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Design And Optimization Of Exhaust Muffler In Automobiles

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ABSTRACT

The present work aims at improve the Frequency of NSD (Nash Shell Damper) muffler by controlling the noise level of a diesel engine by developing an exhaust muffler for the same, since exhaust noise is the single largest contributor to the overall noise from the engine. The TATA INDICA TURBOMAX TDI BSIV four-cylinder diesel engine car was considered for test purposes. In this study Muffler dimensions are measured through the Benchmarking, to create CAD models. The CAD models are created in CATIA V5 R19, later these CAD models of muffler are exported to HYPER MESH for pre-processing work. Free Free analysis is carried out on this muffler by FEA Method using NASTRAN Software.

Keywords – **Automobile Exhaust system, Exhaust Muffler, free free analysis, Catia V5, FEM.**

I. INTRODUCTION:

The main Components in engine exhaust system are as follows

1. Exhaust manifolds or EKE
2. Catalytic converters
3. Muffler
4. Resonator
5. Pipes and tubing

1. Exhaust manifolds or EKE

After completion of fuel combusion procecs in engine,high pressure gases are realesed.These gases are enters into the Exhaust manifold through pipes.

2. Catalytic converter

It is a device used for convert harmfull gases like carbon monoxide(CO) ,nitrogen oxides(NO) into Harmless gases like CO2 and N2 etc., In present days "three-way" (oxidation-reduction) catalytic converters are widely used on diesel engines to reduce hydrocarbon and carbon monoxide emissions. Fig 2 and fig 3 shows details of three way catalytic converter.

Fig 1: Exhaust_manifold or EKE

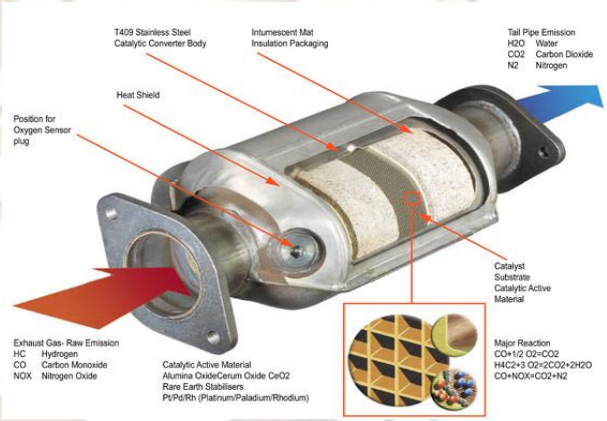


Fig 2: Threeway Catalytic converter

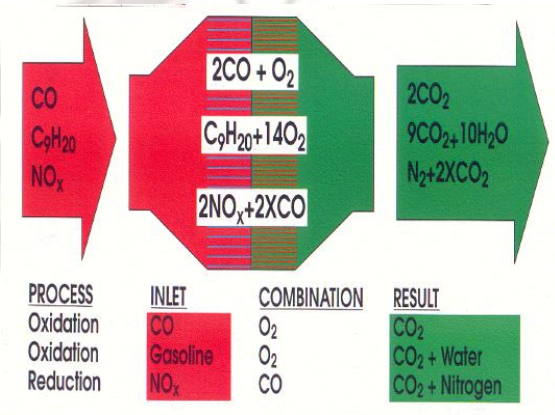


Fig 3: Chemical process in Catalytic converter

3. Mufflers:

The muffler is defined as a device for reducing the amount of noise emitted by a machine. To reduce the exhaust noise, the engine exhaust is connected via exhaust pipe to silencer called muffler.

The various types of mufflers used in automobiles are

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

- An automotive requires a muffler to reduce the amount of noise emitted by a vehicle.
- Mufflers use neat technology to cancel out the noise.
- Mufflers are installed along the exhaust pipe as a part of the exhaust system of an I.C. engine to reduce its exhaust noise.
- The muffler reduces exhaust noise by dampening the pulsations in the exhaust gases and allowing them to expand slowly.
- It was usually made of sheet steel, coated with aluminum to reduce corrosion. Some are made of stainless steel.

II. DESIGN OF EXHAUST NSD MUFFLER USING CATIA V5 R19

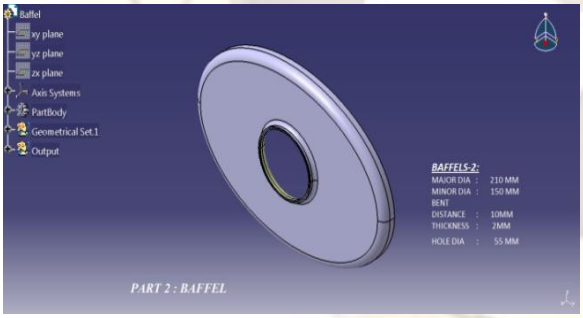


Fig 5: Baffel

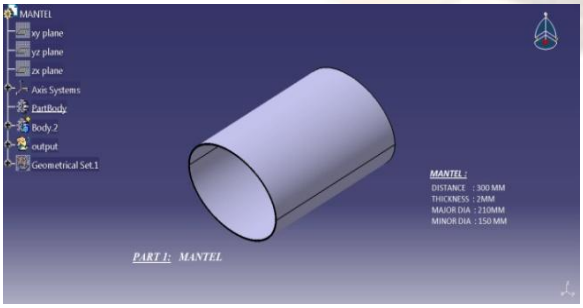


Fig 6: Mantel

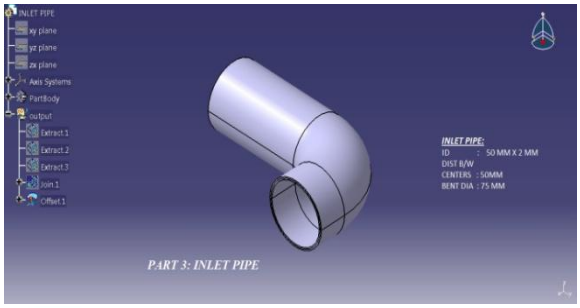


Fig 7: Inlet pipe

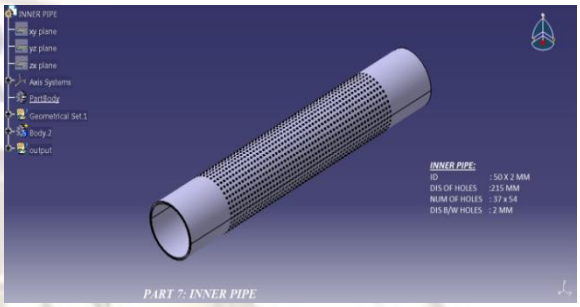


Fig 8: Inner pipe

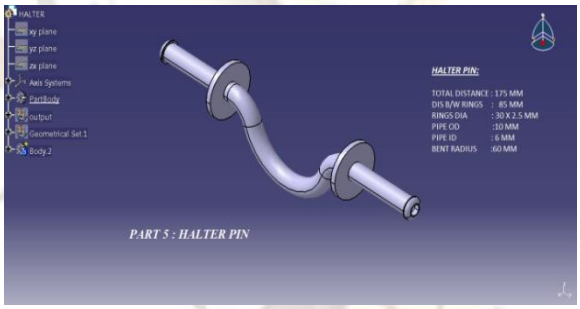


Fig 9: Halter pin

Fig 10: Flange

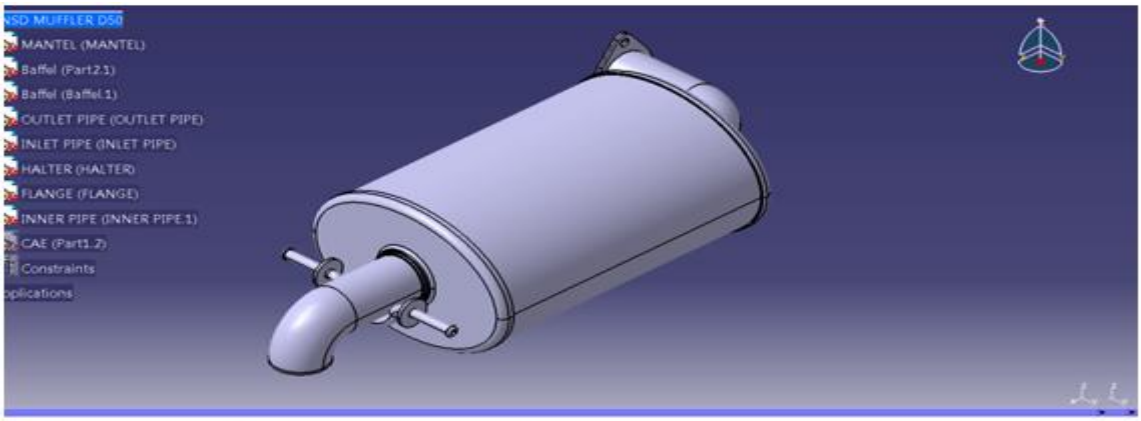


FIG : NSD TATA INDICA TURBOMAX TDI BSIV MUFFLER:

WEIGHT : 4 KG
VOLUME : 7 LITTERS
MATERIAL : STEEL

MANTEL & AUSSENBODEN FOLDED
CONNECTION OUTLET PIPE LEFT

COMPONENTS:

1. **MANTEL**
2. **BUFFELS-2**
3. **INLET PIPE**
4. **.OUTLET PIPE**
5. **HALTER PIN**
6. **FLANGE**
7. **INNER PIPE**

Fig 11: Assembly component

III. FINITE ELEMENT ANALYSYS:

The finite element method has become a powerful tool for the numerical solution of a wide range of engineering problems. It has developed simultaneously with the increase in use of the high speed electronic digital computers and with the growing emphasis on numerical methods for engineering analysis.

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

STEPS In FEM As Follows:

Step i: Descritization of structure (Domain)
Stepii: Selection ofDISPLACEMENT FUNCTION
Step iii: Derivation of element stiffness matrices and load vectors:
Stepiv: Assemble of element stifness 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, analysis can be either linear or non linear. In our present work we are going to consider linear static analysis. The procedure for static analysis consists of these main steps:

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 existing muffler having the Frequency of 281Hz. The new muffler was found to be superior to the existing one in terms of both acoustic performance and engine performance. With the new muffler, thickness of baffles modified 2mm into 3mm the maximum Frequency obtained was 381 Hz. The present work has thus experimentally shown that results from Finite Element Analysis can be modified and applied to an alternative 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

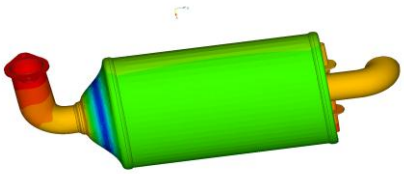


Fig 12: Analysis View of Exhaust Muffler Having baffle thickness 1mm

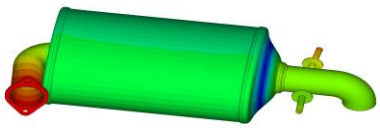
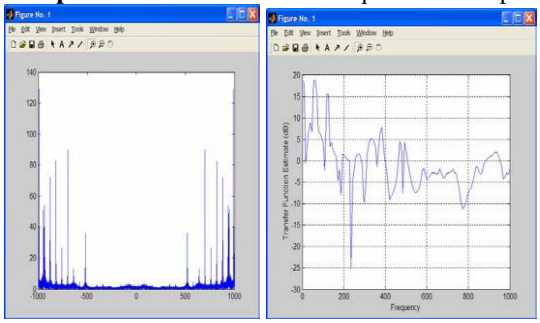


Fig 13: Analysis View of Exhaust Muffler Having baffle thickness 2 mm

Table III
Frequency Values

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

Graphs: Transfer Function & Equivalent Graph



V. CONCLUSION AND FUTURE WORK:

The purpose of this experiment was to conduct design and free free analysis of muffler system in order to determine the resonant frequencies of the system and suggest changes in the system design. For this analysis, Nastran software was used, In order to determine the resonance frequencies, were then compiled to determine which peaks were the most significant for the system. From the data, side baffles were selected as weak parts of the muffler. In order to minimize the effects of these resonance frequencies, the suggested design improvement is to add thickness and also add damping to the system.

Further work has to be done to include the effects of a mean flow in the experimental set up and, additionally, the inclusion of higher order modes in the transfer matrices, which should increase the frequency range in which the predicted values would be reliable.

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