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DESIGNING AND OPTIMIZING THE EXHAUST MUFFLER IN AUTOMOBILES

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ABSTRACT: The primary goal of the continuing project is to increase the frequency of the NSD (Nash Shell Damper) muffler in order to efficiently manage the noise produced by a diesel engine. This is critical since exhaust noise is the most significant contributor to overall engine noise. A TATA INDICA TURBOMAX TDI BSIV automobile with a four-cylinder diesel engine was chosen for testing. The CAD models are developed using benchmarking, which entails measuring the Muffler's dimensions. The CAD models for the muffler are developed in CATIA V5 R19 and then transferred to HYPER MESH for extra pre-processing. The muffler is free-flow analyzed using NASTRAN software and the FEA method.
***Keywords* –** Automobile Exhaust system, Exhaust Muffler, free free analysis, Catia V5, FEM.

I. INTRODUCTION:

The main Components in engine exhaust system are as follows:

- Exhaust manifolds or EKE
- Catalytic converters
- Muffler
- Resonator
- Pipes and tubing

1. Exhaust manifolds or EKE

The engine expels high-pressure gases after completing the fuel combustion procedures.Pipes enable the flow of these gasses into the exhaust manifold.

2. Catalytic converter

The device can convert dangerous gases, such as nitrogen oxides (NO) and carbon monoxide (CO), into non-toxic gases, notably carbon dioxide (CO2) and nitrogen (N2). Diesel engines now frequently use "three-way" catalytic converters, which perform both oxidation and reduction reactions to reduce carbon monoxide and hydrocarbon emissions. Figures 2 and 3 show the detailed characteristics of a three-way catalytic converter.

Fig 1: Exhaust manifold or EKE

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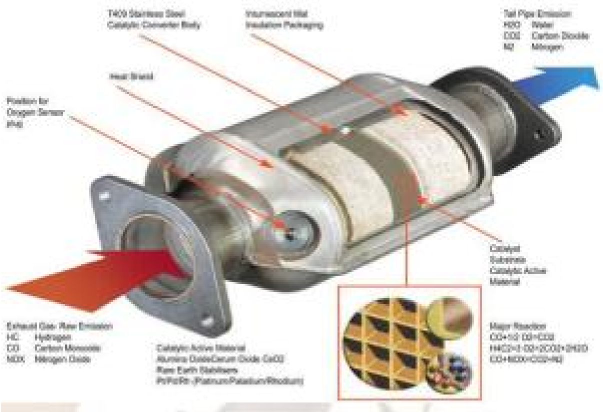

Fig 2: Three way Catalytic converter

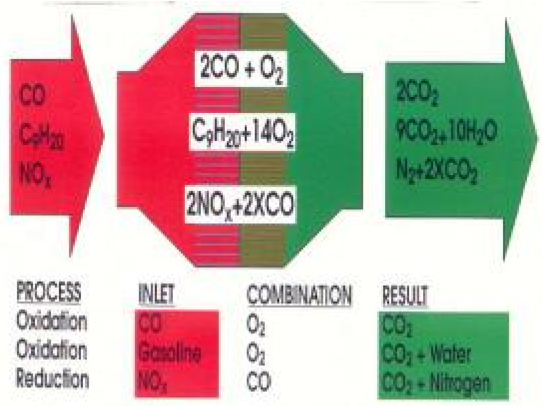

Fig 3: Chemical process in Catalytic converter

3. Mufflers:

A muffler is a device that lowers the decibel level released by a machine. To reduce noise, the engine's exhaust is sent through an exhaust pipe to a muffler, also known as a silencer.

There are several types of mufflers used in automobiles, including

1. Baffle type
2. Resonance type
3. Wave cancellation type
4. Combined resonance and absorber type
5. Absorber type mufflers.

Fig 4: Exhaust Muffler of TATA INDICA CAR Purpose of Muffler

- To lessen the noise generated by an automobile, a muffler is required.
- Mufflers use complex technologies to reduce noise.
- Silencers are fitted to the exhaust pipe of an internal combustion engine's exhaust system to minimize noise.
- The muffler reduces exhaust noise by allowing the exhaust gasses to expand gradually and avoiding pulsation.

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- Typically, it was made of sheet steel coated with aluminum to prevent corrosion. Stainless steel is used in a variety of applications.

II. DESIGN OF EXHAUST NSD MUFFLER USING CATIA V5 R19

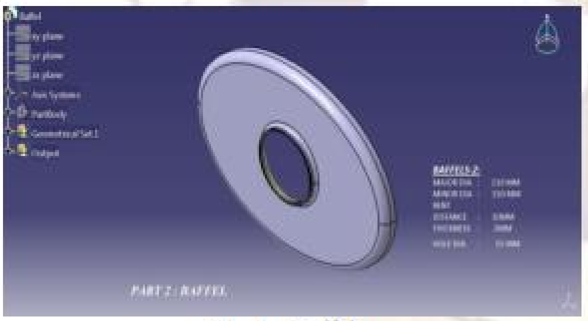

Fig 5: Baffel

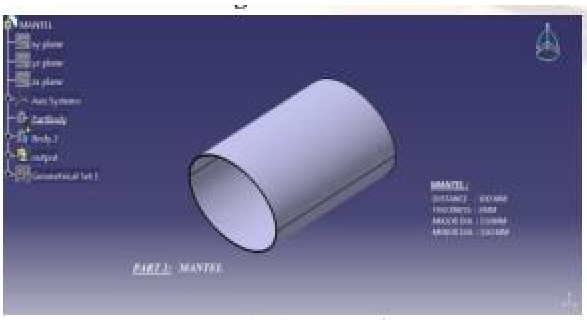

Fig 6: Mantel

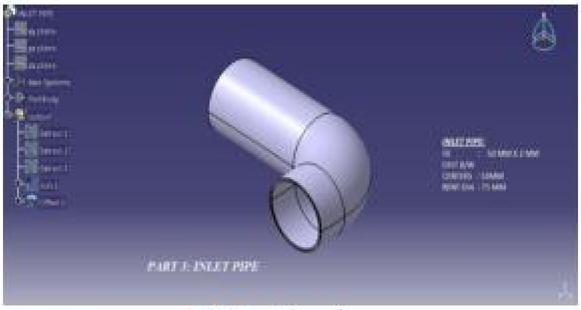

Fig 7: Inlet pipe

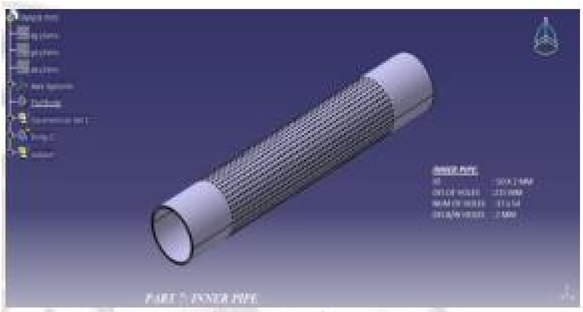

Fig 8: Inner pipe

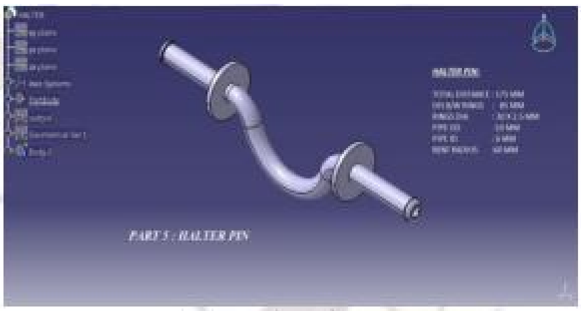

Fig 9: Halter pin

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Fig 10: Flange

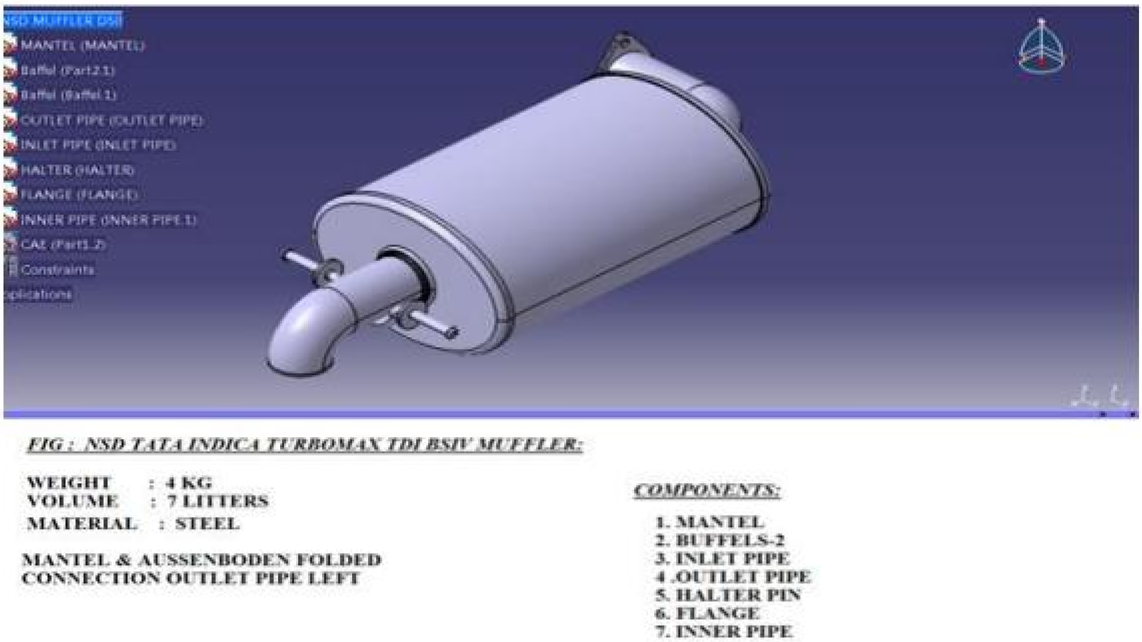

Fig 11: Assembly component

III. FINITE ELEMENT ANALYSYS:

The finite element approach currently allows for the computer resolution of a wide range of engineering issues. The advancement of this technology coincided with the expanding use of high-speed electronic digital computers and the growing emphasis on numerical approaches for engineering analysis.

- Matrix algebra
- Solid mechanics
- Variation methods
- Computer skills

STEPS In FEM As Follows:

Step i: Descritization of structure (Domain)

Step ii: Selection of DISPLACEMENT FUNCTION

Step iii: Derivation of element stiffness matrices and load vectors:

Step iv: Assemble of elements Stiffness matrices to obtain Gobal stiffnes matrix &equilibrium equations:

Step v: Solution of system equation to find nodal values of displacement and degree of freedom.

Step vi: Computation of element strains and stress.

- Pre-processor
- Solver
- Post-processor

Procedure For Nastran Analysis:

A static data collection can be analyzed using either linear or nonlinear methods. This study will concentrate on linear static analysis. The primary stages of the static analysis technique are as follows:

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1. Building the model.
2. Obtaining the solution.
3. Reviewing the results.

Table I Material Properties

Properties	
Name:	Alloy Steel
Yield strength:	6.20422e+008 N/m^2
Tensile strength:	7.23826e+008 N/m^2
Elastic modulus:	2.1e+011 N/m^2
Poisson's ratio:	0.3
Mass density:	7700 kg/m^3
Shear modulus:	7.9e+010 N/m^2
Thermal expansion coefficient:	1.3e-005 /Kelvin

IV. RESULTS

The current muffler has a frequency of 281 Hz. The new muffler was found to provide better engine and acoustic performance than the old one. The modification of the muffler required raising the thickness of the baffle from 2 mm to 3 mm, resulting in a maximum frequency of 381Hz. As a result, this study experimentally shown that Finite Element Analysis results can be adjusted and applied to a specific design.

Table II Units and Mesh Information

Pressure/Stress	N/m^2
Frequency	HZ
Angular velocity	rad / sec
Mesh type	Solid Mesh
Analysis type	Free free analysis
Total Nod	16947
Total Elements	19442
Maximum Aspect Ratio	10.777

Analysis type: Free free analysis

Software: Nastran

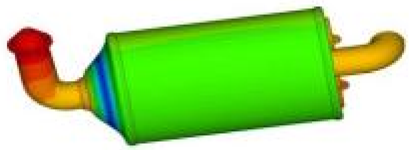


Fig 12: Analysis View of Exhaust Muffler Having baffle thickness 1mm

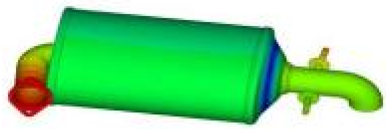


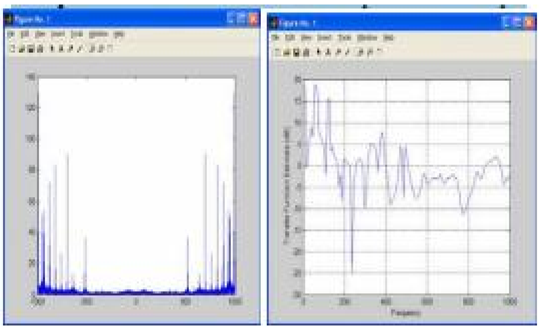
Fig 13: Analysis View of Exhaust Muffler Having baffle thickness 2 mm

Table III

Frequency Values

Baffle Thickness (mm)	Frequency (Hz)
1	255
2	359

Graphs: Transfer Function & Equivalent Graph



V. CONCLUSION AND FUTURE WORK:

The goal of this experiment was to develop and analyze the muffler system for no expense in order to determine the system's resonance frequencies and make design recommendations. The resonance frequencies for this investigation were calculated using the Nastran application. The system identified the most notable peaks. The analysis revealed that the muffler's side baffles were the most vulnerable sections. To reduce the influence of certain resonance frequencies, increase the thickness and damping of the system. Furthermore, higher order modes should be included in the transfer matrices to improve their performance. It is also required to incorporate the impact of a mean flow into the experimental setup. This broadens the frequency range across which the expected values can be depended upon.

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