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DESIGN & ANALYSIS OF REACTIVE SILENCER FOR NOISE CONTROL AND WEIGHT REDUCTION

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Abstract:

IC engines are one of the major sources of noise pollution. Mufflers are generally found with exhaust system. After the combustion the high intensity gas with high pressure passes into the muffler chamber and some of the gas gets reflected back and passes through the combustion chamber causing back pressure. It creates vacuum pressure in combustion chamber and decreases the engine performance. In addition, the presently available reactive silencers are pretty heavy. Hence, the reduction of weight and improved capability of noise absorption by the muffler with minimal back pressure can result in increased performance of the engine. This project mainly targets on designing a muffler to reduce the noise, weight and back pressure. The designed muffler is analyzed for determining thermal, acoustic and flow properties. Two different materials namely steel and aluminium are chosen for the analysis. Based on the results we come to know that the newly designed muffler made of steel gives better performance than aluminium.

Key Words: Exhaust System, Muffler Chamber, Weight Reduction & Noise Control

1. Introduction:

Mufflers are widely used in mechanical systems and obviously affect the comprehensive property of mechanical systems. Its acoustic attenuation performance has been researched by many scholars. Early studies are mostly based on the assumption that the medium inside the muffler is static ideal gas. But, this assumption is not consistent with the actual situation. In fact, mufflers are often used to attenuate the noise from fluid machines, the existence of high velocity airflow may affect the propagation and attenuation of sound wave. Therefore, some scholars discussed the acoustic attenuation performance of muffler under the non-static gas condition. The flow field was assumed to be uniform, that is, the fluid motion of every part has same effect on the propagation and attenuation of sound wave, and the wave equation was deduced in this case. Then, the effect of uniform flow on the acoustic attenuation performance of muffler was explored by experiment, theoretical analysis and numerical simulation. Though the assumption above simplified the flow field inside the muffler and the research, the effect of practical flow field on the propagation and attenuation of sound wave has not been truly reflected. Actually, flow field inside the muffler is very complex and the effects of airflow at all places are not consistent. Thus, the prediction method of acoustic attenuation performance for the muffler with non-uniform flow was discussed. Consequently, the results become closer to the truth. In this project, a muffler is designed using SOLIDWORKS 2018 and analysed using ANSYS version 19.1.

2. Literature Review:

Vaibhav D Prajapati, Ankit J Desai Department of Automobile Engineering Cgpit, Uka Tarsadia University, Bardoli, Gujarat, India found that, noise pollution is a very crucial problem for today's life, so to reduce noise level sound proofing is necessary. Muffler is a very important part of the vehicle exhaust system to reduce the noise produced by engine combustible products when passing through the exhaust system. A conventional muffler of Maruti-Suzuki WagonR is taken as reference and depending upon parameters new muffler is designed and modelled in software and analysis will be done numerical codes. Analysis ease the design parameters to be change, so that an appropriate design can be generate and maximum amount of noise reduction and pressure drop takes place with minimum back pressure. Comparison of conventional muffler and proposed designed muffler is based on amount of noise reduction, pressure drop and muffler life.

Jayashri P. Chaudhari, Amol B. Kakade suggests in their paper that internal Combustion engines exhaust noise pollutes harmful in environment. That is the reason of reduction of exhaust noise & emission from the engines is a critical issue, nowadays. Any type of engine exhaust noise is controlled by utilizing the silencers/mufflers. Attaching a muffler in the exhaust pipe is the most efficient method for reducing the noise. However, muffler requires particular design and development by considering different noise parameters produced by the engine. Here different design parameters with ammonia pulsates have been considered to improve the efficiency & emission control of the absorptive muffler. Aim of this work is to design, develop and analysis of mathematical modelling and derivation of dimensional parameters of absorptive muffler with ammonia pulsator using UG NX-8.0 and ANSYS workbench. The formulated muffler traditional design problem will be solved by new design and optimization.

Praveen. R, S. Kalyana Kumar Mohamed, Rafi, Mufash Ali, Raj Bharath say that,the paper deals with the design of a commercial automotive muffler, which is being used in current automobile vehicles. Initially the muffler is designed in the basic 3D modelling can be done using commercial CAD software package and can be imported into Commercial FEM software using a neutral file format. The propensity to model these mufflers relies vastly on the thermal performance of the material, impedance and the perforations. In muffler the hot gases passes through, which may affect the properties of the muffler. So we have analysed the thermal properties of the muffler and defines the heat transfer occurring inside the muffler. The heat flow causes the variation in the properties of the muffler. In the literature review survey, various journals were referred in order to gain information and

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improve from the mistakes and errors those other authors and papers have faced. This way we can rectify our errors based on the experience of people who have already researched on this. The main aim of the literature survey is to reduce research time and gain experience in the topic.

3. Design of Muffler:

Generally an exhaust muffler is required to satisfy some basic requirements such as adequate insertion loss, low back pressure, muffler sizing which could affect the cost and durability to withstand with rough use, some considerations should be taken for an optimal muffler design.

- Mufflers with extended tube chambers are better than simple chambers.
- There might be a slight difference in insertion loss with flow reversal chambers compared to extended tube.
- The efficiency increases with no. of chambers.
- The increase in the number of chambers generally increases the insertion loss at higher frequencies but decreases it at lower frequencies.

Figure 1: Isometric view

A muffler has to be designed by super critical grade type and it includes three attenuation principles i.e., reactive, followed by absorptive muffler, and a side branch resonator. The interesting events of the design are continuous volume reduction of chambers in the reactive part; the flow pipe cross sectional area is maintained constant throughout, the placing of side branch resonator compactly, a layer of insulation outside the reactive part, option for tuning the resonator using a screw and cylinder.In order to choose a suitable muffler type, some basic information are necessary with respect to how industrial mufflers work. Mufflers attenuate noise by two methods such as reactive attenuation and absorptive attenuation. The first method, reflects sound energy back towards the noise source and second method, absorbs sound by converting sound energy into the small amounts of heat.

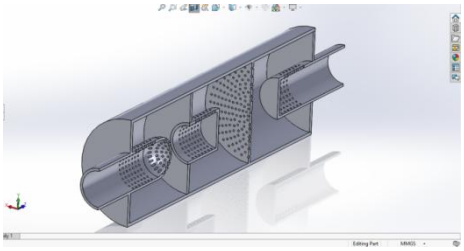

Figure 2: Cut Section 1

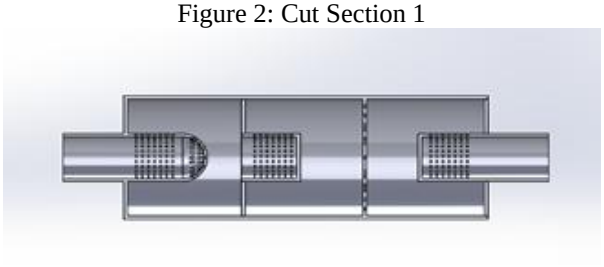

Figure 3: Cut Section 2

There are three types of industrial mufflers that use these methods to attenuate facility noise reactive muffler, absorptive muffler and anyone or both of them combined with resonator. The proper selection of a muffler is done by matching the attenuation characteristics of muffler to the noise characteristics of the source, while still achieving the allowable muffler power consumption caused by muffler pressure drop. Industrial noise sources are divided two categories with specific characteristics. Category - I cover sources that produce mainly low frequency noise and can tolerate relatively high pressure drops. Engines, rotary screw compressors, rotary positive blowers and reciprocating compressors are types of these sources. The nature of these machines is to generate low frequency noise and have pressure volume relationships that are quite tolerant of system pressure drop; such machines are perfectly suited for reactive mufflers. Category - II covers sources that produce mainly high frequency noise and have performance is very sensitive for system pressure losses. These sources are always moving or compressing the fluid with spinning blades. For examples, includes turbines, centrifugal fans, etc. This kind of equipment is best treated with absorptive muffler for both low and high temperature applications.

An absorptive muffler consists of a perforated tube which is installed at the end of exhaust pipe. The perforated tube may have holes with different diameters and the purpose of providing the different diameters hole is to separate gas mass to form smaller gas bubbles. Generally four sets of holes are drilled on the perforated tube and at the other end of the perforated tube are

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closed by plug. Around the circumference of perforated tube a layer of activated charcoal is given and further a metallic mesh covers it. The entire unit is then placed in a water container. A small opening is given at the Top of the container to remove the exhaust gases and a drain plug is given at the bottom of the container for periodically cleaning the container. Also a filler MD2 - 45 4 plug is attached at the top of the container. At the inlet of the exhaust pipe a non-return valve is provided which prevents the back flow of gases and water too.

4. Analysis of Muffler:

Mainly we have chosen two materials for our study and design making namely steel and aluminium. Few tests were conducted based on its physical properties such as Density, Verticity, Pressure, Temperature, Mach number and Acoustic properties and their results are as shown.

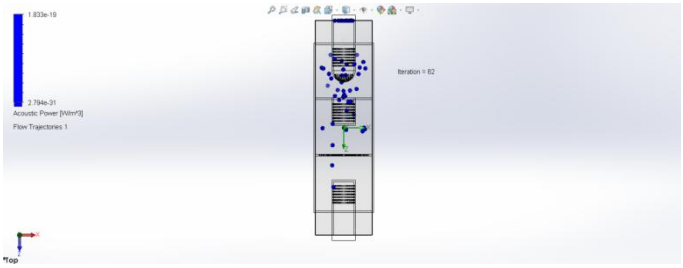

Figure 4: Acoustic power
ACOUSTIC POWER (w/m^3)
MIN: 2.794e-31 MAX: 1.833e-19

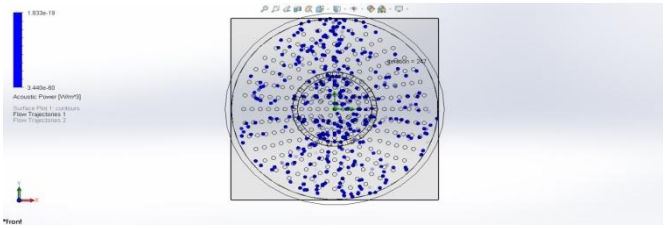

Figure 5: Acoustic power (top view)
ACOUSTIC POWER (w/m^3)
MIN: 2.794e-31 MAX: 1.833e-19

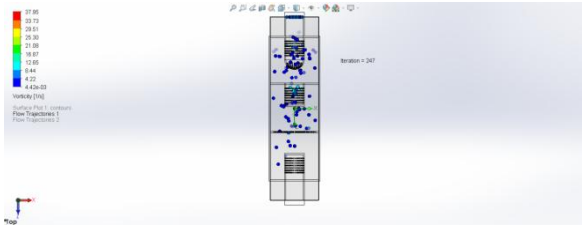

Figure 6: Vorticity
VORTICTY (1/s)
MIN: 4.43e-03 MAX: 37.95

Figure 7: Temperature
TEMPERATURE: 293.20 K

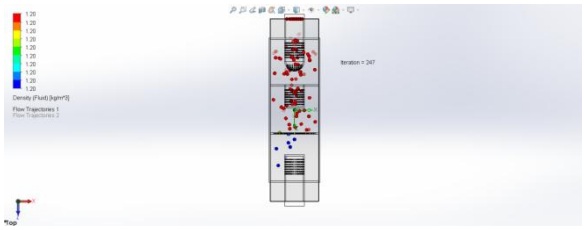

Figure 8: Density
DENSITY 1.20kg/m^3

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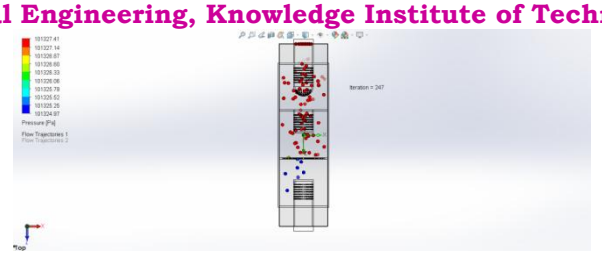

Figure 9: Pressure
PRESSURE (Pa)
MIN: 101324.97 MAX: 101327.47

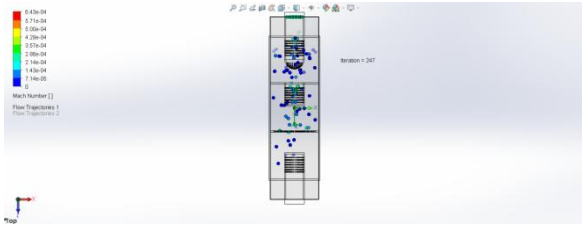

Figure 10: Mach number
MACH NUMBER
MIN: 7.14e-05 MAX: 6.43e-04

5. Results and Discussion:

Dynamic Viscosity

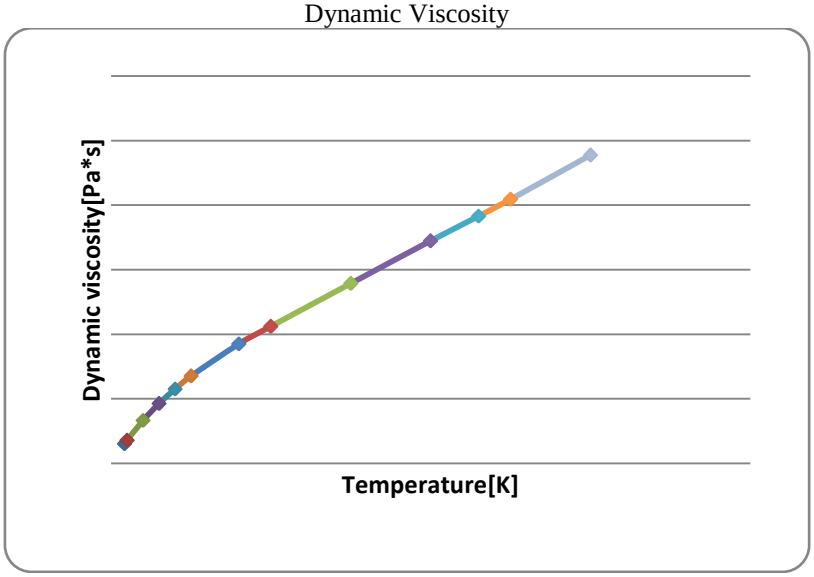

Figure 11: Dynamic Viscosity vs. Temperature
Specific heat (Cp)

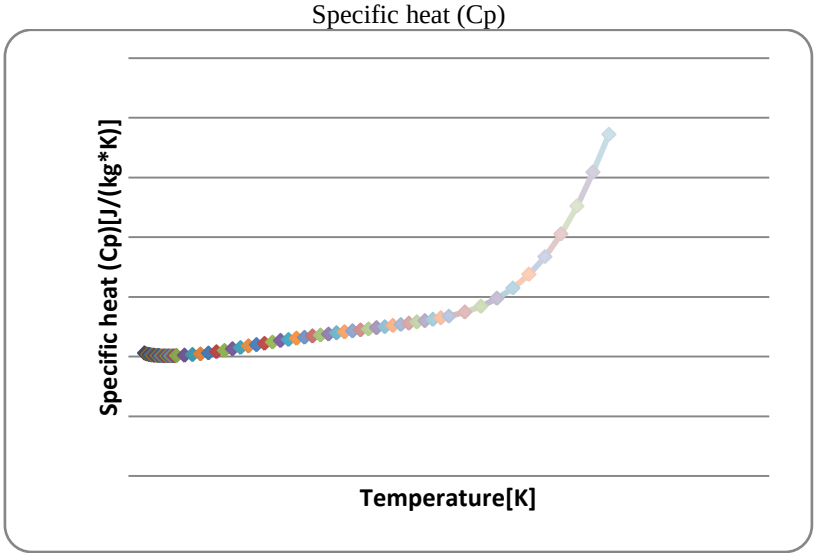

Figure 12: Specific Heat vs. Temperature

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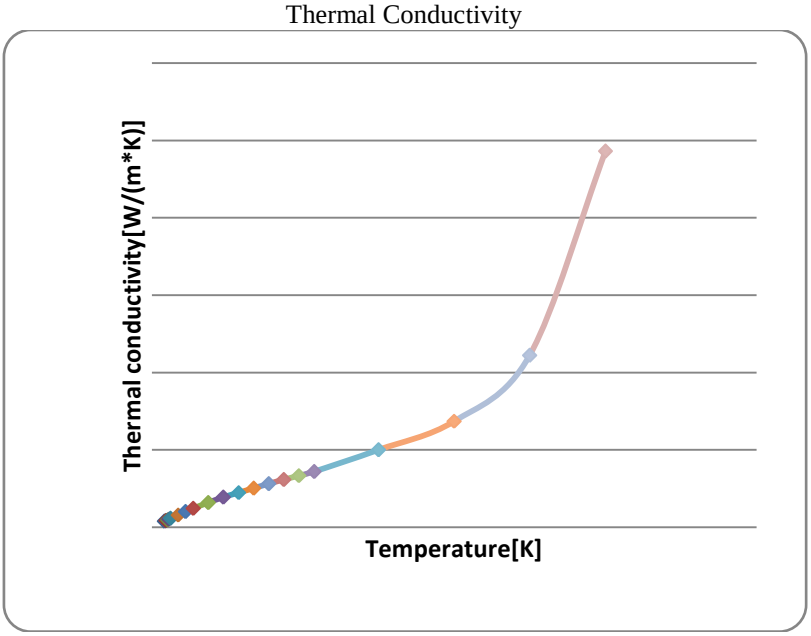

Figure 13: Thermal Conductivity vs. Temperature

From the above mentioned report it is clearly observed that reduction of weight, increasing the capability of noise absorption from the muffler with minimal back pressure can increase the performance of the engine. It is observed that for a temperature inlet boundary condition in model, the gases enter the muffler and maintains the steady state heat flow. This also explains that the heat flux will be minimum at the initial point of the muffler and maximum at the opening. There is also decrease in the density and back pressure as mentioned, in the expansion chamber once the exhaust gas passes through the opening

6. Conclusion:

The thermal analysis of the muffler has been assessed. The results of the simulated muffler models obtained with the use of ANSYS 19.1 are taken for discussion and the following conclusion has been drawn. Reduction of weight and increasing the capability of noise absorption by the muffler with minimal back pressure can increase the performance of the engine. It is observed that for a temperature inlet boundary condition in model, the gases enter the muffler and maintains the steady state heat flow. It has been observed that for a thermal inlet boundary condition of the model, the exhaust from the engine enters the muffler at a particular temperature as mentioned. This model reduces the weight of the muffler as compared to the existing type. This also explains that the heat flux will be minimum at the initial point of the muffler and maximum at the opening. There is also decrease in the density and back pressure as mentioned, in the expansion chamber once the exhaust gas passes through the opening. Thus, with this project, the designing of muffler to reduce the noise, weight and back pressure has been carried out. We have analysed the muffler with two different materials namely steel and aluminium. As a result we came to know that steel performs better than aluminium.

7. References:

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