International Conference On Emerging Trends in Engineering and Management Research
NGSPM's Brahma Valley College of Engineering & Research Institute, Anjaneri, Nashik(MS) (ICETEMR-16)
23rd March 2016, www.conferenceworld.in ISBN: 978-81-932074-7-5

REVIEW ON DESIGN OF RESONATING MEMBRANE TYPE REACTIVE MUFFLER FOR IC ENGINES

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ABSTRACT

In these review paper discuss about the reactive muffler. Various types of engines exhaust noise pollutes harmful in environment. the paper consider the main principles of reducing the noise of muffler. Any type of engine exhaust noise is controlled by using silencers and muffler. The function of the silencer or muffler is reduce the noise attenuation. The work on analysis and design on the reactive muffler has been going on since the early 1920. This noise can be reduced by using the better designed of reactive muffler. In these review paper we are taking different designing parameters and improving the efficiency of the reactive muffler. The formulated muffler traditional design problem is solved for new design and optimization.

Index Terms: Internal combustion, Reactive Muffler , Silencer.

I. INTRODUCTION

Internal combustion engine is a maximum source of noise pollution. These engines are used for various purposes in industries , automobiles, and various manufacturing machinery. muffler are components of an petrol engines and automobiles exhaust system that helps in gases leaves the engine. Generally, noise level of more than 90 dB is injurious for human being. The muffler are created and designed with resonating membrane that reduce noise created by gases leave of the exhaust system. Muffler are coated with different anti corrosion materials that prevent the corrosion by using the charcoal layers. Muffler chamber are designed to reflect sound waves produced by engines. Continuous development has been made in improving performance of the muffler used for automotive exhaust system.if vehicles did not have a muffler there would there would be an unbearable amount of machine leave noise in our environment. this exhaust noise. The velocity of sound in the gas at a given temperature is directly proportional to the square root of the product of the pressure and the ratio of the specific heats (at constant pressure to that at constant volume), and inversely to the square root of the density of the gas.

1.1 Typical Muffler Designs

Two different types of reactive muffler designs are shown in Figure 1.1 and Figure 1.2. The first figure, design shown is frequently chosen because of its minimum cost and because it causes a lowest back pressure. The second figure, design shown in provides maximum attenuation and is typical of the design recommended by muffler manufacturers . However there is no any type of direction connection between the inlet pipe and the outlet pipe so back pressure is generated that can effect engine performance. This is sometimes referred to as a baffled muffler design.

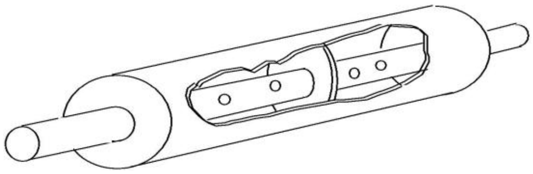

Figure 1.1 Sketch of a reactive muffler with two cavities and no flow restriction

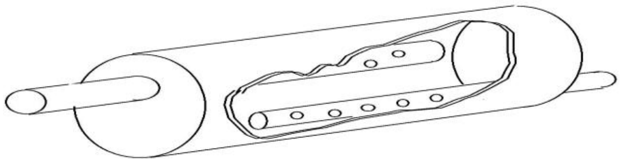

Figure 1.2 Sketch of reactive muffler in which there is no direct passage between the inlet and the exit.

II. LITERATURE REVIEW

In 2015 Milind s swami " principle or optimization of exhaust reactive muffler" The exhaust system being the basic source of engine noise. In our modern, rapidly expanding environment one of the developing problems is that of "Noise". In diesel engine the pollutant is let out noise. In the analysis of C.I. Engine noise the maximum sound pressure level comes out at exhaust and the acoustic power rises as load increases for all internal compression ratios. However this noise can be reduced sufficiently by means of a proper designed muffler. The suitable design and development of muffler will help to reduce the noise level but simultaneously the performance of engine should not be hampered due to back pressure created by muffler. [1] In 2014 Mr. Jigar H. Chaudhri " Muffler Design for Automotive Exhaust Noise Attenuation - A Review" In these review paper different types of mufflers and design of exhaust system belonging engine has been studied. After studying this design methods of muffler, we conclude that combination type of muffler is more effective than reactive and absorptive mufflers. [2] In 2014 Sunil And Dr Suresh P M "Experimental Modal Analysis Of Automotive Exhaust Muffler Using Fem And FFT Analyzer", which is also known as modal analysis or modal testing, deals with the specification of natural frequencies, damping ratios and mode shapes through testing under vibration. The exhaust muffler in an automobile plays an integral role in reducing the sound of the automobile. [3] In 2014 Jin Woo Lee "Optimal Topology Of Reactive Muffler Achieving Target Transmission Loss Values: Design And Experiment". A topology-optimization-based muffler design method for a reactive muffler is nominate and experimentally validated. In a reactive muffler design problem, rigid partitions should be located optimally inner part the muffler to improve its acoustical attenuation performance in the target frequency range.[4] In 2013, Takashi Yasuda Studies On An Automobile Muffler With The Acoustic Characteristic Of Low-Pass Filter And Helmholtz Resonator Based on the predictable structure, a muffler with an interconnecting hole on the tail pipe was proposed to improve its acoustic presentation. Acoustic presentation of the proposed muffler were studied experimentally and theoretically in frequency and time domain. [5] In 2014 Sunil And Dr Suresh P M "Experimental Modal Analysis Of Automotive Exhaust Muffler Using Fem And FFT Analyzer", Also known as modal analysis or modal testing, deals with the determination of natural frequencies, damping ratios, and mode shapes through vibration testing. The exhaust muffler in an automobile plays an integral role in reducing the sound of the automobile. [3]In 2014 Jin Woo Lee "Optimal Topology Of Reactive Muffler Achieving Target Transmission Loss Values: Design And Experiment" A topology-optimization-based muffler design method for a reactive muffler is proposed and experimentally validated. In a reactive muffler design problem, rigid partitions should be located optimally inside the muffler to improve its acoustical attenuation performance in the target frequency range.[4] In 2013, Takashi Yasuda Studies On An Automobile Muffler With The Acoustic Characteristic Of Low-Pass Filter And Helmholtz Resonator. Based on the typical structure, a muffler with an interconnecting hole on the tail pipe was proposed to improve its acoustic performance. Acoustic performances of the proposed muffler were studied experimentally and theoretically in frequency and time domain. [5]In 2012, M RAJASHKUMAR REEDDY "Explain Design And Optimization Of Exhaust Muffler In Automobiles" By Study Of Muffler Dimensions Are calculate Through The Bench-marking, To Create CAD Models The CAD models are created in CATIA V5 R19, later these CAD models of muffler are transmit to HYPER MESH for pre-processing work. Free analysis is carried out on this muffler by FEA Method using NASTRAN Software. [6]In 2011, Jun Chan investigates "CFD Numerical Simulation of Exhaust Muffler based on the physical numerical carving of the flow field of the muffler" In this paper, the author simulated the field by numerical method with Fluent and analyzed the effect which the internal flow field has on the performance of the muffler. [7]In 2010, Wang Jie Have "Study On The Model Analysis Of An Automobile Exhaust Muffler Based On PRO/E And ANSYS In Order To Improve Design Efficiency" The solid model is created by PRO/E and model analysis is created out by ANSYS to study the vibration of the muffler, The natural frequencies and mode shape are considered during the design of the muffler, so avoid the resonance occurred in exhaust system [8]

III. METHODOLOGY

Design Data For the experiment, an existing petrol engine has been used. Calculations are done on the basis of data collected from the engine Specifications of the engine available for testing are as

Specifications of Engine :

Make: Crompton Greaves

Model: IK-35

Engine is two strokes Spark ignition engine with following specifications:

Bore 'diameter: 35 mm

Stroke: 35 mm

Capacity: 34 cc

Power output: 1.2 BHP at 5500 rpm

Torque: 2.72 N-m @ 5000 rpm

Dry weight: 4.3 kg

Ignition: Flywheel magneto

Direction of rotation: Clockwise looking from driving end

Carburetor :'B' type

Cooling: Air Cooled engine

Lubrication: Mist –via petrol

However, some data are applicable to all engines. For designing, the following data are required.

SOUND CHARACTERISTICS (WITHOUT SILENCER)

Rpm of the engine= 5500

Load Sound level

Without any load 9.2 kg 104.5 DBa

50% load 15 kg 106.5dbA

100% load 24 kg 107dbA

3.1. Sound Analysis With Frequency Analyzer (To Obtain The Dominating Frequency)

Two dominating frequencies, the low level and the high level have been obtained. These are: Frequency Level (Hz)

Low 270

High 40000

3.2.Diameter Of Exhaust Pipe Of Engine Inlet Pipe Of Muffler

The Exhaust Pipe diameter: 1.0 inch (25.4 mm)this is in accordance to the standard mounting flange on the engine exhaust.

3.3.The Theoretical Exhaust Noise Frequency Range

From various experiments is has been found that the theoretical exhaust noise frequency is 200-500Hz.

3.4 Reflective Part Design

S1 = Exhaust pipe diameter = 1.0 inch

The dimensions to determine are that of the chamber length L and the body diameter S2.

To determine L, three methods have been used. They are as follows:

3.5.First Method Used To Determine L

Maximum attenuation occurs when $L = n\lambda/4$………………..(1)

where, λ = wavelength of sound (m or ft)

n = 1, 3, 5, …….(odd integers)

Since λ is related to frequency by the speed of sound, one can say that the peak attenuation occurs at frequencies which correspond to a chamber length.

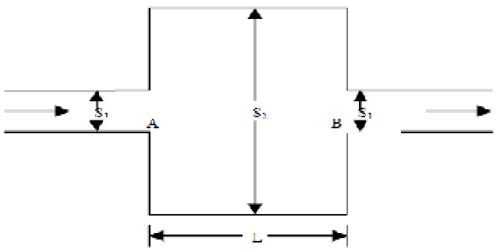

Figure- 3.1 A simple layout of reactive muffler

FREQUENCY	λ=c/f	λ	N=odd integer	L=Nλ/4(inch)
N(Min)	0.5	19.6	1	4.9
200HZ	Max			14.7
N(Max)	0.6	23.6	1	5.9
500	Min		3	17.7

Table 3.1 Calculate wavelength from frequency

From table above we can determine the length for the engine exhaust specifications length is within the range of minimum 4.9 inches to maximum of 17.7 inches as maximum conditions as never achieved because engine is always operated under load hence length of the muffler smaller section is considered to be 5 inches and length of the overall section can be considered to be 17.7 inches or 450 mm

3.6 Range Of Chamber Length Considering The Temperature Of Exhaust Gas

Another factor which must be considered in expansion chamber design is the effect of high temperature of exhaust gases. This factor can easily be included in the design by using the following equation:

$0.5(49.03\sqrt{°R})/2\pi f \leq L \leq 2.6(49.03\sqrt{°R})/2\pi f$ (2) where, $\sqrt{°R}$=absolute temperature of the exhaust gas f = frequency of sound (Hz)

Let the temperature of exhaust is assumed to be 300° F or 759.7° R

Putting this value in equation (2), one obtains,

$0.5(49.03\sqrt{759.7})/2\pi 270 \leq L \leq 2.6(49.03\sqrt{759.7})/ 2\pi 270$

(here, f =270Hz for low frequency reactive muffler)

$0.4 \text{ ft} \leq L \leq 2.04 \text{ ft}$

From the 1st method, L = 17.7 inch = 1.47 ft.

So the condition of $0.4 \text{ ft} \leq 1.47 \leq 2.04$ it is satisfied

3.8 Other Parts Of Reactive Muffler Design

It has always been considered that the flow path diameter does not reduce at any point. Otherwise, there would be a possibility of back pressure. That is the following equation has been used to determine the diameter of the smaller pipes, which are at the outlet of the first two chambers.

$\pi S1^2/4 = \pi d1^2/4 + \pi d2^2/4$

where, d1 and d2 are smaller pipe diameters.

As both pipes are of the same diameter, one gets,

d1 = d2 = 1.06 inch ≈ 1 inch.

Now, the total length L has been divided into three small chamber lengths L1, L2, and L3.

3.9tailpipe Design

According to equation (1), resonance occurs when L = nλ/2. So, for an economical construction, the value of n may be taken as 1. Then the tailpipe must be less than λ/2.

IV. CONSTRACTION AND WORKING

The reactive silencer comprises of the casing plate with end cap-1 & end cap-2 enclosures. The exhaust gas enters the silencer through the inlet pipe and strikes the brass resonator membrane. This membrane is 0.5 mm thick and thus resonates to absorb maximum shock of the exhaust gas pressure wave thereby leading to maximum drop in pressure of the exhaust gas. The gas from the resonator chamber is now directed to the outlet tailpipe through the intermittent plates 1&2. Between these two intermittent plates are sandwiched two layers of active charcoal which will absorb the free carbon suit and carbon monoxide. The pressure of the gas further drops to slightly above atmospheric as it is muffled between these intermittent plates. The exhaust gas is then discharged out of silencer through the tail pipe.

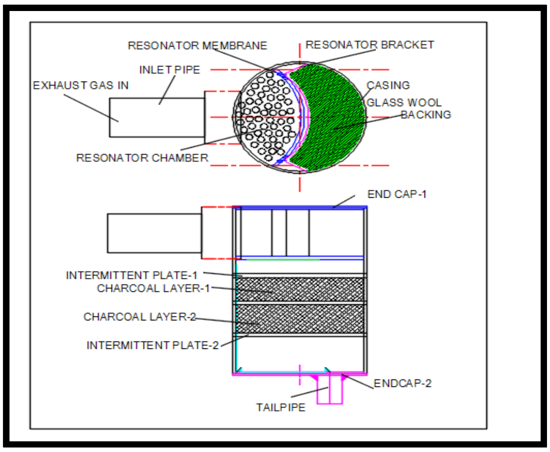

Figure-4.1 Basic constriction of muffler

4.1 Basic Design Of The Casing Pipe

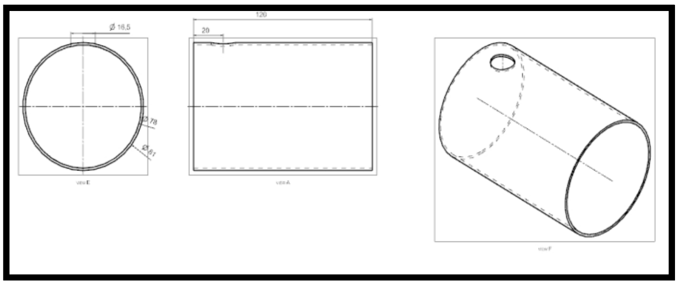

Figure- 4.2 Geometry of the casing pipe

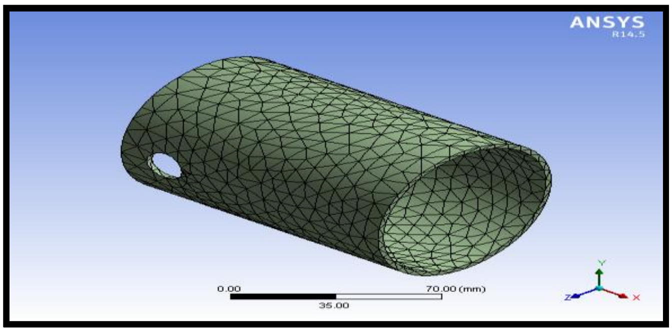

Figure-4.3 Meshing of the casing pipe

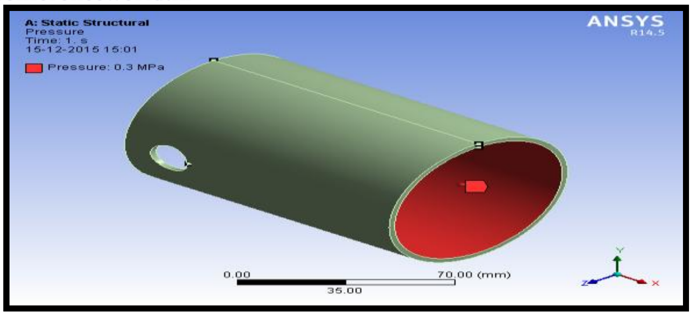

Figure-4.4 Static structure with pressure of Casing pipe

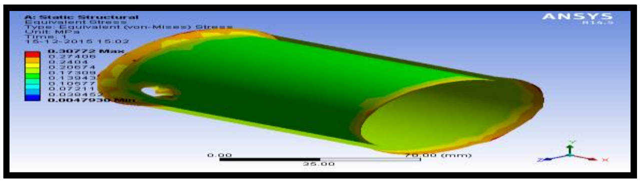

Figure -4.5 Static structure with equivalent stress(von-mises) of Casing pipe in ansys

4.1.1 Hoope's stress due to exhaust gas pressure :-

Maximum pressure induced in system due to exhaust gases=3 bar= 0.3 Mpa

$$fc_h = \frac{P\,x d}{2t}$$

$$fc_{act} = \frac{0.3 \times 81}{2 \times 1.5}$$

$$fc_{act} = 8.1\ N/mm^2$$

As $fc_h < fc_{all}$; casing pipe is safe

4.1.2 Longitudnal stress due to to exhaust gas pressure :-

Maximum pressure induced in system due to exhaust gases = 3 bar= 0.3 Mpa

$$fc_l = \frac{P\,x d}{4t}$$

$$fcl_{act} = \frac{0.3 \times 81}{4 \times 1.5}$$

$$fcl_{act} = 4.0.5 N/mm^2$$

As $fc_l < fc_{all}$; casing pipe is safe

4.2 Basic Design Of The Resonator Membrane

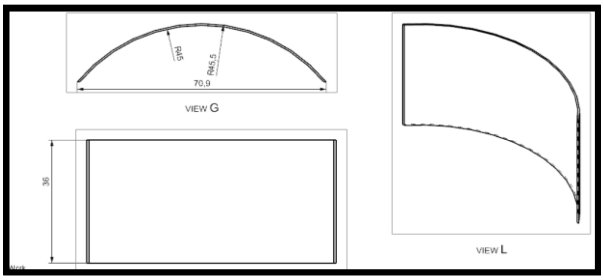

Figure- 4.6 Geometry of the Resonator membrane

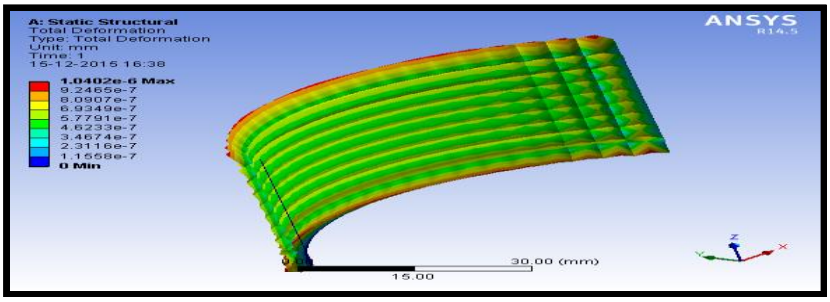

Figure- 4.7 Static structure with Total deformation of resonator membrane in ansys

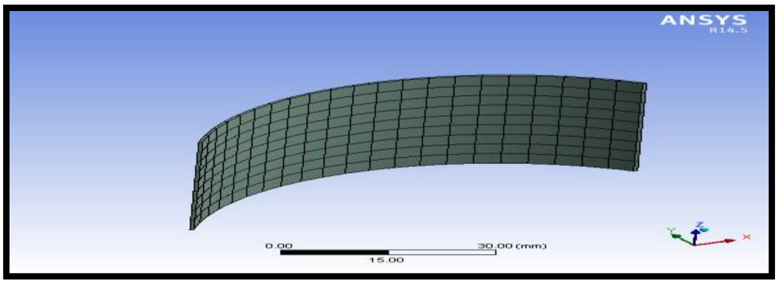

Figure -4.8 Meshing with resonator membrane

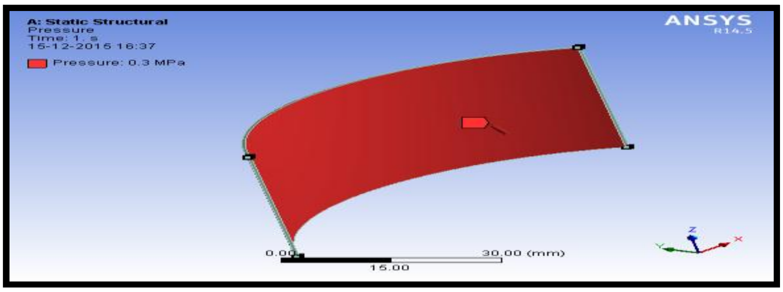

Figure-4.9 Static structure with pressure resonating membrane

Part Name	Maximum theoretical stress N/mm^2	Von-mises stress N/mm^2	Maximum deformation mm	Result
1.Casing pipe	8.1	0.307	2.12E-6	Safe
2.Resonator Membrane	0.344	0.2518	1.04E-6	Safe

V. CONCULSION

In these review paper we outcoms about the various component of design reactive muffler.we are finding the maximum therotical stress result of casing pipe and resonating membrane. These result comparing with von-mises stress, maximum stress by therotical method and von-mises are well below the allowable limits, means the design of casing pipe and resonator membrane is safe design. Casing and resonator membrane shows negligible deformation under the action of system of forces.

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