THE DESIGN AND OPTIMIZATION OF EXHAUST MUFFLERS FOR AUTOMOBILE MANUFACTURERS

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ABSTRACT: The purpose of this research is to enhance the efficiency of the Nash Shell Damper (NSD) muffler so that it can better reduce the amount of pollution that is produced by diesel engines. This will be accomplished by building an exhaust filter that is specifically built for the purpose, given that the exhaust system is responsible for producing the majority of the noise that is generated by the engine. In order to conduct the tests, four-cylinder TATA INDICA TURBOMAX TDI BSIV automobiles were selected. In the current research, the comparison method was utilized to find out the size of the mufflers so that CAD models could be constructed. CATIA V5 R19 was used to construct the CAD models that were utilized for this inquiry. After the CAD models for the muffler had been completed, they were submitted to HYPER MESH so that the preprocessing could begin. The muffler undergoes exhaustive testing with the use of NASTRAN apparatus and the Finite Element Analysis (FEA) technique.

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

1. INTRODUCTION

The following is a list of the most important parts that make up the engine exhaust system:

➤ Components of automotive exhaust systems include resonators,

➤ Mufflers,

➤ Catalytic converters,

➤ Exhaust manifolds,

➤ Exhaust headers.

Exhaust manifolds or EKE

At the conclusion of the fuel combustion process, the engine releases high-pressure gasses into the atmosphere. Conduits carry the gases to the exhaust manifold where they are collected.

Catalytic converter

The suggested system is capable of converting potentially harmful gases like nitrogen oxides (NO) and carbon monoxide (CO) into less harmful gases like nitrogen (N2) and carbon dioxide (CO2). In modern diesel engines, oxidation-reduction catalytic converters, also known as three-way catalytic converters, are used extensively in order to lower emissions of carbon monoxide and hydrocarbons. A three-way catalytic converter is broken down into its component parts in images 2 and 3.

Fig 1: This is one of the most vital parts of an internal combustion engine, often known as an EKE.
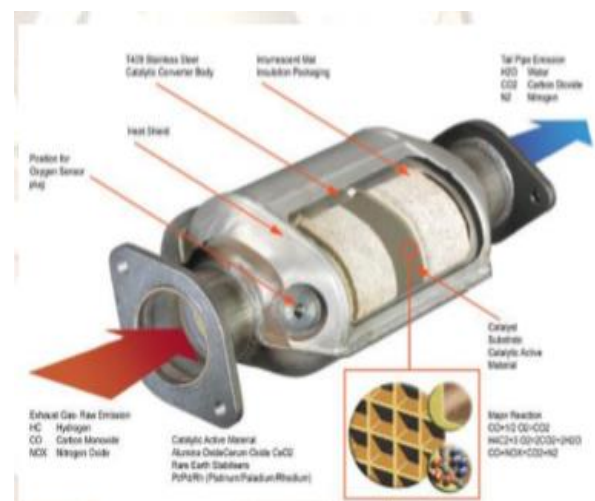

Fig 2: Automobile exhaust systems typically feature a three-way catalytic converter as a means

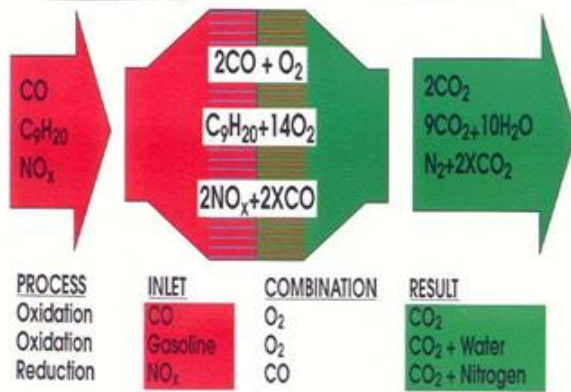of reducing the amount of harmful pollution discharged into the environment.

Fig 3: The catalytic converter is an essential component of the chemical system that reduces the amount of pollutants caused by automobile exhaust.

Mufflers:

It is possible to think of the muffler as an element that is responsible for reducing the amount of noise that is produced by a machine. The byproducts of the engine are transported through the exhaust conduit to the muffler, where they are rerouted so that there is less noise.

This results in a lower overall level of commotion being produced.

➢ Mufflers come in a wide variety of configurations,

➢ With the most common ones being baffle,

➢ Resonance, wave cancellation,

➢ Combined resonance and absorber,

➢ Absorber.

➢ These mufflers are typically seen in automobiles.

Fig 4: The resonator that was located on the back of the Tata Indica and was responsible for expelling the exhaust.

Purpose of Muffler

➢ In order to lessen the amount of noise that is produced by a vehicle, it must have a muffler.

➢ Mufflers make use of modern technologies to effectively reduce the amount of pollutants released.

➢ Mufflers are a common component found in the exhaust systems of internal combustion engines. Their primary function is to dampen the sound pollution caused by the engine's output.

➢ The muffler allows the exhaust gases to gradually expand and slow down their vibrations, which results in a reduction in the amount of noise produced by the exhaust.

➢ In order to reduce its susceptibility to corrosion, it was frequently fabricated out of sheet steel that had been treated with aluminum. Stainless steel is a versatile metal that may be fabricated into a wide range of products.

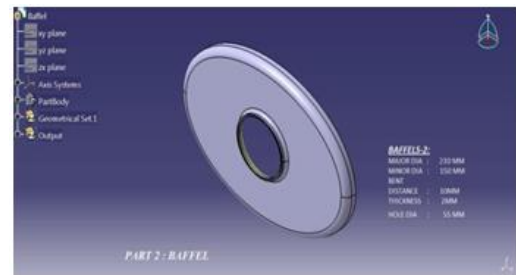## 2. DESIGN OF EXHAUST NSD MUFFLER USING CATIA V5 R19

Fig 5: People often struggle to comprehend what is meant when they use the word baffel to refer to the concept or item in question.
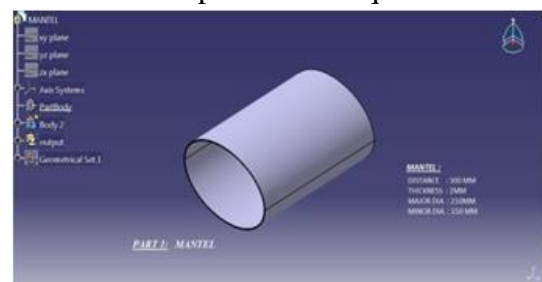

Fig 6: In the context of a fireplace, a mantel can refer to either a piece of built-in furniture or a shelf that is positioned directly above the hearth.
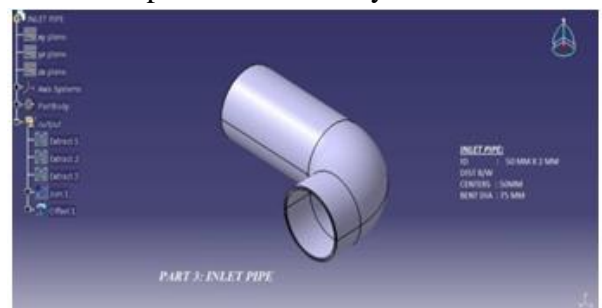
Fig 7: Through the input pipe of a device or machine, fluids or gases may be introduced into the device or machine.
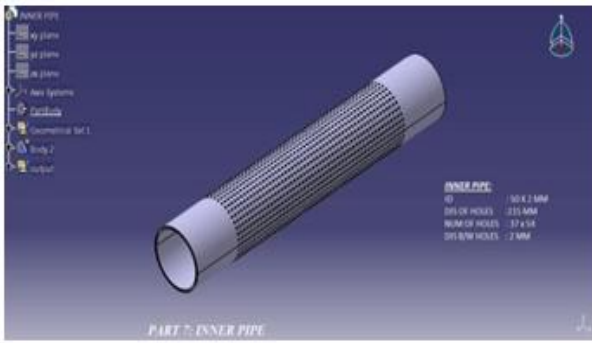

Fig 8: The configuration referred to as a inner pipe is one in which one cylinder structure is contained within another cylinder structure.
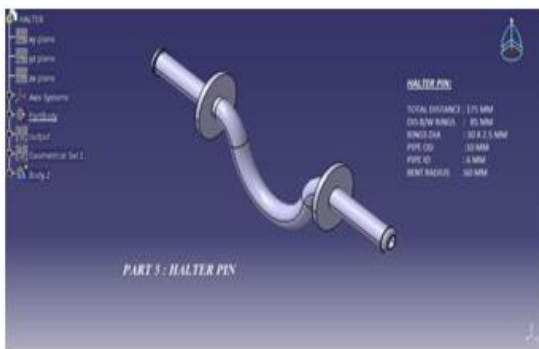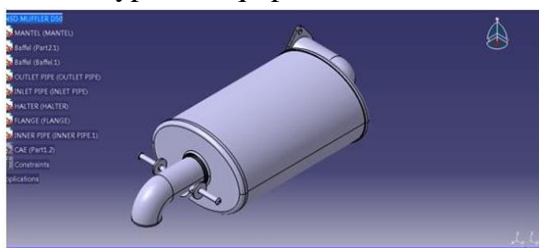

Fig 9: A halter pin is a popular type of attaching device that is utilized in equestrian equipment, particularly in the saddle.

Fig 10: A piece of equipment known as a flange is utilized in the process of connecting two pipes or other types of equipment to one another.

Fig 11: The construction industry and the manufacturing industry both rely heavily on the assembly industry. The term component refers to an independent element or section that is incorporated into another whole.

3. FINITE ELEMENT ANALYSYS

It has been demonstrated that the finite element method is capable of successfully resolving a wide variety of challenging engineering problems. In recent years, there has been a concomitant increase in the use of numerical methods for engineering research along with the proliferation of the use of more powerful digital computers.

➤ Matrix algebra, solid mechanics, variation techniques, and computer proficiency are some of the topics that pique people's interest in learning more about them.

STEPS In FEM As Follows:

The initial step in the process is discretizing the structure, also known as the domain.

The second step is to establish the reason for the replacement. Calculate the load vectors and stiffness matrices for each component as part of Step III of the process.

The construction of the element stiffness models constitutes the initial stage of the technique. The second step is to obtain the global rigidity matrix after first compiling the matrices that represent the stiffness of the elements. In the third step, equilibrium formulas are eventually constructed by employing the global stiffness matrix as a resource.

The investigation is now at its fifth stage, which has just commenced. By solving the equation for the system, one can derive the nodal values of motion as well as the degrees of freedom.

After that, it is necessary to ascertain the loads and stresses that are present in the elements.

The pre-processor, the solution, and the post-processor make up the computer's three components.

Procedure For Nastran Analysis:

Linear and non-linear investigations are the two categories that make up the category of simple investigations.

➤ The study of linear static analysis will be the primary topic of this class. In static analysis, there are a few steps that are particularly

important.

➤ The process consists of the following steps: constructing the model, obtaining the solution, and analyzing the outcomes.

Table I All of the aforementioned are umbrella phrases that are utilized when describing the qualities and advantages of certain drugs. These features offer vital insights into the behavior and capabilities of the entities being discussed.

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

4. RESULTS

This muffler has an active frequency of 281 Hz at the moment. A comparative analysis found that the newly designed muffler functioned more effectively with the vehicle's engine and generated far less noise than its predecessor. The maximum frequency of the new muffler was determined to be 381 hertz after the wall thickness was increased from 2 millimeters to 3 millimeters. According to the findings of this research, the results from a finite element analysis can be modified and incorporated into a different design by making use of experimental methods.

Table II Particular emphasis is being given to the intricacy and units of the mesh.

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

Unconstrained Analysis is the type of analysis being performed.

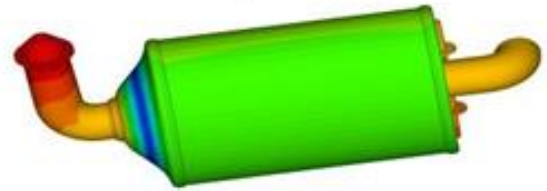The program known as Nastran is the subject of this conversation.

Fig 12: This page provides a comprehensive examination of the exhaust muffler. The thickness of the shield is 1 millimeter.


Fig 13: from the point of view of the examination of the exhaust pipe. It is required that the shield be constructed with two millimeters.

Table III The numerical representations of the frequencies

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

Graphs: The transfer function and the graph that goes along with it are fundamental ideas in control systems. The transfer function is a mathematical representation of the link that exists between the inputs and outputs of a system. In the process of planning and analyzing control systems, it is utilized rather frequently. The representation of the transfer function looks like this:
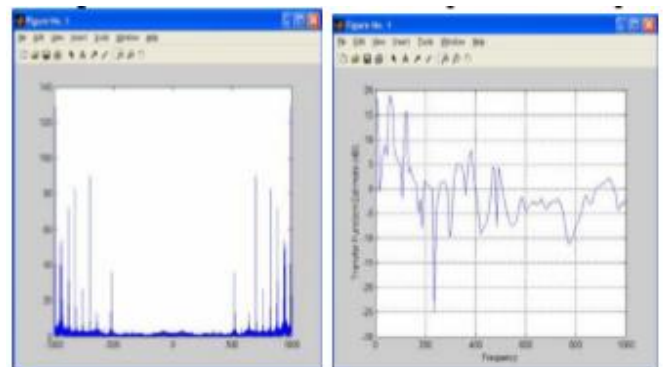
5. CONCLUSION AND FUTUREWORK

The purpose of this experiment was to determine the resonance frequencies of the muffler system and to make some suggestions for improvements to its design. This was accomplished by looking at

the design of the system and the vibrations that occurred on their own. The Nastran tool was utilized in order to arrive at the results for this challenge's resonance frequencies. The information that was gathered was then put to use in order to locate the system's most prominent peaks. According to the examination of the data, the side apertures can make the muffler system less effective. The thickness of the system should be increased, and dampening devices should be implemented if the design is to be improved so that the impacts of resonance frequencies can be reduced.

Additional study must be conducted before the influence of a mean flow may be incorporated into the experimental configuration. In addition to this, it is of the utmost importance to solve the issue of including higher order modes in the transfer matrices. As a consequence of this modification, the frequency range in which it is more likely that the values that have been predicted are accurate should be widened.

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