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CFD Analysis of a Resistance Muffler

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Abstract: In this project, design and CFD (computational fluid dynamics) of a car muffler has been presented. The designing and CFD is done in the 3D Modeling Software, DSS Solid Works 2014. The main objective of the project is to reduce the velocity at the exhaust, Car muffler is most widely used in the sports and family cars. We have made two different car muffler designs. With the help of flow simulation we will be able to get an idea of how a car muffler is able to absorb the sound produced by the engine and how its proper designing reduces Exhaust Velocity results in increased horsepower of the engine. The CFD has been done for all the two models. Based on the result generated by the software we came to know that which one of the two models is the best.

Keywords: Resistance muffler, cfd, flow field, pressure loss, automotive and design.

I. INTRODUCTION TO MUFFLERS

The Mufflers are currently used in various Big nations like USA Australia Canada to prevent the harm full emissions coming from the vehicle therefore many kinds of emissions are to be prevented using the Various types of the Mufflers it consist of a catalyst which helps in possible chemical reaction to reduce the emissions however decrease in the velocity coming from the vehicle is not possible to recoup the efficiency that has been well known in the past so in the absorptive mufflers and resistive mufflers Resistive mufflers are used to reduce velocity. Muffler is characterized as a mechanical gadget used to drain the commotion produced by an inward burning motor. The muffler decreases commotion , as well as reduces vibrations .It was created by "Milton" and "reeves" and they have taken patent in1897 at 'US PATENT' with application number:582485 Have you at any point heard clamor conveyed by an inner ignition without the utilization of a muffler? It gives parcel of inconvenience for the travelers and the general population around .The flag produced by the inner ignition motor has a high

recurrence on the grounds that the fumes gasses discharged into the environment has roughly a weight of 7 bar and 2000k temperature .Whenever the pressurized waves go into the climate at customary interims of time ,it makes 'undesirable sound'. Not just that, it additionally makes a vibratory movement on the motor in view of persistent heartbeats in view of Newton's third law (action= - reaction).Here activity is the high pressurized waves which are discharged from an IC motor and response is the vibration of the motor. In the event that you change the speed of the motor that naturally impacts the recurrence era .The variety of speed is specifically corresponding to the recurrence.

F=N*n/120 for 4-stroke motor

F=N*n/60 for 2-stroke motor

F=frequency generated=speed of the motor in rpm, n= number of cycles By and large ,in perfect condition , the recurrence created is 73HZ and the recurrence of the fluctuates between 50HZ to 800HZ. In common sense, that scope of constant recurrence is impractical. So that is the motivation behind why mufflers are presented. By presenting the mufflers (silencer), the vibrations are lessened and the recurrence of the muffler is additionally decreased to discernable range .Because of the sending of the muffler, the entire framework has turned out to be more effective which is constantly central .The muffler goes about as the go between the motor and the climate .So

that is the motivation behind why , the gasses are cooled and killed before into the framework.

The muffler similarly decreases the heaviness of the vapor gasses before releasing into the air and in this way , a vast part of the deviations are diminished. The muffler is an empty tube shaped question which has 2 ports (one gulf and outlet).At the channel , pressurized gas goes into the muffler chamber and when the gas turns out both the weight and clamor are fundamentally exhausted.

The silencer can just diminish clamor, yet muffler can decrease both commotion and vibration and which is the reason muffler is more favorable. In this unit , we have examined about muflers and in the second unit , sorts of mufflers are talked about.

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Fig 1: muffler model

A. *Types Of Mufflers*

There are by and large 2 sorts of mufflers which are recorded underneath

1) Absorptive muffler
2) Reactive muffler

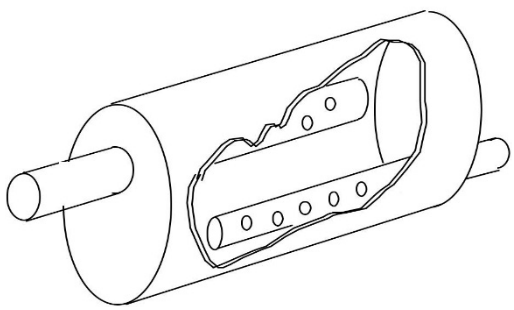

Fig 2: Absorptive muffler

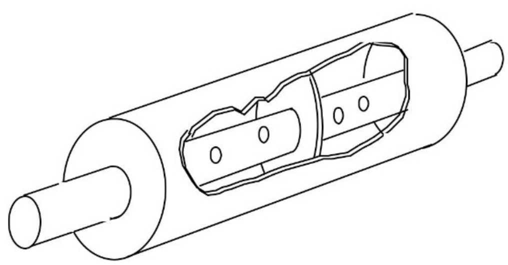

Fig 3: Reactive muffler

II. LITERATURE REVIEW

BarbieriR[1]. [2006] portrays a technique which consolidates limited component investigation and Zoutendijk's possible headings strategy for mufflers shape plan. The fundamental objective is to get the measurements of the acoustic muffler with the transmission misfortune (TL), being expanded in the recurrence scope of intrigue.

BroatchA(1991).[2]. [2007] clarified a near investigation of the execution of various plans used to tackle one-dimensional gas stream conditions when connected to the calculation of the recurrence reaction of fumes mufflers is introduced. The outcomes give rules to an appropriate decision of the numerical plan, considering the work dispersing.

Chiu M.C.[3]. [2010] exhibited in his paper, the four-shaft framework lattice utilized as a part of assessing acoustic execution is determined by utilizing the decoupled numerical technique. Additionally, a reenacted strengthening (SA) calculation, thus, the approach utilized for the ideal plan of commotion end proposed in this investigation is absolutely simple and effective.

Chiu.[4]. [2008] upgraded state of single-chamber mufflers with side channel/outlet by utilizing limit component strategy, scientific angle technique and hereditary calculation in managing the end of unadulterated tone commotion of 500 Hz under space.
Mimani and Munjal[5]. [2011] gave the 3-D semi-logical technique for the circular chamber mufflers having an end-channel and a side-outlet and demonstrated that a proper position of the ports can prompt the concealment of the proliferation of higher request modes, bringing about a broadband weakening.
Panigrahi and Munjal[6].[2007] received electro-acoustic analogies to figure addition loss of a muffler. A lot of work has been distributed from that point forward on the premise of the plane wave hypothesis for the expectation of muffler execution
Wu C.J. [7].[2008] displayed the acoustical execution forecast on single delta/twofold outlet (SIDO) and twofold gulf/single-outlet (DISO) extension chamber mufflers with rectangular segment. Articulations for the transmission misfortune (TL) of this sort of mufflers are defined by utilizing the collocation approach.
Yasuda T. [8].[2010] clarified the tail pipe commotion from a business car muffler was contemplated tentatively and numerically under the state of totally open throttle increasing speed.
Yasuda [9].[2013] proposed muffler which can constrict the commotion of low recurrence and center recurrence in the meantime by presenting interconnecting openings and Helmholtz resonator on the tailpipe.

III. METHODOLOGY

A. *Solid works Flow Simulation*

Solid works flow simulation is one of the most possible and advanced Cfd tools which we can efficiently to solve problems like aerodynamics hydrodynamics , heat transfer , mass transfer , combustion , multiphase and the volume of fluid ii has a specialized data base and instructions to integrate the cfd with the known design module cfd stands for computational fluid dynamics where it is science that studies the behavior of fluid.Below is the procedure which explains the step by step process of solving our muffler problem in the solid works flow simulation .

1) *Step 1*

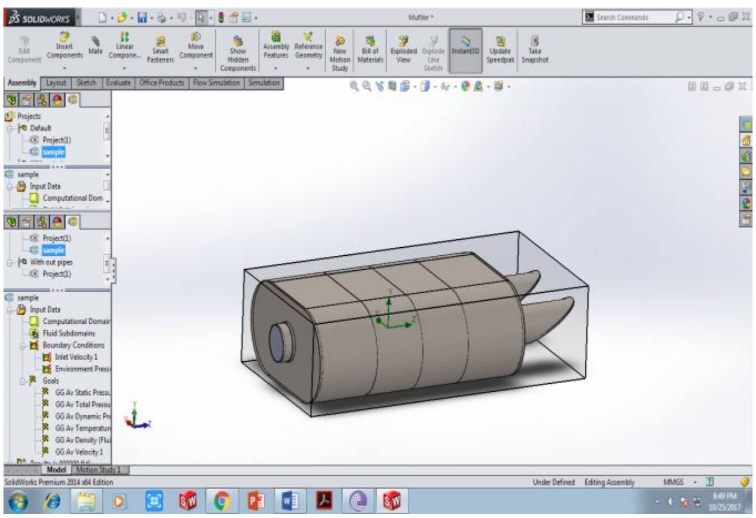

Fig 4Extracting the computational domain is the key process in any cfd related software

B. *Computational Domain* .

The above figure represents the cfd model of the muffler imported to solid works flow simulation and extracted computational domain.

C. *Computational Domain*

The Computational domain is said to be expanded in minimum and maximum direction x y and z in both positive and negative direction therefore in x direction minimum -0.155m x direction maximum 0.155 y direction minimum -0.080m y maximum 0.080 z minimum -0.243 z maximum 0.361

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1) Step 2

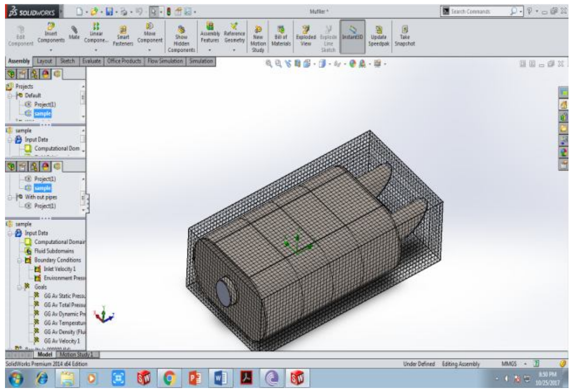

Fig 5 Discretization Process

D. Discretization of the system

1) Calculation Mesh: Calculation of the mesh in the sense the number of cell in the wholes analysis considered and discredited in the directional vector the directional cell count is as follows x=1000 , y= 600 z=2100.

Number of Cells Number of cells as per the notation of entity there fore the count of cells in fluid solid and partial medium is said to be total cells=308210 Fluid cells =162530 solid cells = 33760 partial cells = 33760. Are present in the computational mesh we have created.

1) Step 3

Table 1: Material properties

Property	Units	Value
Density	Kg/m3	7900
Specific heat	J/(kg*K)	500
Thermal conductivity	W/(m*K)	16.2
Conductivity type	isotropic	Isotropic

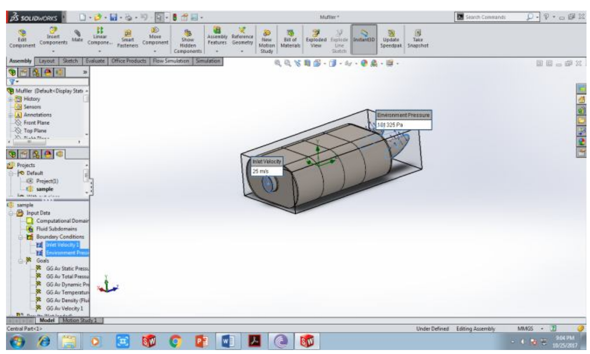

Fig 6 Boundary Conditions

E. Boundary Conditions

Table 2. Dimensional data

Entity	Dimension(mm)
Shell length	500
Shell Dia	187
Inlet pipe Dia	62.33
Inlet pipe length	85
Outlet pipe Dia	62.33
Outlet pipe length	85

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Table 3 Initial values for velocity inlet as the inlet boundary conditions

Area (m2)	0.003051
Temperature(K)	470
Viscosity (kg/ms)	2.7e-0.5
Enthalpy (J/kg)	749575.3
Density (kg/m3)	0.696
Length (mm)	500
Velocity (m/s)	25
Ratio of specific heats	1.4

Table 4 Initial values for pressure inlet as the Inlet boundary conditions

Area (m2)	0.003051
Temperature (K)	470
Viscosity (kg/ms)	2.7e-0.5
Enthalpy (J/kg)	749575.3
Density (kg/m3)	0.696
Length (mm)	500
Velocity (m/s)	25

IV. RESULTS AND DISCUSSION

A. Boundary Conditions

Inlet Velocity 1

The inlet velocity at the face of face number lid 3-1 with a velocity of 25 m/sat a temperature of 553 m/s with the reference axis of x at an environmental pressure condition

Environment Pressure 1

The outlet pressure at the face of face number lid 4-1 with a velocity of 25 m/sat a temperature of 553 m/s with the reference axis of x at an environmental pressure condition

B. Calculation Mesh

Calculation of the mesh in the sense the number of cell in the wholes analysis considered and discretized in the directional vector the directional cell count is as follows x=1000 , y= 600 z=2100.

C. Number of Cells

Number of cells as per the notation of entity there fore the count of cells in fluid solid and partial medium is said to be total cells=308210 Fluid cells =162530 solid cells = 33760 partial cells = 33760. Are present in the computational mesh we have created.

D. Validation

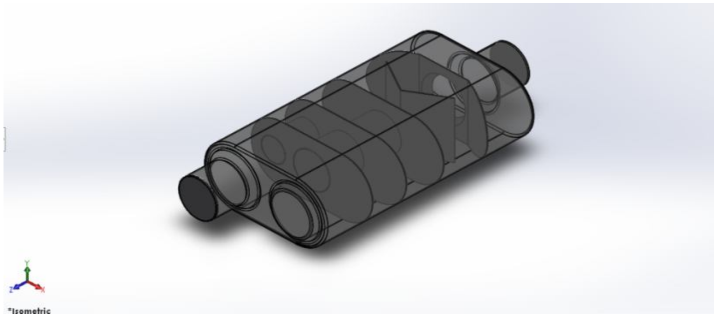

Fig 7: Modeled 3D CAD model of Base paper

In the paper I have selected the above model is implemented to reduce the velocity contour of the flow the total reduction in velocity obtained is 16 m/s where the in let velocity is 25m/s

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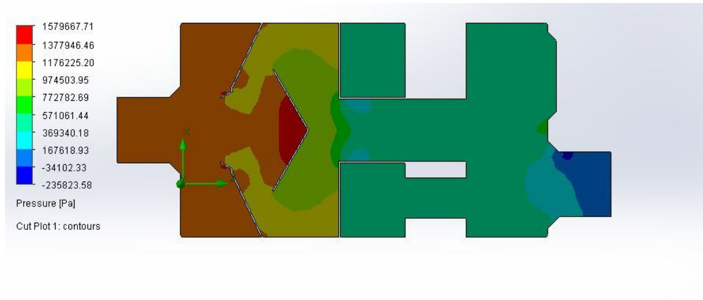


Fig 8: Pressure contour of the Base paper model

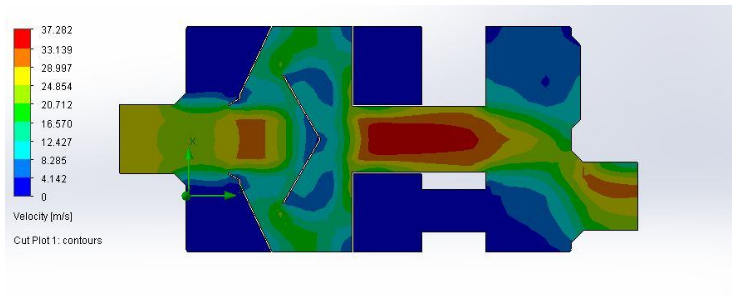
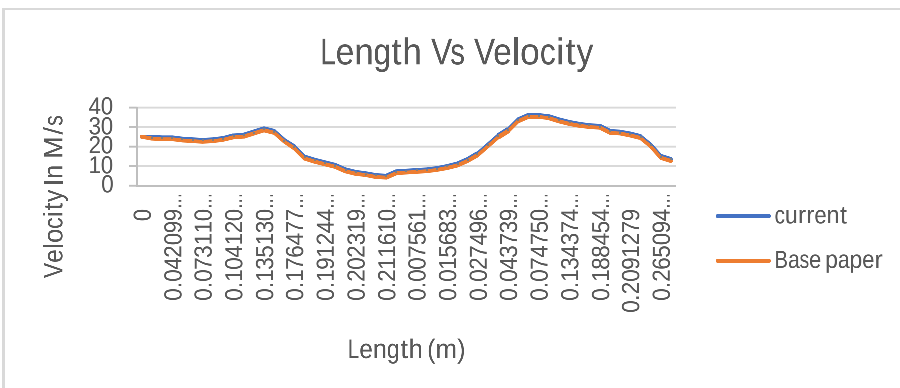


Fig 9: Velocity contour of the Base paper model



E. Validation Graph With the Base paper model

The above figure reprents the velocity contour of the base paper model. The above is the X-Y plot of the length vs velocity plot X represents in length(m) and Y axis represents the velocity in m/s. we can observe the velocity behavior of muffler without pipe decreasing up to 17 m/s as in base paper and 15.42 m/s in the current paper at the outlet due to arrangements of baffles.

F. Results of Muffler with pipes

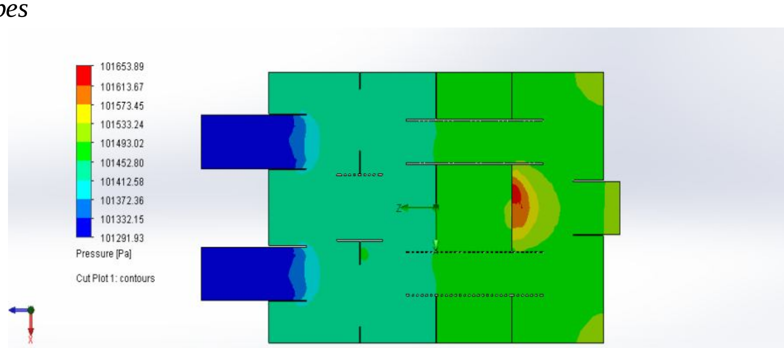


Fig 10: Figure Pressure Contour of Muffler With pipes

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The above figure represents the Pressure distribution of the fluid inside the Muffler geometry the pressure is moderate in the current model because controlled path from the inlet and the outlet. There for in the controlled path the pressure will be distributed in a control volume left side colored bar is know as the legend where blue represents the minimum value and red represents the maximum u can obserce the colored contours in the pressure distribution.

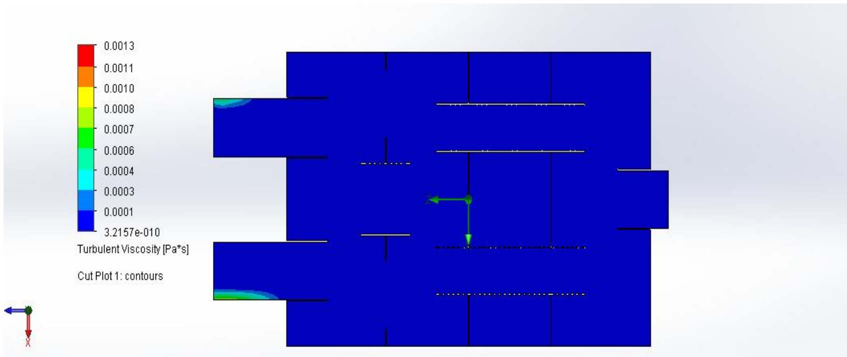

Fig 11: Turbulence Contour Of muffler with pipes

The above figure represents the Turbulence of the fluid inside the Muffler geometry the pressure is moderate in the current model because controlled path from the inlet and the outlet. There for in the controlled path the Turbulence will be distributed in a control volume left side colored bar is know as the legend where blue represents the minimum value and red represents the maximum u can obserce the colored contours in the Turbulence .

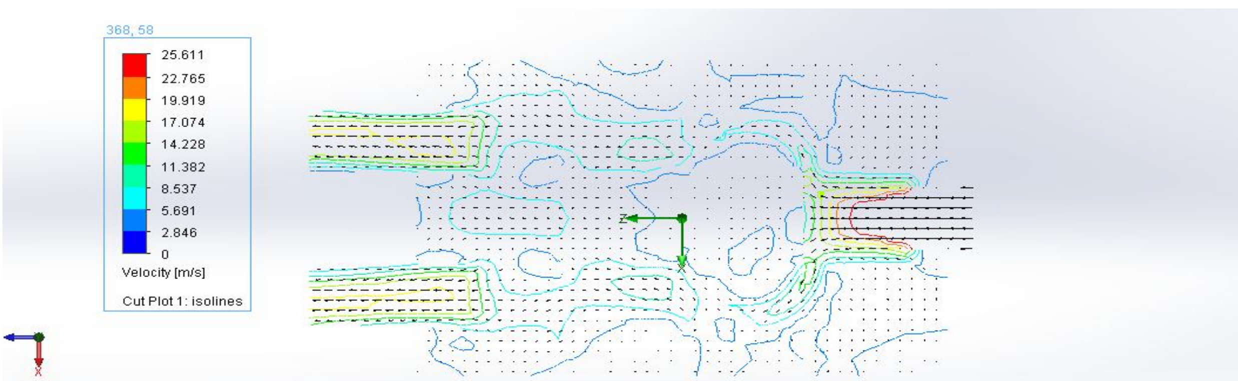

Fig 12: Vector representation of Flow from inlet to outlet

The above figure represents the Velocity distribution of the fluid inside the Muffler geometry the pressure is moderate in the current model because controlled path from the inlet and the outlet. There for in the controlled path the Velocity will be distributed in a control volume left side colored bar is know as the legend where blue represents the minimum value and red represents the maximum u can observe the colored contours in the Velocity distribution. The velocity will be increase where the pressure is lesser

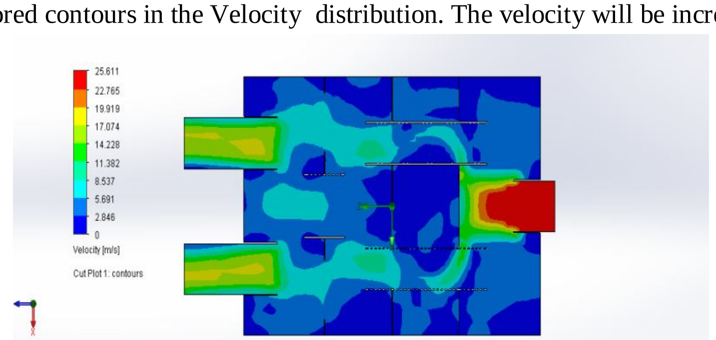

Fig 13: Velocity of Muffler

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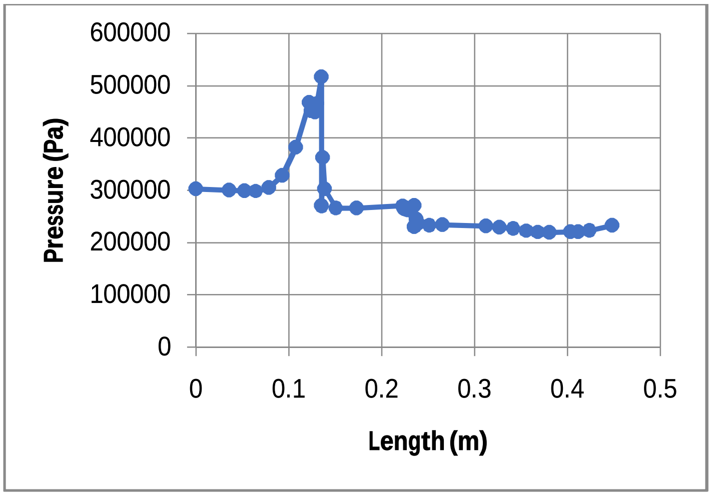
The above figure represents the Velocity distribution of the fluid inside the Muffler geometry the pressure is moderate in the current model because controlled path from the inlet and the outlet. There for in the controlled path the Velocity will be distributed in a control volume left side colored bar is know as the legend where blue represents the minimum value and red represents the maximum u can observe the colored contours in the Velocity distribution. The velocity will be increase where the pressure is lesser we can observe the gradual decrease of the Velocity from inlet to outlet.



Graph 2 Length VsPressure With pipes inside the muffler

The above Graph represents the pressure distribution along the length of the muffler From inlet to outlet the behavior of the graph because of the distribution of fluid created by the holes designed in the pipes of the Muffler assembly because of the hole the fluid is distribution is carried out and results in the Higher pressures.

G. Results of Muffler without Pipes

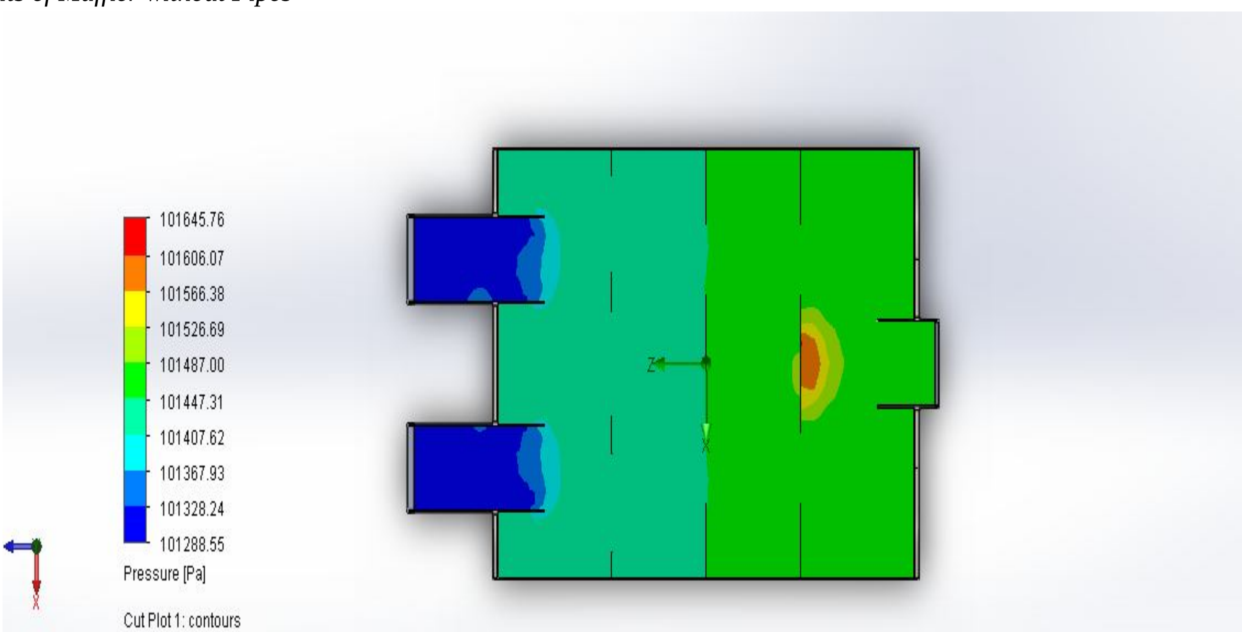


Fig 14: Pressure Contour Of muffler Without pipes

The above figure represents the Pressure distribution of the fluid inside the Muffler geometry the pressure is moderate in the current model because There is no controlled path from the inlet and the outlet. There the pressure will be distributed in a Free volume left side colored bar is know as the legend where blue represents the minimum value and red represents the maximum u can obserce the colored contours in the pressure distribution.

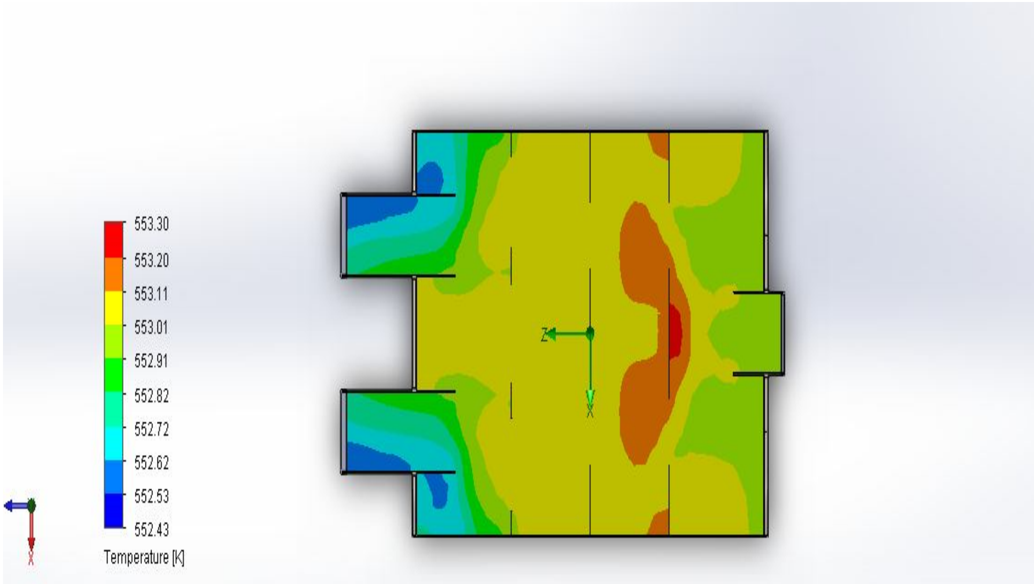


Fig 15: Temperature Contour Of muffler Without pipes

The above figure represents the temperature distribution of the fluid inside the Muffler geometry the temperature is moderate in the current model because There is no controlled path from the inlet and the outlet. There the temperature will be distributed in a Free volume left side colored bar is know as the legend where blue represents the minimum value and red represents the maximum u can obserce the colored contours in the temperature distribution.

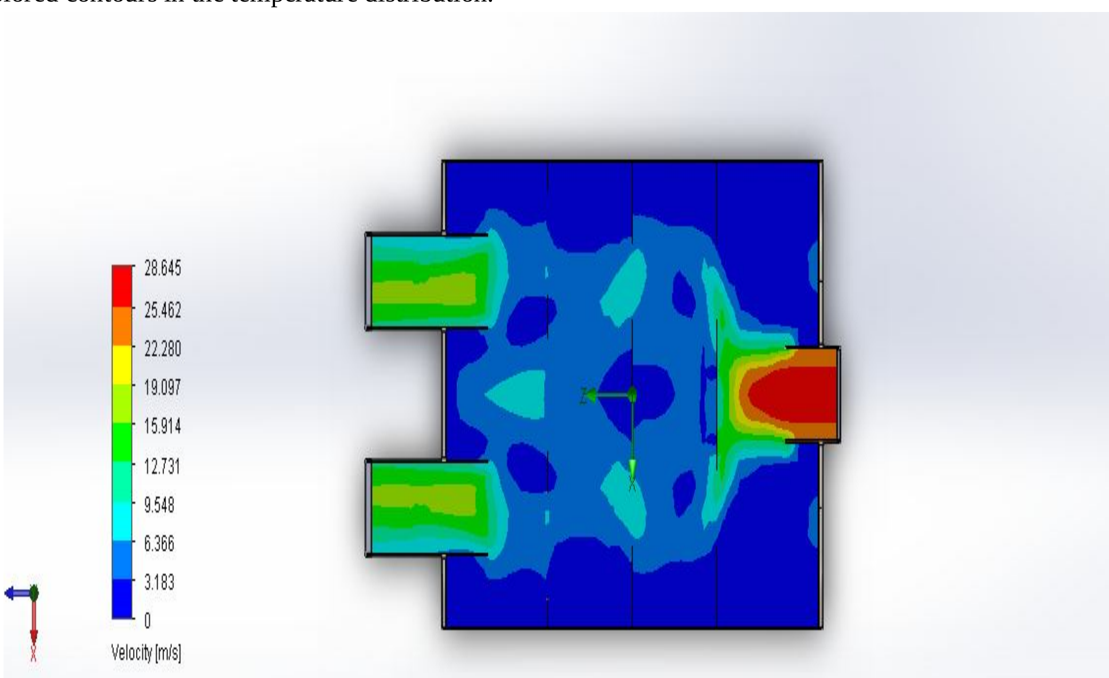


Fig 16: Velocity Contour of Velocity without pipes

The above figure represents the Velocity distribution of the fluid inside the Muffler geometry the pressure is moderate in the current model because Free volume nature from the inlet and the outlet. There for in the Velocity will be distributed in a Staggered nature left side colored bar is know as the legend where blue represents the minimum value and red represents the maximum u can observe the colored contours in the Velocity distribution. The velocity will be increase where the pressure is lesser we can observe the gradual decrease of the Velocity from inlet to outlet.

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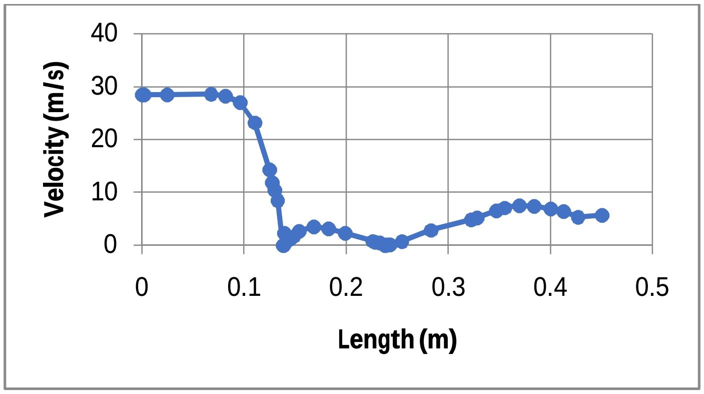
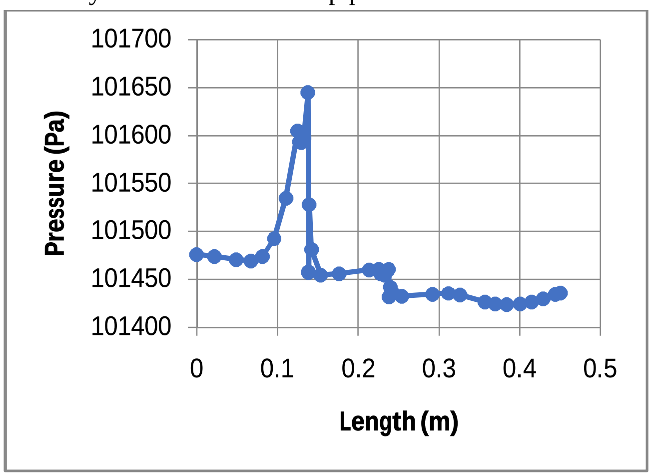
H. Graphs



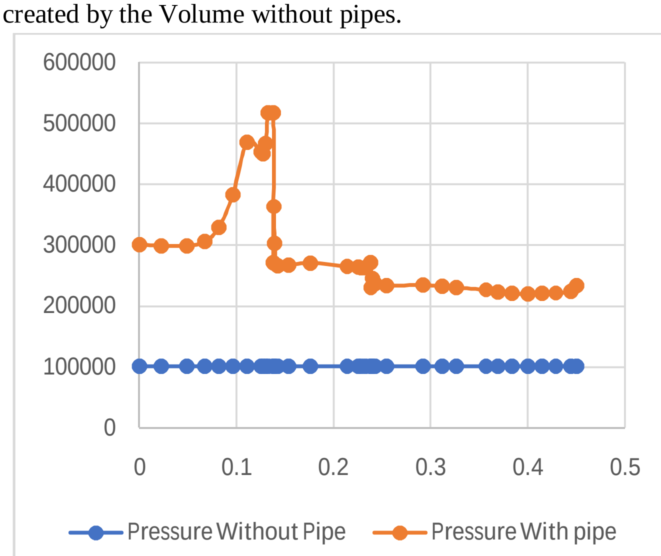
Graph 3 1 Length Vs Velocity With out pipes inside the muffler

The above Graph represents the Velocity distribution along the length of the muffler From inlet to outlet the behavior of the graph because of the distribution of fluid created by the Volume without pipes.

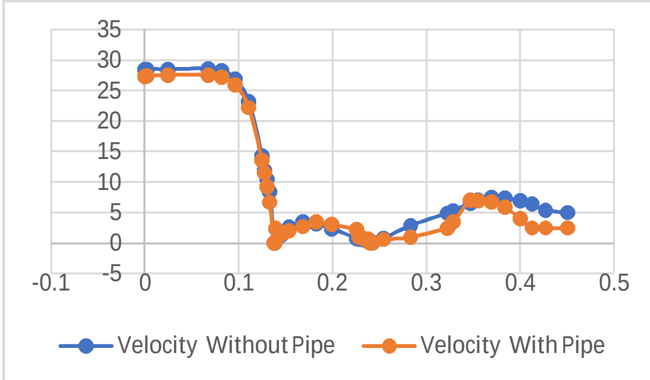


Graph 4 Length VsPressure With out pipes inside the muffler

The above Graph represents the Pressure distribution along the length of the muffler From inlet to outlet the behavior of the graph because of the distribution of fluid created by the Volume without pipes.



Graph 5 Comaprision Between Pressure With pipe and without pipe



Graph 6 Comparision Between Velocity with pipe and without pipe

Parameter	With Pipes	Without pipes
Pressure (pa)	234120	101456
Velocity (m/s)	2.47	5.34

IV. CONCLUSION

In this Current project models of two different mufflers is been done from the previous base paper where The decrease in Velocity Results in Lowest possible Echo That means reduction of sound velocity at the exhaust is noted to be 17.66 m/s at with the previous model where as the minimum velocity noted in the current Design is 4.46 m/s for model 1 and 2.47m/s for model 2 there fore there is a significant decrease in the Velocity compared to the Previous model

1) Minimum Velocity Noted in the Previous Muffler is 17.66 m/s.
2) Minimum Velocity noted in the current design model 1 is 5.34 m/s.Because of higher volume without Pipes
3) Minimum Velocity Noted in the current design model 2 is 2.47 m/s. because of lower volume with pipes

Where as in all the above cases same boundary condition is noted as inlet velocity to be 25 m/s.

V. FUTURE SCOPE

The Project done so far for a resistance muffler is changing the design orientation and controlling the volumetric flow of the exhaust. It can be extended to using multiphase mixture model to determine the mass fractions of the exhaust gas coming from the outlet of the model

The velocity reduction is possible for the absorptive muffler and can compare between these to models there is a significant work on the absorptive muffler that can be refered and extended accordingly.

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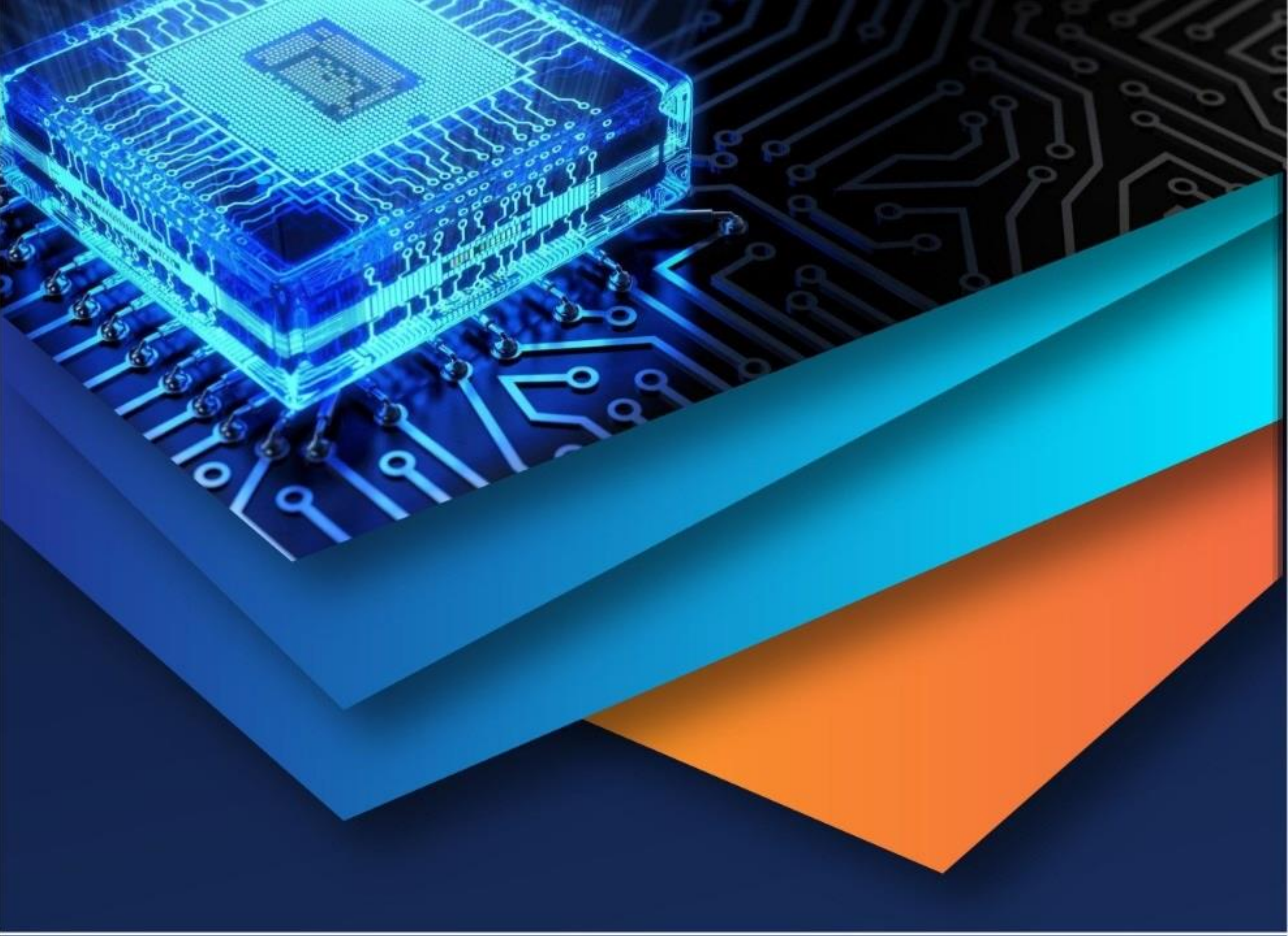

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