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AUTOMOBILE MUFFLER DEIGN FOR BETTER STRUCTURAL INTEGRITY USING FLUID STRUCTURE INTERACTION

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Abstract:

The present work focuses on the design of muffler for the structural integrity for checking the structural vulnerability for minimization of turbulence intensity. Three sizes of the muffler is selected based on the CFD analysis and the forces coming due to hot exhaust flow inside the chamber is considered for checking the structural parameters like shear and von-mises stress and deflection over its surface. The optimized model is selected based on the outcome of the simulation done using Finite element method for minimization of structural vulnerability for efficient design.

Keyword: ***Automobile muffler, CFD, FEM, turbulence intensity***

I. INTRODUCTION

As we know that silencers are used in automobiles for exhaust of flue gases formed in the strokes. If they are not properly removed out then it may badly affect the efficiency of engine and performance in later future. The formation and elimination depends on the design of silencer body. In this project, we are focusing on the different shape and sizes of silencer and their corresponding results for emission of flue gases. We are suggesting the modification in existing design if required.The main pollutant contributed by exhaust system of automobile is flue gases. Automobile is not the only source of air pollution other source such as electric power generation system.

An automotive muffler (or silencer) is a device for reducing the amount of noise emitted by an exhaust gas of engine and the exhaust gas blows out through this device and finally to the atmosphere. Mufflers are typically installed along the exhaust pipe as part of the exhaust system of an internal combustion engine to reduce its exhaust noise. The muffler accomplishes with a resonating chamber, which is specifically tuned to destructive interference of opposite sound waves that cancel each other, Catalytic converters also often have a muffling effect. The effect is mainly generated largely by restriction, rather than by cancellation.

OBJECTIVE:

- To design Muffler for the minimum structural vulnerability and for reducing noise.
- Fluid Dynamics and Structural Physics are two prominent disciplines inside the chamber.
- The CFD (Computational fluid dynamics analysis) is performed on different muffler shapes to calculate the pressure coming over its surfaces.

- The pressure is used as input in FEM(Finite Element Method) Analysis for checking the structural integrity of the different shapes.

II. FLUID STUCTURE INTERACTION

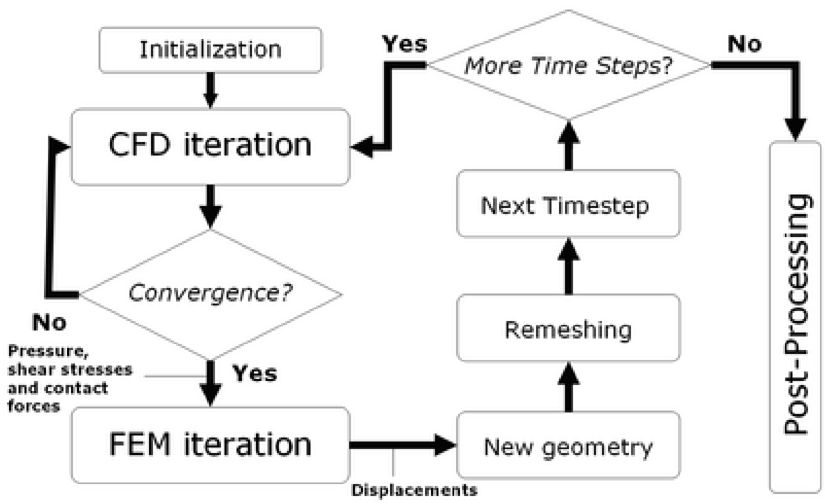

FIG. 1 FSI FLOW CHART

FSI Procedure

- Modeling the geometry of Muffler for the given dimensions
- CFD Boundary condition assignment: Pressure inlet and pressure outlet to the inlet and outlet of geometry
- CFD Initialization of pressure and velocity
- Solving CFD Equations i.e. momentum and continuity till convergence
- The output of CFD Analysis: Pressure on the walls
- Assignment of CFD output i.e. pressure on the walls as input for structural analysis using FEM (Finite element method)
- Application of Load i.e. pressure on the walls and constraining the muffler sides
- Solving FEM Equations to calculate the turbulence intensity using FEM Analysis.
- Repeating the above procedure for other cases

III. ANALYTICAL METHOD TO CFD RESULT AND DISCUSSIONS

Consider the conservation system defined by the equation,

- Turbulent Intensity (%) = Threshold Value / Average Total Domain Value

- Mathematically,

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$$I = u' / U$$

Where,

u'= Root mean square of turbulent velocity fluctuation

U = Mean Velocity

Particular	Case-1	Case-2	Case-3
Turbulent Intensity (%)	**62.16**	**44.29**	**47.98**

IV. FSI OF MUFFLER

Mufflers are installed within the exhaust system of most internal combustion engines, although the muffler is not designed to serve any primary exhaust function. The muffler is engineered as an acoustic soundproofing device designed to reduce the loudness of the sound pressure created by the engine by way of acoustic quieting. The majority of the sound pressure produced by the engine is emanated out of the vehicle using the same piping used by the silent exhaust gases absorbed by a series of passages and chambers lined with roving fiberglass insulation and/or resonating chambers harmonically tuned to cause destructive interference wherein opposite sound waves cancel each other out. An unavoidable side effect of muffler use is an increase of back pressure which decreases engine efficiency. This is because the engine exhaust must share the same complex exit pathway built inside the muffler as the sound pressure that the muffler is designed to mitigate.

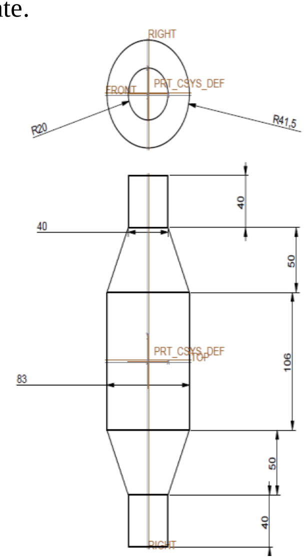

FIG. 2 DMODEL OF MUFFLER

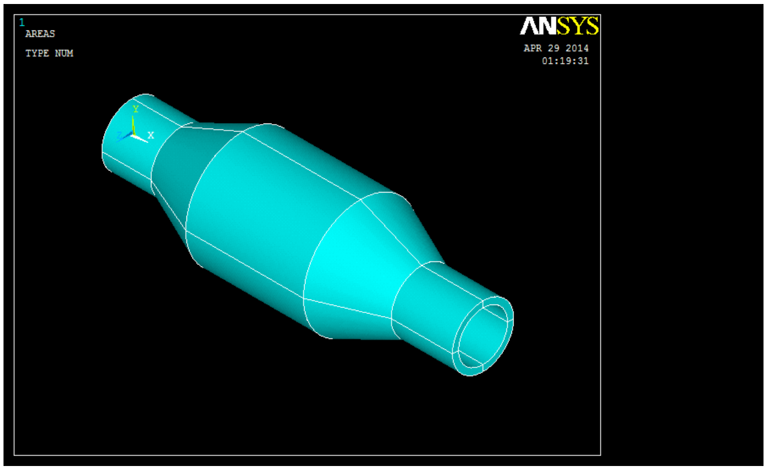

FIG. 3 MODEL OF MUFFLER GENERATION IN ANSYS

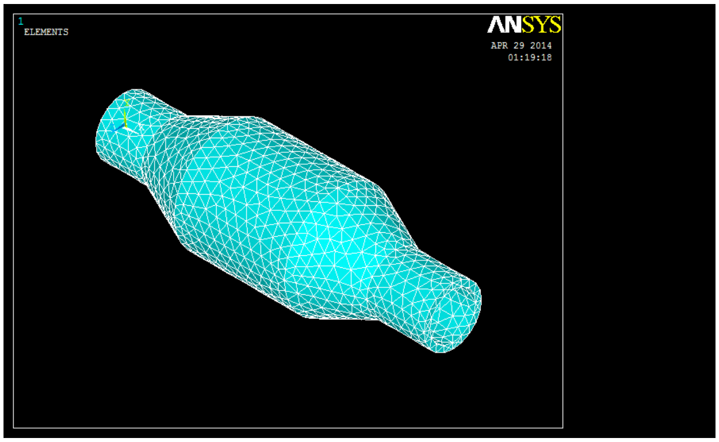

FIG.4 MESH MODEL

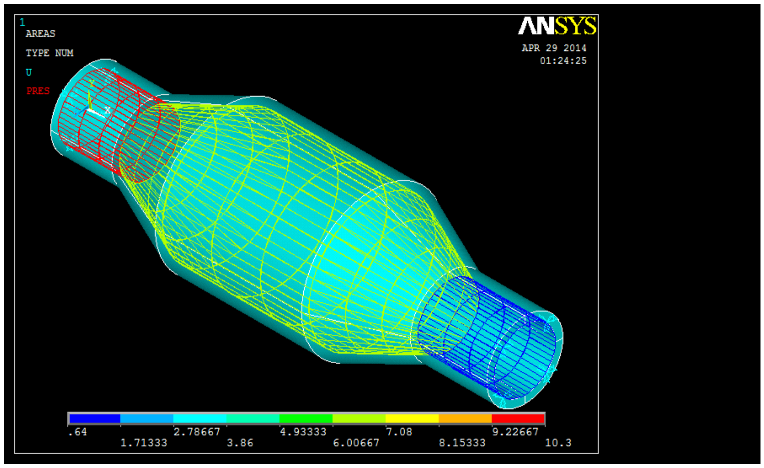

FIG. 5 BOUNDARY CONDITIONS

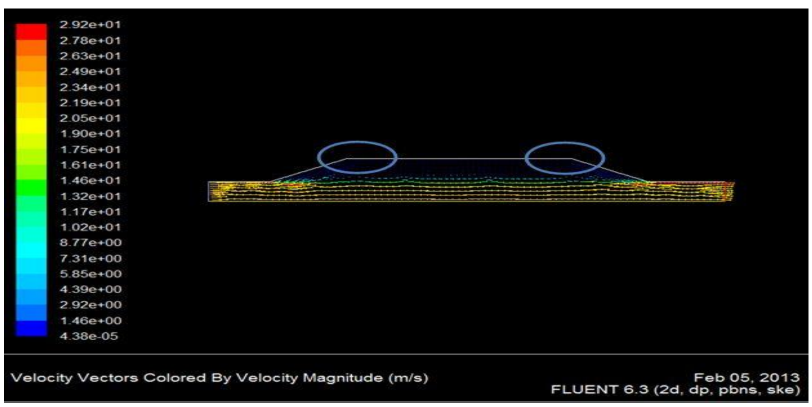

FIG. 6:- CONTOUR OF VELOCITY VECTOR

In this figure the maximum turbulence intensity at one grid point is more than 2 so there is highest turbulent intensity **as** compared to other two cases

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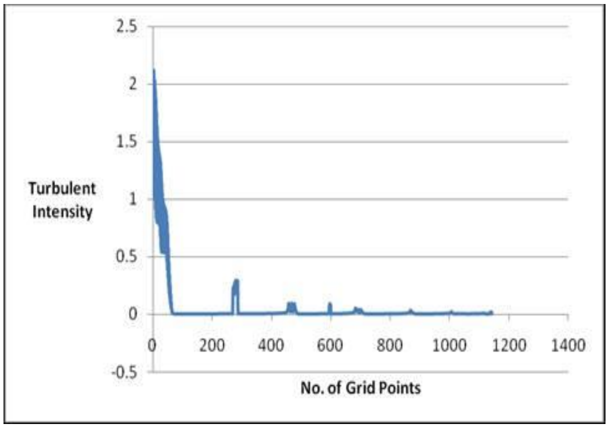

FIG. 7: TURBULENTGRAPH (CASE1)

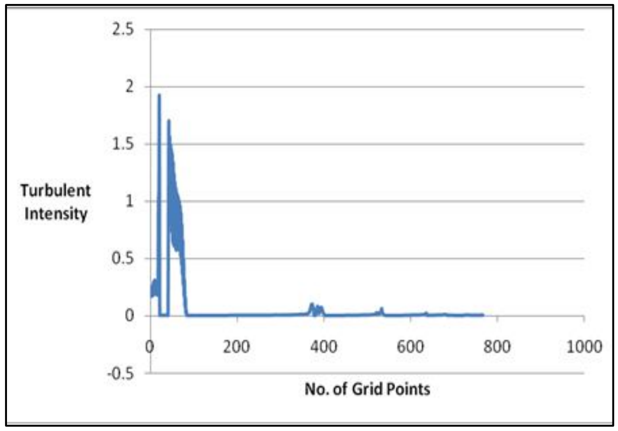

FIG. 8: TURBULENT GRAPH (CASE2)

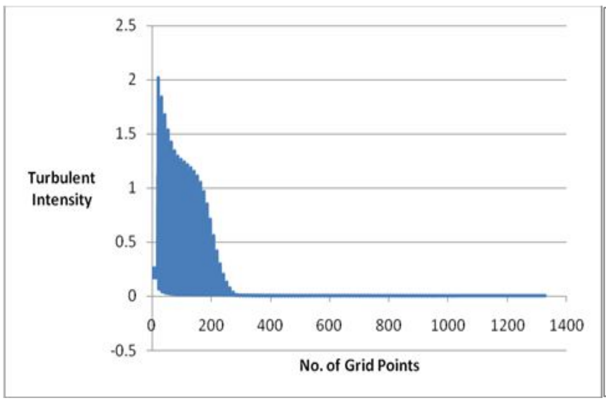

FIG. 9: TURBULENT GRAPH (CASE3)

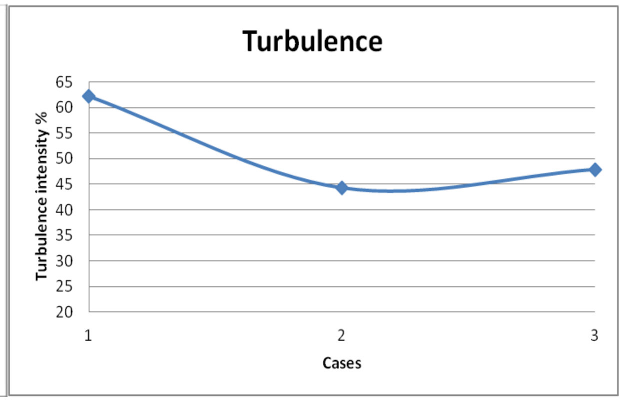

FIG. 10: FSI RESULTS

V. CONCLUSIONS

From the results, it is clear that turbulence is least for case 2 i.e. minimum noise generation The turbulence intensity is not changing significant for Case 2 and Case 3, as Case 3 has slightly higher value of turbulence intensity (47.7%) compared to case 2 (44.5%) Therefore, Case 3 is the better case compared to the other on the structural integrity basis as well as less turbulence intensity.

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