International Journal of Scientific Research in Science, Engineering and Technology
Print ISSN: 2395-1990 | Online ISSN : 2394-4099 (www.ijsrset.com)
doi : https://doi.org/10.32628/IJSRSET

Design and Analysis of X Shaped Exhaust System Operation Using Different Types of Profiles on High Capacity Vehicle

Menaka Muchhetti*[1], Dharamkar Sai Suman[2], Boyanpally Abhiman[3], Samatham Madhukar[4]

*[1,2,4]Assiatant Professor, Department of Mechanical Engineering, Lords Institute of Engineering and Technology, Osmania University, Telangana, TS, India.

[3]Research Scholar, Department of Mechanical Engineering, University College of Engineering, Osmania University, Telangana, TS, India.

Article Info
Volume 8, Issue 4
Page Number : 19-27

Publication Issue :
July-August-2021

Article History
Accepted : 01 July 2021
Published: 05 July2021

ABSTRACT

The exhaust system used in a 4-stroke IC engine is mounted on the cylinder head of an engine. The gases exhausted from the engine recollected by the exhaust system and it is sent to a catalyst converter. The exhaust manifold has an important role in the performance of an engine system. The exhaust manifold affects the efficiencies of emission and fuel consumption. During the process of collecting the gas from engine and exhaust to catalyst converter, the exhaust manifold experiences temperatures of 800°c and the pressures varying from 100 to 500kpa. Here in this thesis we are going to choose a 4 cylinder 1500cc diesel engine of a car. In this paper, design of the original model and the modified models of X shaped systems using Catia software and then analysed using CFD software for the flow rates and the temperature distribution of the exhaust models. Finally better modification can be determined.

Keywords : Exhaust System, CATIA, Ansys

I. INTRODUCTION

An exhaust manifold is a part of the internal engine that collects the exhaust gases from multiple cylinders into one pipe. In internal combustion engines, exhaust gas recirculation (EGR) is a nitrogen oxide emissions reduction technique used in diesel engines. EGR works by recirculating a portion of an engine's exhaust gas back to the engine cylinders. The three main types of exhaust systems are header-back, cat-back, and axle-back.[1–4] Depending on what type of system youchoose, aftermarket systems will come with some combination of header or intermediate pipes, cross over pipe, catalytic converter, mufflers, and tailpipes. Cat-back exhaust systems replace exhaust components from the catalytic converter back. These systems typically include a muffler and tailpipe, but depending on the make and model, they can also come with a mid-pipe, X-pipe, H-pipe or a Y-pipe. Cat-back systems are among the most popular exhaust upgrades for several reasons.[5,6]

A cat-back exhaust system is a relatively simple modification that will free up your exhaust gas flow. The result is good "bang-for-your-buck" power gains, although the exact amount of horsepower depends on the remaining stock exhaust components and design of the catalytic converters.[7,8] The freer exhaust flow can also help your engine operate more efficiently, leading to improved fuel economy. Cat-back systems also produce a more aggressive exhaust note and are typically emissions-legal because they retain the use of the stock catalytic converters.[9,10]

Figure 1 : Cat Back Manifold

II. Working Principal

A car's exhaust system consists of several components that work in harmony to funnel gases from the engine's combustion chamber out the back end of the car. If one of those parts isn't working properly, it can cause the whole system to run less efficiently. “The exhaust system serves two main functions, “A it’s for noise reduction. Without an exhaust, it’s going to be horribly loud. The other purpose is to funnel the exhaust safely away from the vehicle so it doesn’t enter the passenger compartment." Vehicle exhaust contains contaminates that can negatively impact public health, so a properly working exhaust system can protect both the vehicle driver and the public by reducing its harmful emissions.[11–13]

A. Exhaust pipe

The exhaust pipe runs the length of the vehicle and is connected to all of the exhaust system's components. Most exhaust pipes found on newer vehicles are made of steel.Some vehicles have dual exhaust systems, meaning they have two exhaust pipes instead of just one.

B. Exhaust manifold

The engine’s cylinders – whether it be four or six – funnel the remaining fuel-air mixture from the combustion chamber into a device called the exhaust manifold. The basic job of the manifold is to collect the gas from the cylinder heads and distribute it to the exhaust pipe.

C. Oxygen sensors

Located in the exhaust pipe or manifold, the oxygen sensor's job is to measure the ratio of oxygen to the exhaust gases. It detects the oxygen and helps control the fuel for efficiency. "The oxygen sensor, which is an electronic device, will alert the car's computer if the emission levels are too high.

D. Internal pipe or resonator

From there, the remaining exhaust gases travel to an internal pipe or a resonator, which Waeiss says operates like a mini-muffler or front muffler. This eliminates some of the frequencies that come through the exhaust system.

E. Muffler

Perhaps one of the most commonly referred to components of an exhaust system, the muffler’s job is to limit noise as the gases leave the exhaust system.

F. Tailpipe

This is the final section of the exhaust pipe and is often the only visible part of the exhaust system. This is where the exhaust gases exit the vehicle into the air.

III. DESIGN AND MODIFICATIONS

A. Original Design and Modified Designs

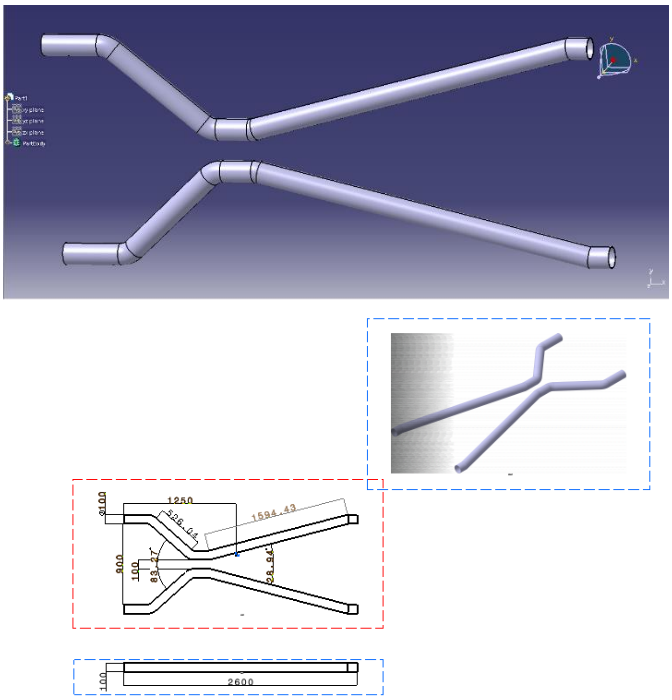

Figure 2 : Original Model without Modifications

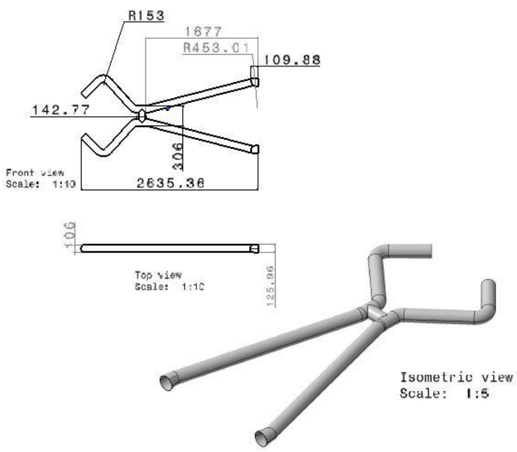

Figure 3 : Design Modification-1

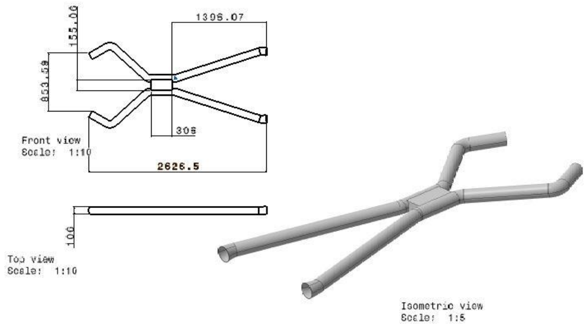

Figure 4 : Design Modification-2

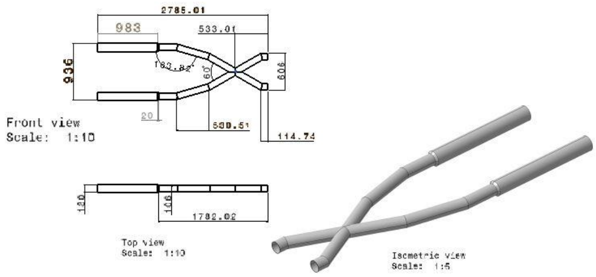

Figure 5 : Design Modification-3

B. CFD Analysis of X Shape Exhaust

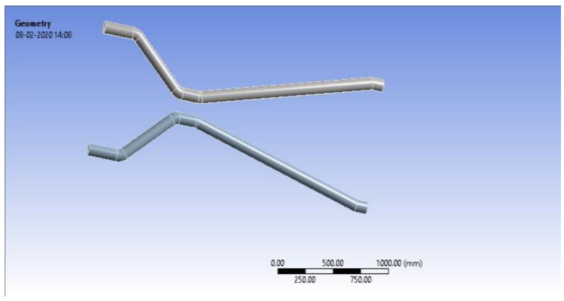

Figure 6 : Design of X Shape Exhaust original Model

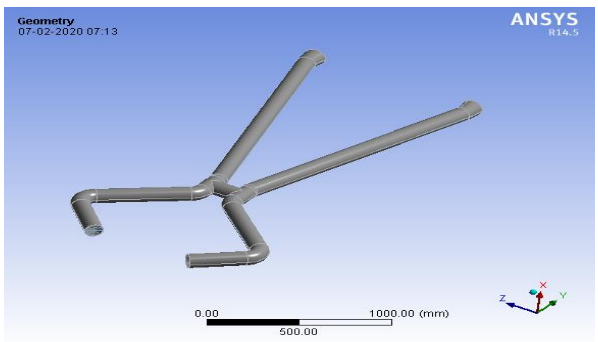

Figure 7 : Design of X Shape Exhaust Model of Modification -1

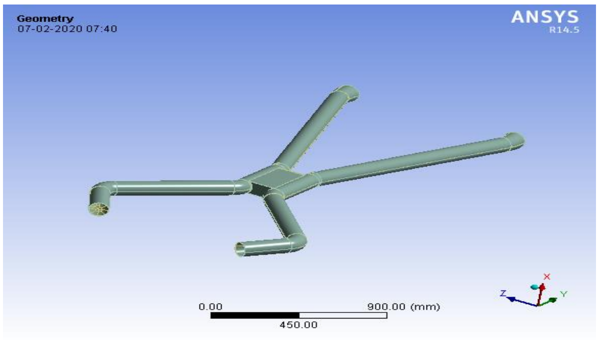

Figure 8 : Design of X Shape Exhaust Model of Modification -2

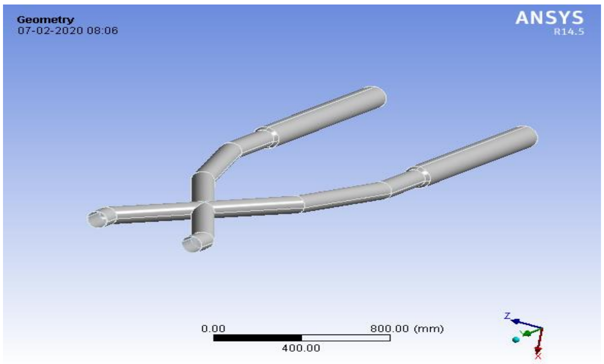

Figure 9 : Design of X Shape Exhaust Model of Modification -3

Here in the below figure we can see the original designed model of the chassis frame structure. This file is designed in **Solid Works** and it has been converted to **STP** format file as to import in to the Ansys for the validation. Here initially after opening of the Ansys geometry file, we can see an option import external geometry file, as this is designed in external software, and it is called as an external geometry. We can find that in the file option situated in the menu bar. Then later on we have to set the standards of length to "mm". Now close the file and proceed to meshing.

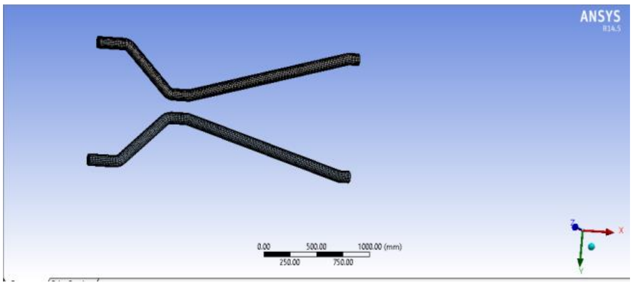

Figure 10 : Meshed model of X Shape Exhaust original Model

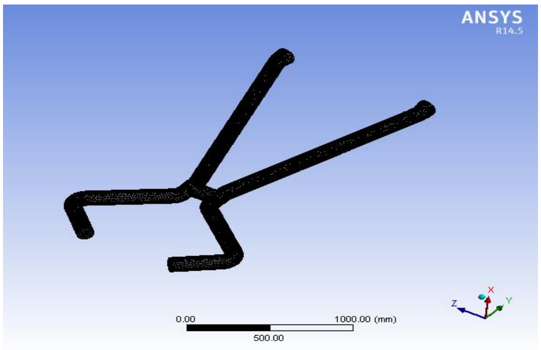

Figure 11 : Meshed model of X Shape Exhaust Model of Modification-1 Design

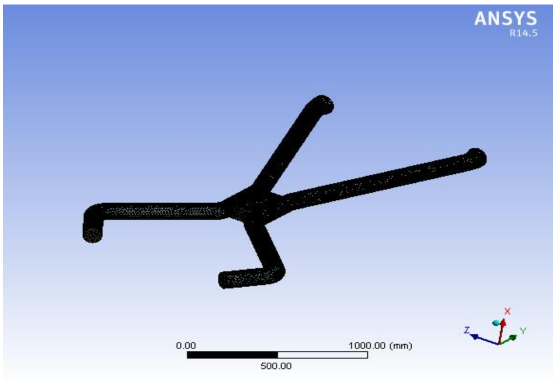

Figure 12 : Meshed model of X Shape Exhaust Model of Modification-2 Design

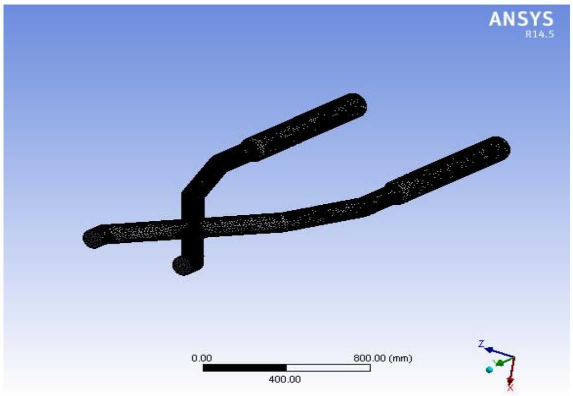

Figure 13 : Meshed model of X Shape Exhaust Model of Modification-3 Design

The above figures represents the meshed file, as this is the next step to the geometry file. Here mesh is created as to create nodes and elements. As to find out the best output approximately this is required to do as possible as to smaller nodes. As in meshing a set of nodes are called as element. Here in meshing there are different types of meshing ways, such as tetra mesh, quadrilateral mesh, prism mesh, triangular mesh and hexa mesh. Here in this project we have used triangular mesh with fine mesh model.

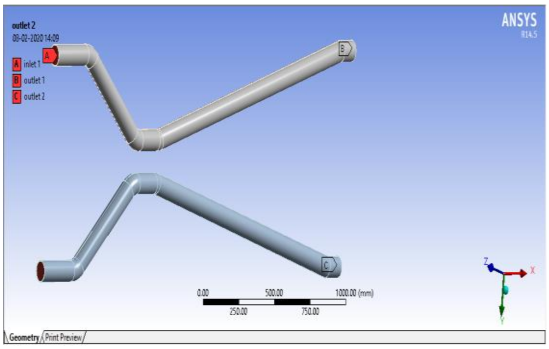

Figure 14 : Inlet and Outlet Flow of X Shape Exhaust original Model

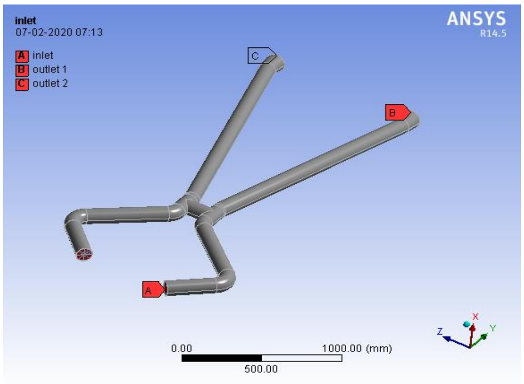

Figure 15 : **Inlet and Outlet Flow** of X Shape Exhaust Model of Modification 1

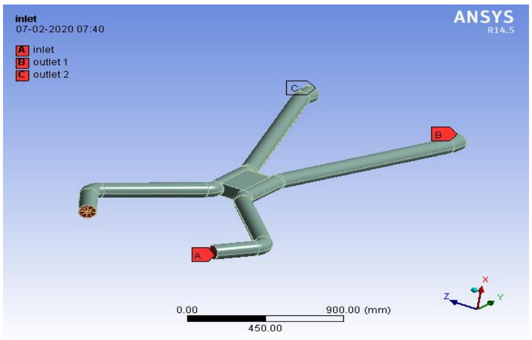

Figure 16 : Inlet and Outlet Flow of X Shape Exhaust Model of Modification 2

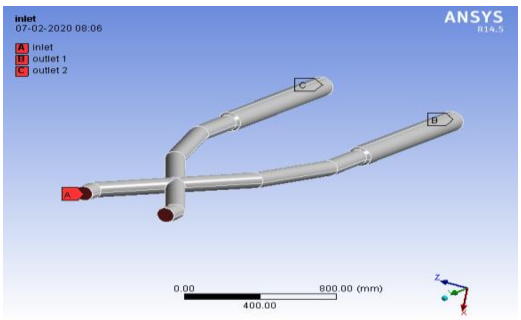

Figure 17 : Inlet and Outlet Flow of X Shape Exhaust Model of Modification 3

IV. RESULTS AND DISCUSSIONS

A. Scale Residuals

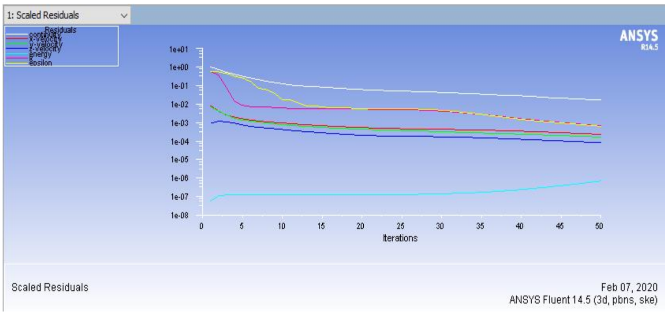

Figure 18: **Scaled residuals** of X Shape Exhaust original Model

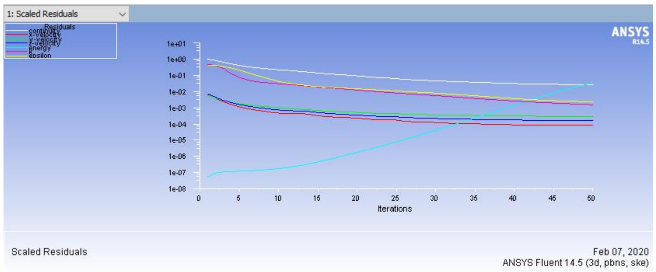

Figure 19 : **Scaled residuals** of X Shape Exhaust Model of Modification 1

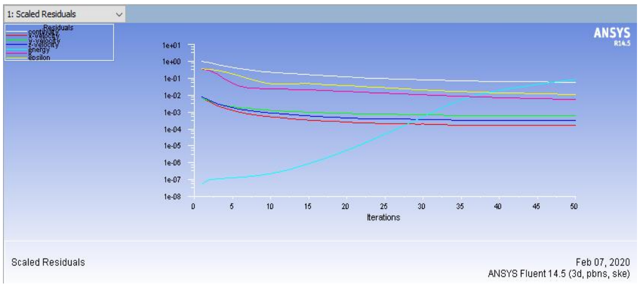

Figure 20 : **Scaled residuals** of X Shape Exhaust Model of Modification 2

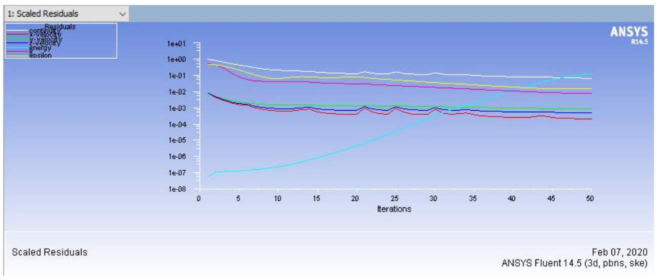

Figure 21 : **Scaled residuals** of X Shape Exhaust Model of Modification 3

B. **Contours of static pressure**

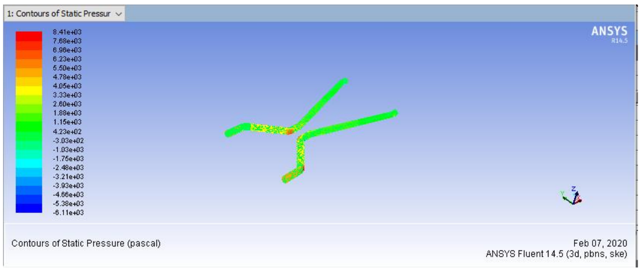

Figure 22 : **Contours of static pressure** of X Shape Exhaust Original Model

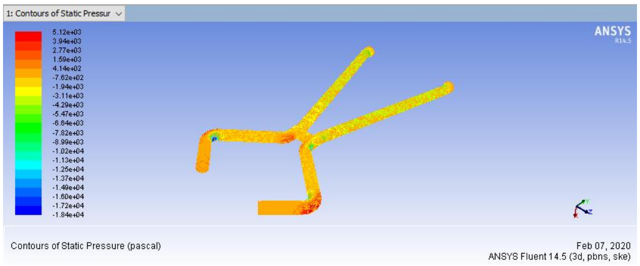

Figure 23 : **Contours of static pressure** of X Shape Exhaust Modification-1 Model

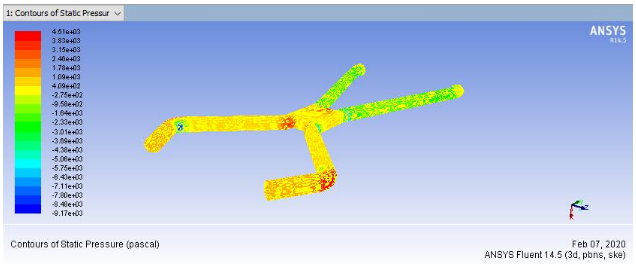

Figure 24 : **Contours of static pressure** of X Shape Exhaust Modification-2 Model

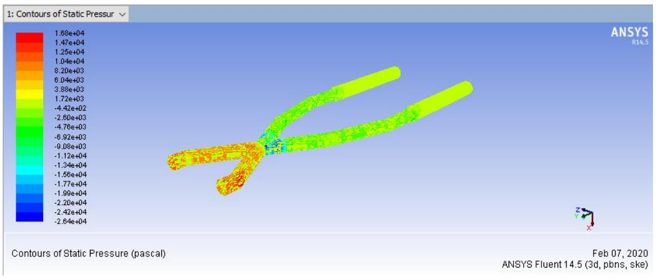

Figure 25 : **Contours of static pressure** of X Shape Exhaust Modification-3 Model

C. **Contours of static temperature**

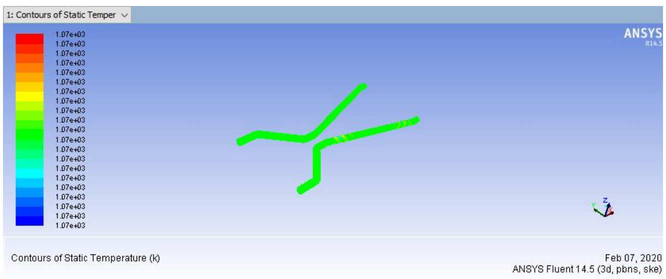

Figure 26 : **Contours of static temperature** of X Shape Exhaust Original Model

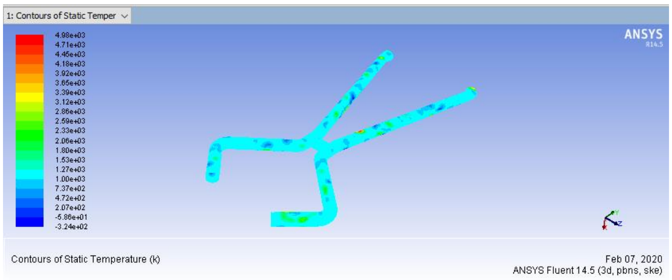

Figure 27 : **Contours of static temperature** of X Shape Exhaust Modification-1 Model

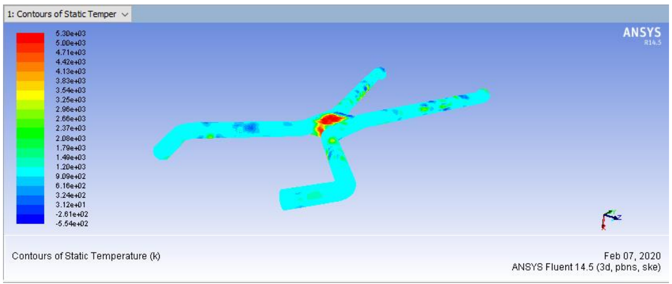

Figure 28 : **Contours of static temperature** of X Shape Exhaust Modification-2 Model

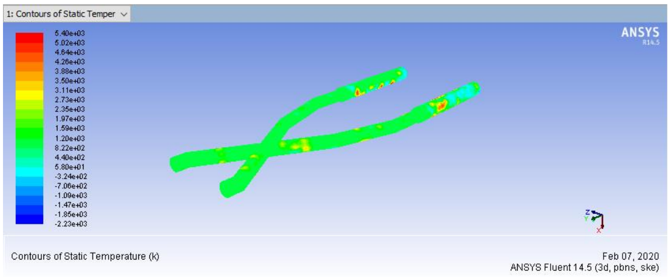

Figure 29 : **Contours of static temperature** of X Shape Exhaust Modification-3 Model

D. **Contours of turbulent kinetic energy**

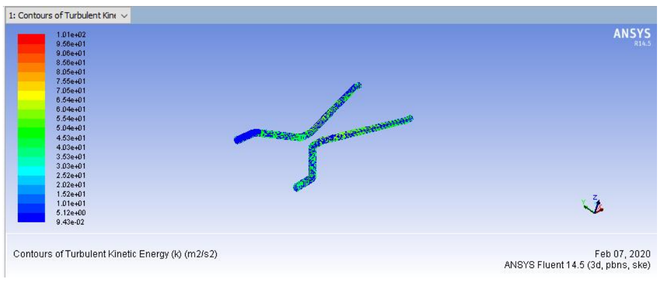

Figure 30 : **Contours of turbulent kinetic energy** of X Shape Exhaust Original Model

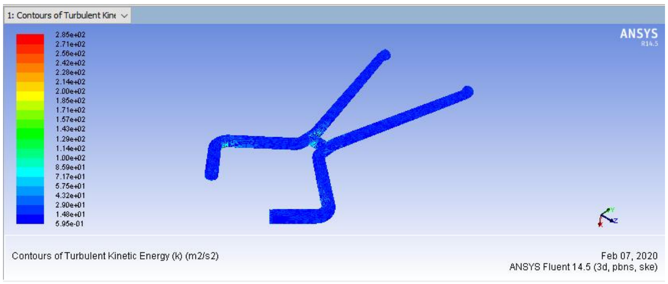

Figure 31 : **Contours of turbulent kinetic energy** of X Shape Exhaust Modification-1 Model

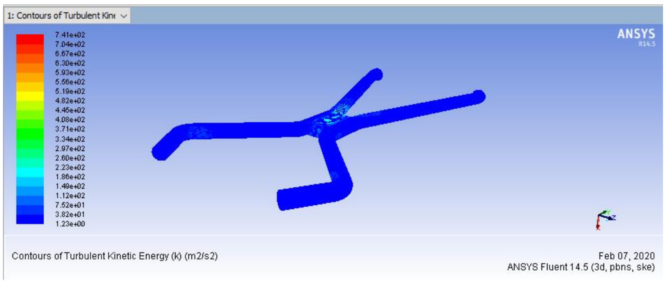

Figure 32 : **Contours of turbulent kinetic energy** of X Shape Exhaust Modification-2 Model

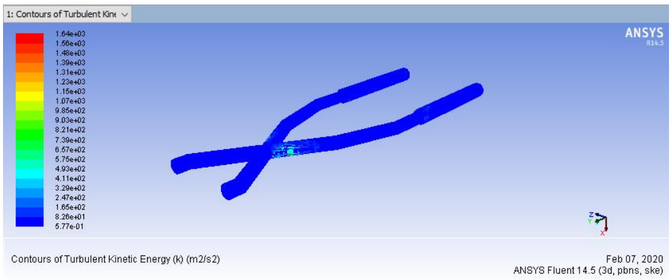

Figure 33 : **Contours of turbulent kinetic energy** of X Shape Exhaust Modification-3 Model

E. Contours of wall shear stress

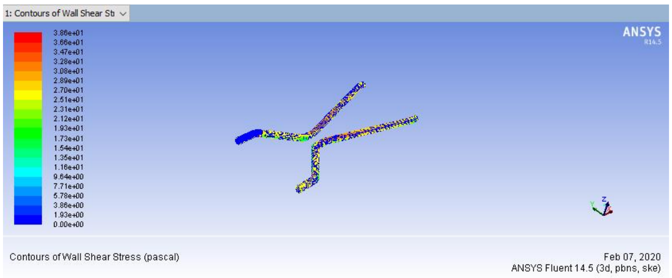

Figure 34 : **Contours of** wall shear stress of X Shape Exhaust Original Model

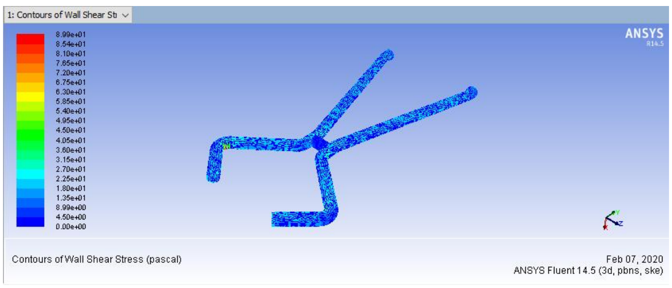

Figure 35 : **Contours of** wall shear stress of X Shape Exhaust Modification-1 Model

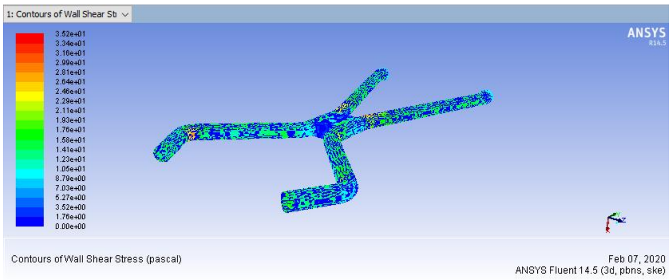

Figure 36 : **Contours of** wall shear stress of X Shape Exhaust Modification-2 Model

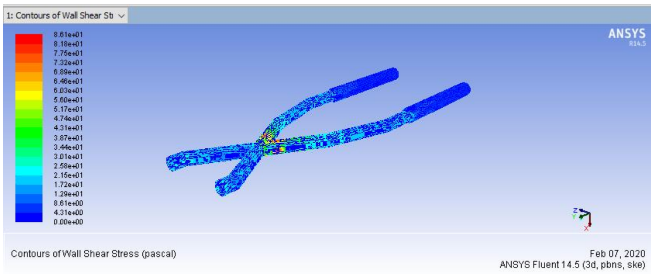

Figure 37 : **Contours of** wall shear stress of X Shape Exhaust Modification-3 Model

F. **Velocity streamlines**

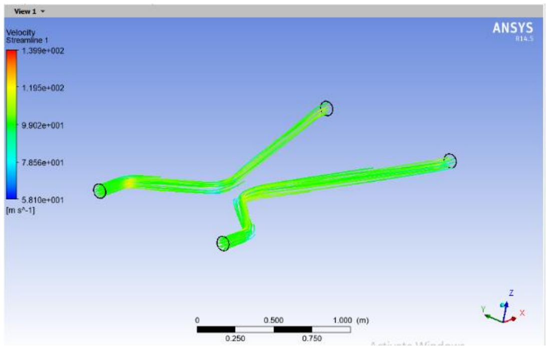

Figure 38 : **streamlines** of X Shape Exhaust original Model

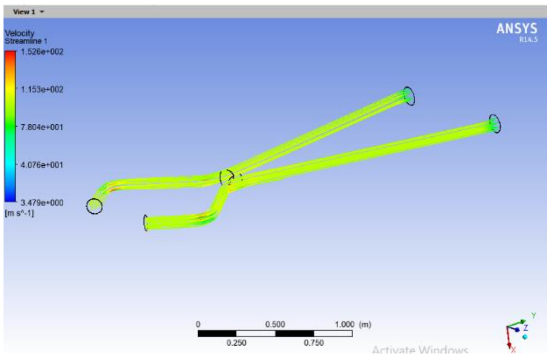

Figure 38 : **streamlines** of X Shape Exhaust Modification-1 Model

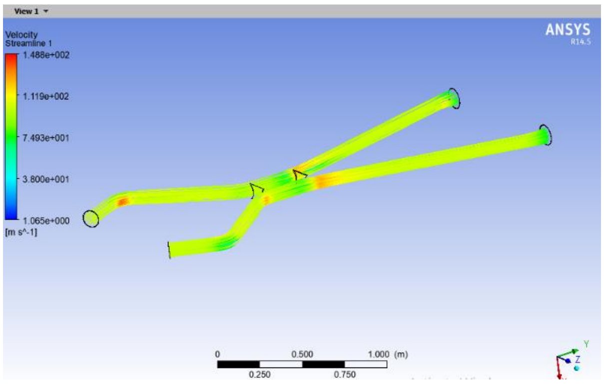

Figure 39 : **streamlines** of X Shape Exhaust Modification-2 Model

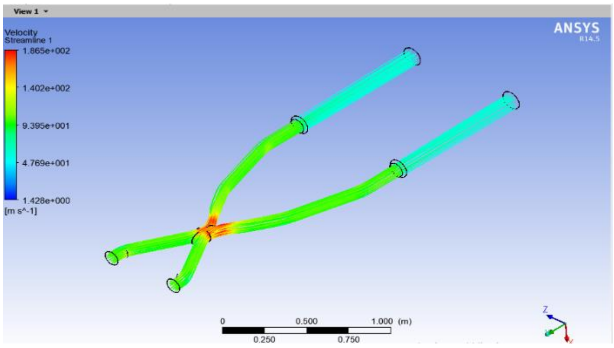

Figure 40 : **streamlines** of X Shape Exhaust Modification-3 Model

G. Mass Flow Rate and Total Heat Transfer Rate

1) Mass Flow Rate and Total Heat Transfer Rate of X Shape Exhaust original Model

Total Heat Transfer Rate	(w)
inlet_1	2075278.1
outlet_1	-1037636.4
outlet_2	-1037602.5
Net	39.25

Mass Flow Rate	(kg/s)
inlet_1	2.4407554
outlet_1	-1.2203742
outlet_2	-1.2203349
Net	4.6253204e-05

Figure 41 : Mass Flow Rate and Total Heat Transfer Rate of X Shape Exhaust original Model

2) Mass Flow Rate and Total Heat Transfer Rate of X Shape Exhaust Modification-1 Model

Total Heat Transfer Rate	(w)
inlet	2347983
outlet_1	-1175874.6
outlet_2	-1178990.1
Net	-6881.75

Mass Flow Rate	(kg/s)
inlet	2.7614861
outlet_1	-1.3828708
outlet_2	-1.3785014
Net	0.00011384487

Figure 42 : Mass Flow Rate and Total Heat Transfer Rate of X Shape Exhaust Modification-1 Model

3) Mass Flow Rate and Total Heat Transfer Rate of X Shape Exhaust Modification-2 Model

Total Heat Transfer Rate	(w)
inlet	1496687
outlet_1	-747886.31
outlet_2	-748987.56
Net	-186.875

Mass Flow Rate	(kg/s)
inlet	1.7368823
outlet_1	-0.86795634
outlet_2	-0.86942023
Net	-0.00049424171

Figure 43 : Mass Flow Rate and Total Heat Transfer Rate of X Shape Exhaust Modification-2 Model

4) Mass Flow Rate and Total Heat Transfer Rate of X Shape Exhaust Modification-3 Model

Total Heat Transfer Rate	(w)
inlet	2348669.5
outlet_1	-1145030.1
outlet_2	-1162924.8
Net	40714.625

Mass Flow Rate	(kg/s)
inlet	2.7622967
outlet_1	-1.3810077
outlet_2	-1.3798655
Net	0.0014234781

Figure 43 : Mass Flow Rate and Total Heat Transfer Rate of X Shape Exhaust Modification-1 Model

F. Comparison of original and modified models

Table 1 : Comparison of original and modified models

	Original	Modification 1	Modification 2	Modification 3
Pressure	8.41e+03	5.12e+03	4.51e+003	1.68+04
Temperature	1.07e+03	4.98e+03	5.30e+03	5.40e+03
turbulent kinetic energy	1.01e+02	2.85e+02	7.41e+02	1.64e+03
shear stress	3.89e+01	8.99e+01	3.52e+01	8.61e+01
Velocity streamlines	1.399e+002	1.526e+002	1.488e+002	1.865e+002

V. CONCLUSION

In this work exhaust system with modified designs models have been developed to apply computational fluid dynamics CFD analysis and compare with original designed exhaust model to get better results to them. In this work we tried to overcome the problem of exhaust back pressure issue one of the major issue of exhaust system and got some better results to us in some applications.

VI. REFERENCES

[1]. P.V. Sai, S. Madhukar, M. Krishna, P. Reddy, N.V.S.R. Rao, A Review on Machinability Aspects of Titanium grade-2, Ijsrset. (2017).

[2]. S. Madhukar†, B.R. Harshith Reddy, G.A. Kumar, R.P. Naik†, A Study on Improvement of Fatigue Life of materials by Surface Coatings, Int. J. Curr. Eng. Technol. 8 (2018) 5–9. https://doi.org/10.14741/ijcet.v8i01.10878.

[3]. H. Saikiran, I. V Kaushal, M.A. Chandra, Experimental and Numerical Analysis of Metal Removal Rate and Surface Finish on Orvar Supreme (H-13), 20 (2016) 978–93.

[4]. M.K. Prasad Reddy, R. Prashanth Naik, M. Samatham, C. Harish Kumar, Review on different welding techniques of Titanium and its alloys, Int. J. Sci. Res. Sci. Eng. Technol. (2020). https://doi.org/10.32628/ijsrset207150.

[5]. M. Kanazaki, M. Morikawa, Multiobjective Design Optimization of Merging Configuration for an Exhaust Manifold of a Car Engine, (n.d.).

[6]. K.H. Park, B.L. Choi, K.W. Lee, K. Kim, Y.Y. Earmme, Modeling and Design of Exhaust Manifold Under Thermomechanical Loading, (n.d.) 1–38.

[7]. N. I, Design Optimization of Exhaust Manifold for a Car Engine Using MOGA, (2002). https://doi.org/10.1299/kikaib.67.2746.

[8]. Designing Exhaust Manifolds Using Integral Engineering Solutions, (n.d.).

[9]. C.J. Krishnara, S.R. Ruban, N. Subramani, Analysis of exhaust manifold to improve the engine performance, 7 (2018) 539–542.

[10]. M.M.M.K. Varma, L.S. Kumar, Exhaust Manifold Design – FEA Approach, 17 (n.d.) 485–489.

[11]. DESIGN MODIFICATION AND ANALYSIS OF ENGINE EXHAUST MANIFOLD, (2016) 210–220.

[12]. E.E.D.F.O.R. Cooling, Contents 1, (n.d.).

[13]. S. Issue, I. Journal, C. Proceedings, M. Engineering, Structural and Thermal Analysis of an Exhaust Manifold of A Multi Cylinder Engine, 3 (2015) 2–5.

Cite this article as :

Menaka Muchhetti, Dharamkar Sai Suman, Boyanpally Abhiman, Samatham Madhukar, "Design and Analysis of X Shaped Exhaust System Operation Using Different Types of Profiles on High Capacity Vehicle", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 8 Issue 4, pp. 19-27, July-August 2021. Available at

Journal URL : https://ijsrset.com/IJSRSET218411