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MODELLING AND 3D-PRINTING OF 4-WHEELERMUFFLER (SILENCER)

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ABSTRACT

The primary function of an automobile muffler is to reduce engine noise by dampening the sound produced by the combustion process as it passes through the exhaust system. Mufflers are engineered to meet specific targets for noise reduction and backpressure. Modern exhaust systems are designed to minimize noise and emissions while maximizing durability, safety, flow rates, and cost-effectiveness. Attributes such as vibration, acoustics, thermal distribution, durability, flow, power loss, and integration with the vehicle are also considered in exhaust system design.

3D printing, a form of additive manufacturing, builds three-dimensional objects by depositing successive layers of material. It offers advantages such as speed, affordability, and ease of use compared to other additive manufacturing technologies. The term "3D printing" is increasingly used to encompass all additive manufacturing processes. Its value has been steadily increasing across various sectors, including manufacturing and defense, due to its costeffectiveness, efficiency, and user friendliness.

Keywords: Muffler, Noise, 3D Printing, Rapid Prototyping, Design

I. INTRODUCTION

Muffler

Fig.1 Cross sectional view

Mufflers are typically installed within the exhaust system of internal combustion engines, primarily serving as acoustic soundproofing devices to reduce engine noise. They achieve this by absorbing and

dissipating the sound pressure generated by the engine through a series of passages and chambers lined with materials such as fiberglass insulation. This design aims to create destructive interference, where opposite sound waves cancel each other out, thereby reducing noise.

However, an unavoidable consequence of muffler use is an increase in back pressure, which can decrease engine efficiency and power. Performance-oriented mufflers and exhaust systems seek to minimize back pressure while attenuating sound using various technologies and methods. Despite efforts to balance power and noise, many high-performance exhaust systems tend to produce more noise.

Noise Pollution Control:

Table-1:Pollution Control

Area	Day time noise limit (dB)	Night time noise limit (dB)
Industrial area	75	70
Commercial area	65	55
Residential area	55	45
Silence zone	50	40

To address noise pollution, the Central Pollution Control Board established a committee that recommended noise standards for both ambient air and automobiles across different zones. These noise limits for vehicles were incorporated into the Environment (Protection) Amendment Rules of 2000. Noise limits applicable to vehicles at the manufacturing stage, effective from April 1st, 2005, were specified accordingly.

NOISE STANDARD IN INDIA

The Noise Limits for vehicles were notified by Environment (Protection) Amendment Rules, 2000. Noise limits for vehicles applicable at manufacturing stage applicable from 1st April, 2005 are as given in the table below: Table 1.2 Noise Limits for Vehicles

Table-2:Noise standards in India

Categories	Noise limit in dB
Motor cycle and scooter	75 to 80
Three Wheelers	77 to 80
Passenger cars	78 to 80
Transport Vehicles	77 to 80

WORKING OFMUFFLER

Mufflers are primarily designed to mitigate the loud noises generated by the engine's pistons and valves. As the exhaust valve opens, the burned gases produced during the engine's combustion are released into the exhaust system, creating powerful sound waves. Understanding the principles of sound generation is crucial to grasp how mufflers function. Sound is essentially a pressure wave resulting from vibrations, characterized by alternating high and low air pressure pulses.

As high-pressure gases enter the exhaust system, they interact with low-pressure molecules, giving rise to pressure waves (sound) that propagate through the exhaust system. Destructive interference is a phenomenon where sound waves can be neutralized. This occurs when a pressure wave that is the exact opposite of the initial sound wave is introduced, leading to the cancellation of sound.

The design of mufflers is straightforward yet precise. Inside the muffler, there are perforated tubes that guide the sound waves through the muffler and eventually out of the system. Sound waves initially enter through a central tube, strike the back wall, pass through a hole into the center chamber, and then traverse another hole into the resonator chamber located near the front of the muffler. Some of the sound waves reflect off the walls of the center chamber, contributing to the process of sound cancellation.

II. LITERATURE SURVEY

Vijay M. Mundhe highlights the significance of mufflers within engine systems for mitigating exhaust gas noise levels. A thorough examination of existing literature underscores that the noise level of exhaust gas is contingent upon several factors. These include the geometry of the muffler, extensions in inlet and outlet valves, as well as the number and diameter of perforations Balraj D. Kawade and Niranjan D. Khaire delved into design alternatives for automobile silencers. Silencers play a crucial role in reducing the noise and vibrations produced by exhaust gases, which exit the engine at high speeds and temperatures. However, these components are prone to thermal, vibration, and fatigue failures, leading to the formation of cracks. Therefore, it is imperative to analyze the vibrations to inform future projects aimed at minimizing cracks and enhancing the longevity and efficiency of silencers.

Prof. Bharat S. Patel, Kuldeep D. Patel, and colleagues, the focus was on addressing air pollution stemming from mobile sources, a matter of widespread concern. With the projected growth of the vehicle population nearing 1.3 billion by 2030, there's an increasing issue of incomplete combustion within engines, resulting in emissions of incomplete combustion products such as CO, HC, NOx, and particulate matter. This review paper examines automotive exhaust emissions, their environmental impacts, and the role of platinum-group metal-based catalysts in catalytic converters for emission

control. It discusses the history, types, limitations, and achievements of catalytic converters.

Vinay Gupta and colleagues outlined the initial stage in designing an exhaust system, focusing on modeling the system using SolidWorks software and comparing the deformation of silencer parts made from different materials under the same exhaust thrust. The study plays a crucial role in determining the lifecycle of silencers.

M. L. Munjal discussed recent advancements in muffler acoustics, highlighting challenges such as size constraints, back pressure limitations, and cost concerns. Achieving sufficient insertion loss at engine firing frequencies and controlling breakout noise from muffler shells and end plates were identified as major challenges. Breakthroughs have been made in predicting and managing breakout noise, as well as modeling diesel particulate filters and inlet air cleaners acoustically.

S. Balamurugan and team designed a muffler for a four-stroke diesel engine, incorporating baffle arrangements to impede exhaust flow from the engine. The exhaust pipe design aimed to safely expel toxic gases away from users and ensure heat resistance to prevent damage. This design contributes to ecofriendly vehicle production by reducing toxic exhaust emissions, fuel usage, and back pressure, thereby increasing the range of continuous exhaust flow.

Xiaofeng Shi and Cheuk-Ming Mak investigated wave propagation in microperforated tube mufflers through theoretical, numerical, and experimental approaches. They found that micro-perforated tube mufflers provide effective sound attenuation due to their high acoustic resistance and low mass reactance. Arranging multiple microperforated panel absorbers in parallel enhances absorption bandwidth compared to single absorbers. The periodic distance of perforation significantly influences sound attenuation within certain frequency ranges.

III. METHODOLGY

This methodology explains the step by step process which are carried out to accomplish the completion of entire modelling and 3Dprinting of 4 wheeler Muffler. Using Solid works, the computer model of Muffler will be designed. The 3D-model design is then printed by using the 3D printer. The 3D model of Muffler is printed by using Fused deposition Modelling technique.

Acrylonitrile butadiene styrene(ABS) and Polylactic acid(PLA) are basically used material for preparing a model in 3D printing. The use of 3D printing technology

allowed for the customization of the Muffler design and the creation of complex geometries that would be difficult or impossible to produce using traditional manufacturing methods.

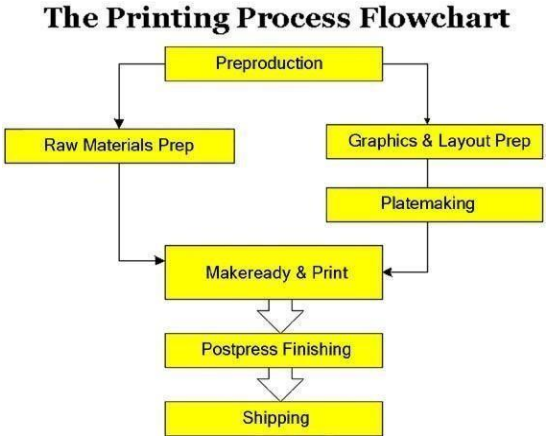

Fig-2:Printing process flow chart

MODELLING OF MUFFLER

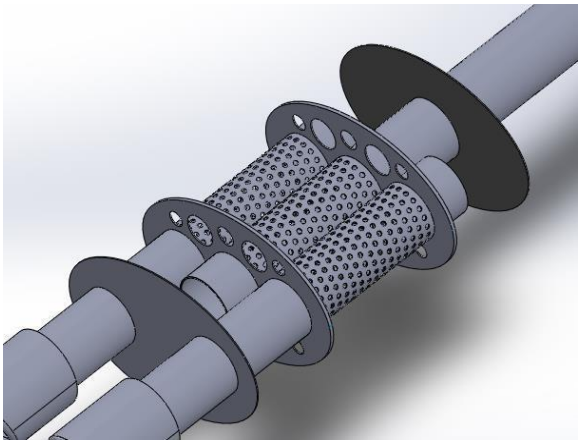

Fig-3:Model of Muffler

PRINTING OF MUFFLER

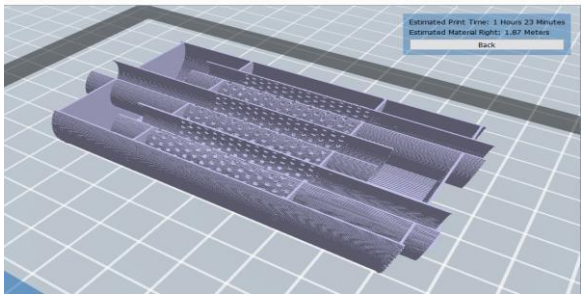

Fig:4:Printing of Muffler

CONCLUSION

The prototype of 4-wheeler muffler is designed in solid works software and then it is printed by using 3d printer. The proposed has the reduced weight by changing the manufacturability. Designing this new silencer reduces the number of parts for simplifying the assembly process. The ability to create intricate and tailored designs using 3D printing technology provides a level of flexibility previously unseen in traditional manufacturing

processes. This adaptability allows for the 4wheeler muffler specifications to meet specific project requirements, ultimately improving performance and productivity on construction sites. This digital 3d modal is converted into a set of instructions for the 3d printer which is called slicing process. Then the 3d printer will take the input and it will build the required 4-wheeler muffler. A simple model of muffler is designed which can reduce the noise pollution.This

4wheeler muffler model is properly designed in the designing software i.e., Solid Works and perfectly printed by the 3d Printer.

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