument three-way exhaust systems (TWCC) utilized in car fumes lines for the lessening of fuel discharges. Two fired converters of various cell thickness, substrate length, and water driven channel measurement and divider thickness were concentrated on to explore the impact of changing key parameters on transformation efficiencies and weight drop.

2. Selection of filter material

There are numerous sorts of channel materials are utilized as a part of inner ignition motor. They are Ceramic stone monument, fired froth, steel wire networks, artistic silicon fiber, permeable clay honeycomb are the few sorts of channel materials. Out of these channel materials, steel wire cross section is chosen as channel material in light of the fact that sewed steel wire network material is positioned first for its gathering productivity of particulate matter.

Alternate purposes behind its choice are,

- Thermal dependability amid recovery.
- Good mechanical properties.
- Long toughness.
- Easy accessibility and less cost

2. 1.Construction

The exhaust system comprise of

- Inlet channel
- Inlet tapered mixture
- First compartment
- Second compartment
- Outlet tapered bit
- Outlet channel

Every one of these parts have been appeared in the figure 1. The front of first compartment and second compartment are observed for CO mass division and weight dispersion utilizing CFD investigation

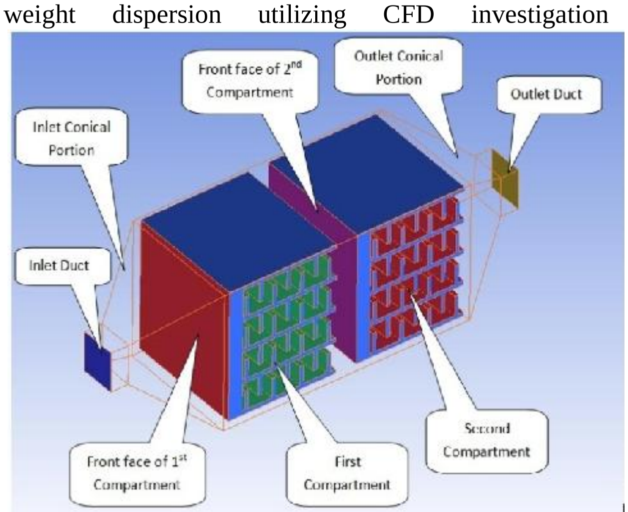

Fig.1 3D view of Catalytic convertor

3. Wire mesh specifications

Two wire mesh models have been studied MC-1 and MC-2 respectively as shown in the figure.

Void space in MC-1 is 64% for each compartment, while in MC-2 it is about 0.68%.

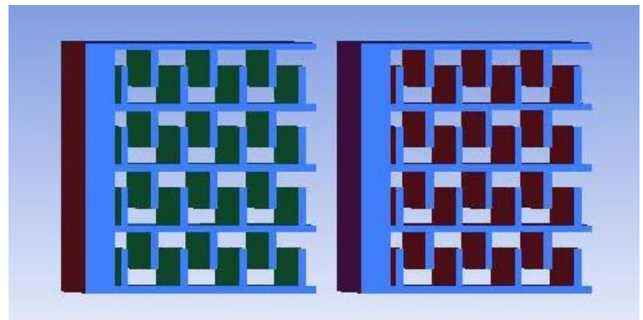

Fig.2 3D view of Catalyst bed for MC-1

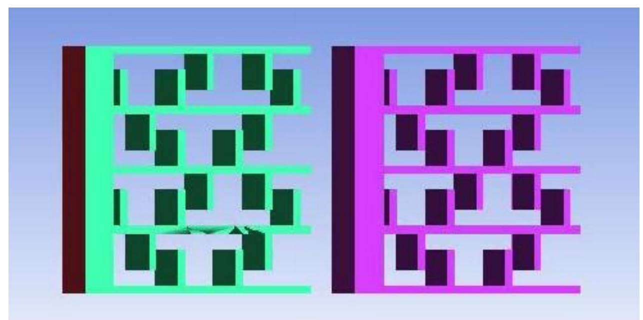

Fig.3 3D view of Catalyst bed for MC-2

4. Working principle

In the first compartment the exhaust gas passes through catalytic beads and steel wire mesh material which are coated with metal catalyst. As the hot gases contact the catalyst and the coated wire mesh, most of the exhaust pollutants such as CO, gaseous hydrocarbons, and unburned fuel and lube oil, toxic aldehydes etc. are oxidized to CO_2 and water, thus reducing harmful emissions. In the second compartment ammonia plus exhaust gas is passed through catalytic beads and steel wire mesh material which are coated with metal catalyst. Ammonia derived from urea is used to reduce NO_X from diesel engines. Ammonia is produced on-board by rapid hydrolysis of nonhazardous form of urea solution. In second compartment the NO_X are converted into nitrogen and oxygen.

In both compartments a part of the exhaust gas passes through the wire mesh layers which trap a portion of the soot. The remaining exhaust gas flows out to the neighboring bead placed in the same line – similar to a flow-through substrate. The soot trapped in the wire mesh material is combusted by the NO_2 that is generated by the upstream catalyst and thus the filter is regenerated continuously. If a situation occurs where filter regeneration is stopped and a saturation point occurred with the collected soot, the wire meshes placed over the catalytic beads will not plug as happened in wall flow filter. As the path of the gas is not totally blocked, the back pressure developed inside the catalytic converter is very much limited and no further increase in back pressure can happen beyond certain limit, irrespective of the soot loading over a period of time. A compressed air cleaning process is suggested to clean the PM deposition on steel wire meshes and catalytic beads. In this process, two numbers of compressed air inlet points are placed in between two compartments at diametrically in opposite position.

5. Modeling and meshing

The geometry of catalytic converter is modeled and meshed in ICEM CFD. And the flow equations solved in ANSYS FLUENT.

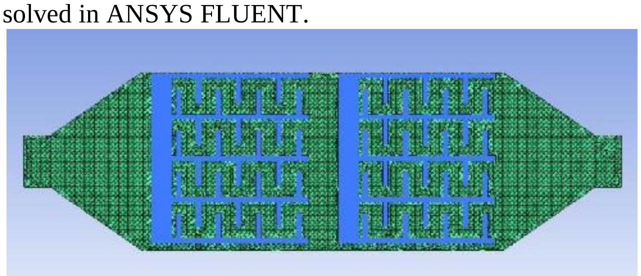

Fig.4 The meshed catalytic convertor

5.1 Domain conditions

The coherence and 3-dimensional energy conditions will be understood for the isothermal stream displaying. Turbulence will be displayed by k-ε RNG turbulence model suitable to represent high speeds and solid streamline shape in the stream area. The reference weight will be set at 1.33 atm and all weight inputs and yields will be acquired as gage qualities concerning this.

Air will be the working liquid thought to work at 350 0C and 1.35 bar.

Table 1The material properties under these conditions are:

Property	Air
Density (kg/m3)	0.7534
Viscosity (Pa.s)	3.0927 x 10-5
Specific heat (J/kgK) (not used)	1056.6434
Thermal conductivity (W/mK) (not used)	0.0242

5.2 Boundary condition

The motor chose for this study is a four stroke twin chamber (80mm bore and 110mm stroke length) water cooled diesel motor. The motor dislodging is ascertained as 603 cm3/s for the accepted vehicle velocity of 60 m/s. This gives the important gulf velocity to the exhaust system with delta cross segment of 50 mm x 50 mm as roughly 25.05 cm/s.

Subsequently, delta speed will be kept up at a somewhat higher estimation of 0.3 m/s and the working weight will be kept up at 1.33 atm. The outlet will be considered as a weight outlet at zero gage weight. A high turbulence force of 10% will be stream will be expected for the gulf while the water driven distance across at the channel will be considered to close the turbulence model conditions.

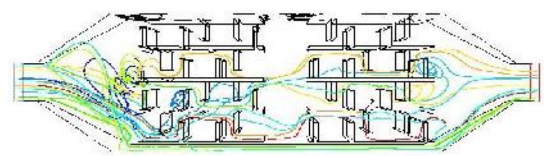

Fig.5 Pathlines of CO inside catalytic convertor

5.3 Methodology

A single phase single-species of carbon monoxide (CO) with mass fraction of 0.4 for incompressible flow simulation with Air as the working fluid will be carried out.

The mesh configuration chosen as MC-1and MC-2 for the catalytic converter model with inlet and outlet conical portion length 90 mm.

6. Results and discussion

We have considered the steel wire mesh configuration as MC-1 and MC-2 of catalytic converter having conical portion length 90 mm respectively.

6.1 Catalytic convertor– 90mm – MC – 1

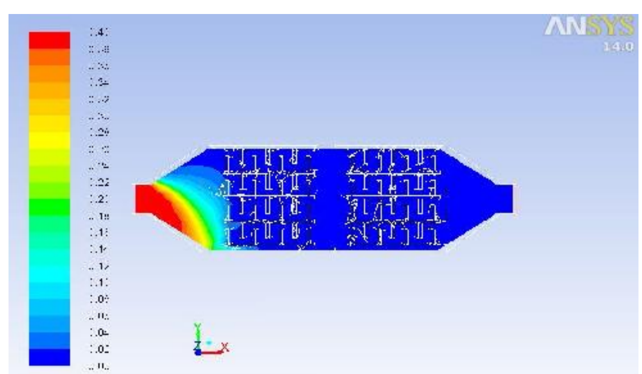

Fig.6 Contours of Mass fraction of CO (ppm) at 1 sec

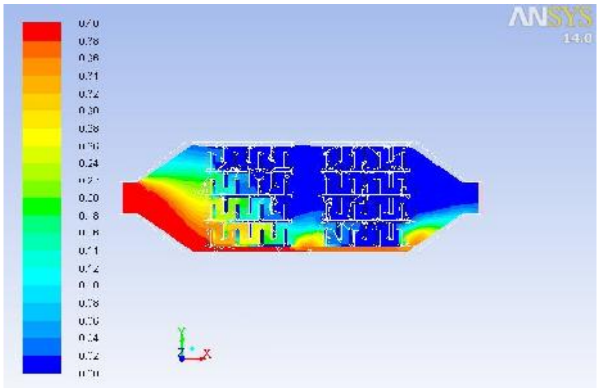

Fig.7 Contours of Mass fraction of CO (ppm) at 5 sec

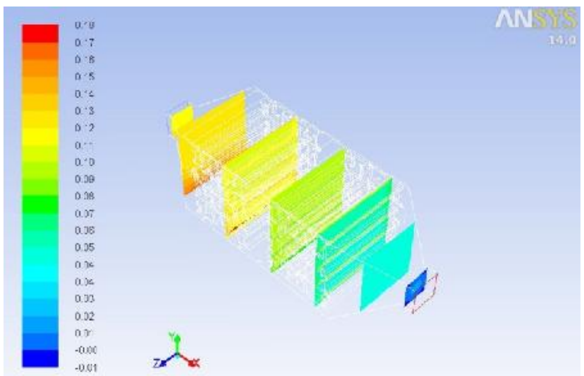

Fig.8 Contours of Static Pressure (pa) at 1 sec

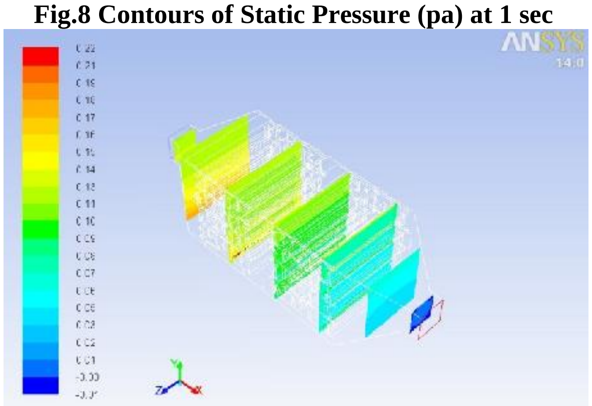

Fig.9 Contours of Static Pressure (pa) at 5 sec

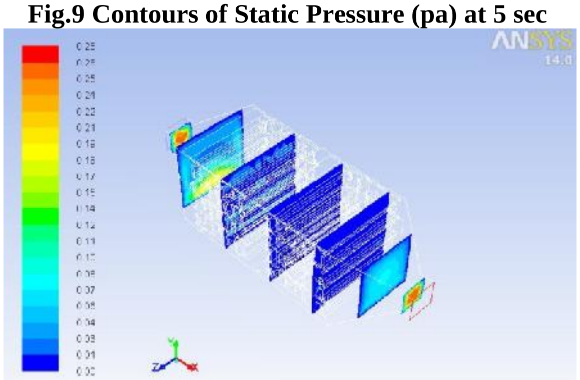

Fig.10 Contours of Velocity magnitude (m/sec) at 1 sec

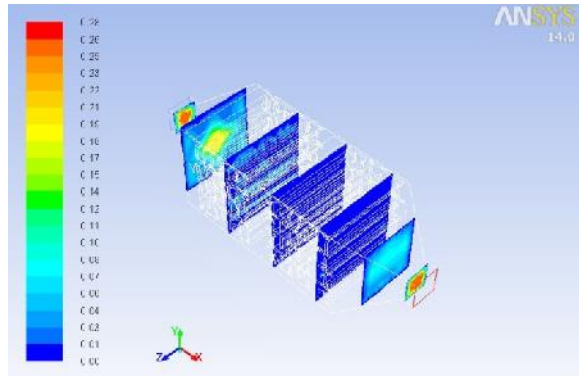

Fig.11 Contours of Velocity magnitude (m/sec) at 15 sec

6.2 Catalytic convertor– 90mm – MC – 2

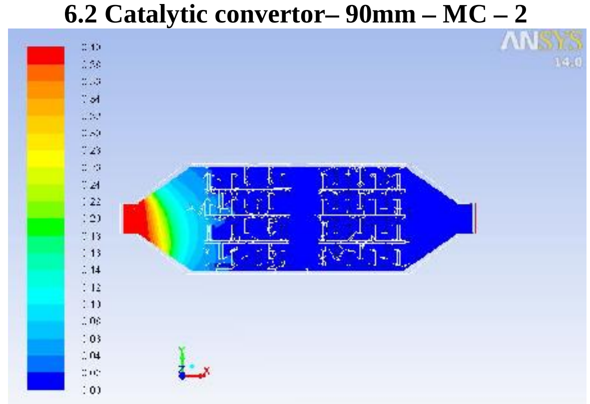

Fig.12 Contours of Mass fraction of CO (ppm) at 1 sec

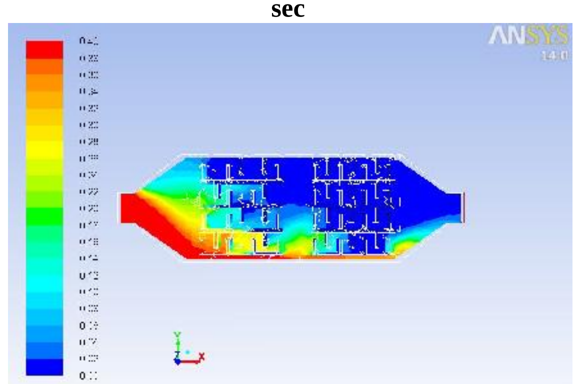

Fig.13 Contours of Mass fraction of CO (ppm) at 5 sec

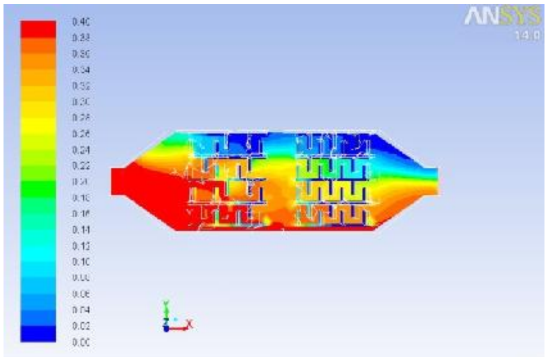

Fig.14 Contours of Mass fraction of CO (ppm) at 15 sec

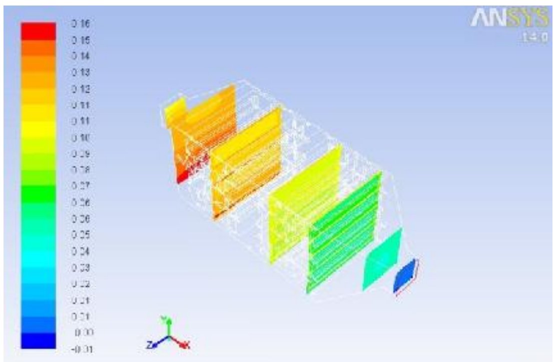

Fig.15 Contours of Static Pressure (pa) at 1 sec

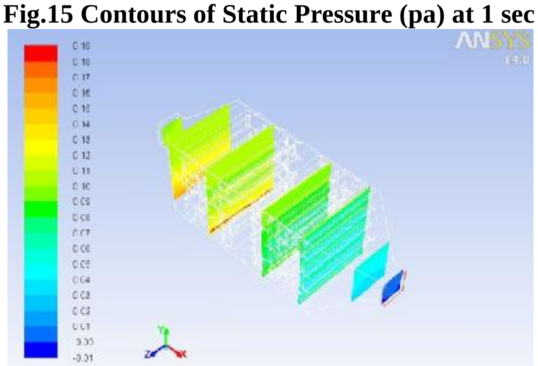

Fig.16 Contours of Static Pressure (pa) at 5 sec

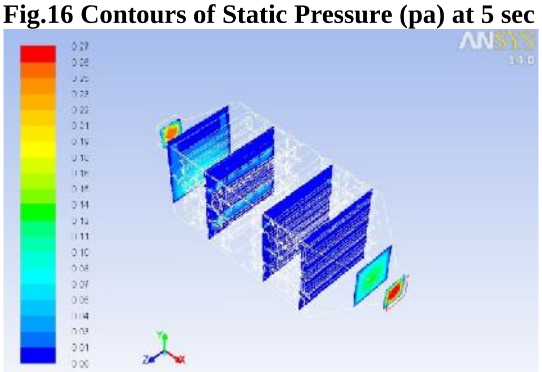

Fig.17 Contours of Velocity magnitude (m/sec) at 1 sec

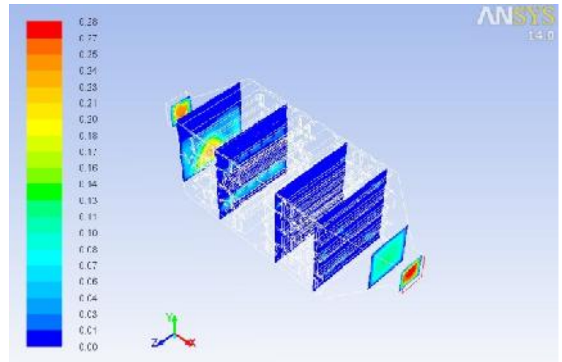

Fig.18 Contours of Velocity magnitude (m/sec) at 5 sec

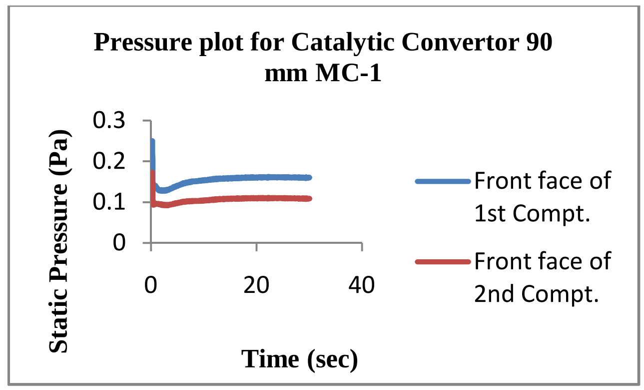

Fig.19 Pressure plot for MC-1

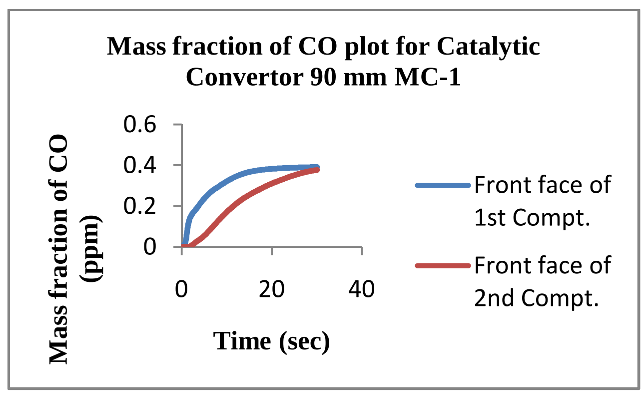

Fig.20 Mass fraction of CO plot for MC-1

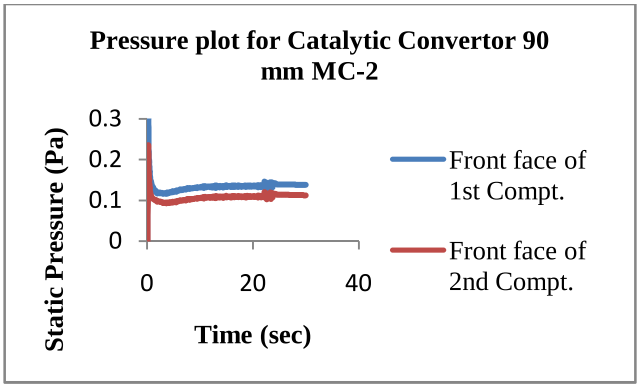

Fig.21 Pressure plot for MC-2

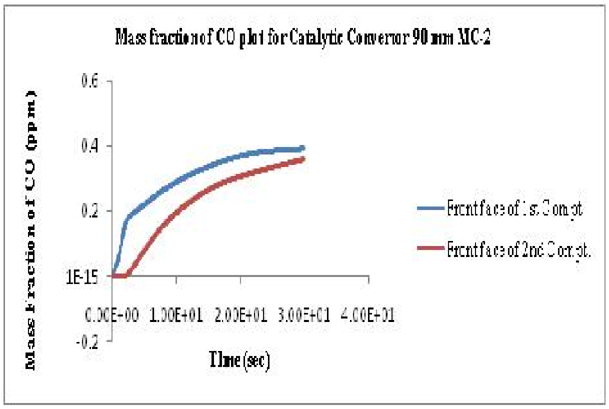

Fig.22 Mass fraction of CO plot for MC-2

Conclusions

By breaking down the weight plots of MC-1 and MC-2 in figure 35 and 37 separately. It is reasoned that the exhaust system 90mm-MC-2 has the least weight drop among the exhaust system with various wire network framework sizes, because of lower weight drop the fuel utilization get to be lower and volumetric productivity gets to be higher. The exceptional molded synergist dabs permit the fumes gas to stream uninhibitedly without making any impediment or blocking. It constrains the back weight to the base level bringing about better motor execution and fuel sparing. The reactant globules are hard, no wear and tear of impetus can occur, and thus long existence of impetus is guaranteed.

References

1. L.Andreassi, S.Cordiner and V.Mulone,;Cell shape influence on mass transfer and backpressure losses in an automotive catalytic converter,*SAE International*, 2004-01-1837, 2004.
2. S.Rajadurai, S.Jacob, C.Serrell, R.Morin and Z.Kircanski,;Wiremesh Substrates for Oxidation.TWC and SCR Converters; GPC 2006 *Advanced Propulsion and Emission.*
3. F.Ekstrom and B.Andersson, “Pressure drop of monolithic catalytic converters experiments and modeling” *SAE Internationals*, 2002-01-1010, 2002.
4. S. Narasimha Kumar, K. Kishor,M. V. S.Murali Krishna and P.V. K. Murthy, “Studies on Exhaust Emissions from Copper-Coated Gasohol Run Spark Ignition Engine with Catalytic Converter” *International Scholarly Research Network ISRN Mechanical Engineering* Volume 2011.
5. A.K.M. Mohiuddin and Muhammad Nurhafez – “Experimental Analysis and Comparison of Performance Characteristics of Catalytic Converters Including Simulation”, *International Journal of Mechanical and Materials Engineering (IJMME),* Vol. 2 (2007), No. 1, 1-7.
6. PL.S. Muthaiah, Dr.M. Senthil Kumar, Dr. S. Sendilvelan – “CFD Analysis of catalytic converter to reduce particulate matter and achieve limited back pressure in diesel engine”, Global journal of researches in engineering – *A: Classification(FOR) 091304,091399*, Vol.10 Issue 5 (Ver1.0) October 2010.