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## Design and Development for Exhaust Back Pressure Reduction with Noise Control for Motorcycles

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**ABSTRACT:** Motorcycle Back Pressure reduction is the process of reducing the resistance created by the motorcycle exhaust system that has been created for Noise Reduction so as to meet the standards of Noise Pollution within the atmosphere. The design is based on the concept of reducing the Back Pressure created inside and to maintain the noise at the tail pipe of the exhaust system by the introduction of new concept of Wedge Theory which has been designed and Analyzes on ANSYS Software for its advantages, and also the introduction of Pressure Maintainer Valve helps in maintaining the reduced back pressure for, so as to maintain a correct ratio maintaining.

**KEYWORDS:** Back Pressure, Noise Reduction, Wedge Theory, ANSYS Software, Pressure Maintainer Valve.

### I. INTRODUCTION

The conventional mufflers commonly use the baffle system that it generate high amount of back pressure that hinders the working of engine by resisting the flow creating a high pressure at the port with respect to the exhaust system this enables the air fuel get choked inside the combustion chamber, each cycle when this happens for the next cycle we will have to accelerate the engine because when the exhaust gas gets trapped inside the chamber of combustion there may not have enough space for the fresh air to enter the chamber of combustion so for the power stroke or expansion stroke does not get enough power from the fresh fuel because of trapping. So for combating this problem we are introducing the absorption system, which enables the flow of exhaust gas to move freely but there comes the problem of sound, according to standards of exhaust the vehicle or the motorcycle that we are considering has the standard of about maximum of 90dB, the maximum loudness the Indian standards are allowing for the reduction of noise pollution in the atmosphere. So we must design a muffler that reduces back pressure as well as noise that paves a way for the increase of power inside the engine and can reduce the process on noise generation.

### II. RELATED WORK

[1] Design and Analysis of Automotive Silencer for Effective Corrosion Control, Automobile silencers have the headache of corrosion from existence. So, initial corrosion resistant materials are growing day by day. We here use

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different corrosion combating materials (Composites) for silencers and further they are analyzed and compared to different stresses and strains created in the silencer both pressure and thermal loads. Then the materials are valued for their best working. The current material is Mild steel which is compared with the selected materials that are as follows Stainless steel, Carbon fibre and Glass fibre. These materials are selected because of their high strength with their high resistant to corrosion. Materials here are analyzed in Ansys for Stress, Strain and Deformation, analyzed and the best material is selected likely and rated for their effective working.

[2] Thermal analysis in motor-bike exhaust silencer for promising reduction in hot spots via design enhancement. The exhaust sub-system is pressurized to high temperatures as they wov the passage for the hot gases released during combustion of fuel to be liberated to the atmosphere. But there are other prominent areas which have to be focused during the design phase; the uniform distribution of heat along the entire exhaust system (including the silencer) is of significance for redefining enhanced life of the elements in the sub-system. The problem identified in this proposed dissertation thesis is to assess in the heat flow during the passage of hot gases and design the passage so as to decrease the harmful effects of hot spots along the entire length of the silencer, specially at the front of the end touching the exhaust manifold.

[3] Design and Development of Automobile Silencer for Effective Vibration Control, a Silencer is a module of the exhaust system of an automobile that plays an important role. It requires having modes, which are located away from the intensities that the engine operates at, whether the engine is at idle condition or running at the maximum value of revolutions per second. This work defines the first stage in the design analysis of an exhaust system. With the stipulated properties of the material, the exhaust system is designed by using a reliable FEM package. The results are matched with the reading taken with FFT analyzer, so as to differentiate working frequency to natural frequency and to eliminate resonating condition.

[4] Design and Development of Aqua Silencer, Aqua Silencer is a new version of the conventional silencer focused at the decrease of toxic emissions from the exhaust of an IC engine to the atmosphere and also to combat the noise that is generated by damping method which involve water and results the stated above value. It focuses the usage of lesser quality chemicals like lime water, activated charcoal and water with the use of least but effective change in the modeling and manufacture of the silencer to decrease the noise and toxic emission problems.

[5] Thermal analysis of silencer pipe, Automotive and heavy machineries engines in industries have exhaust system which is keen in eliminating the exhaust air, heat which increases air pollution, increasing speed increases noise pollution, human harmful atmospheric environment which has to be required to prevent and resist harmful atmospheric gases. The silencer is used to control air pollution, noise pollution, to subtract (Catalytic converter) the chemical toxic elements. The main work of exhaust system is to throw the exhaust gases of the engines which will not affect atmospheric equilibrium.

This project defines the investigation of hotspots or surfaces where the temperature concentration takes place, for example in case of mating areas between two pipes. Temperatures at differentiable points on the silencer are found by experimental setup on a car by considering the results of temperatures geometric designing is done on the current model of silencer in abacus and stress analysis is carried out on the same.

The main aim in this is to decrease the hotspots in the silencer therefore improves the efficiency of heat transfer and for improving the life span of the silencer. From this result we can match a relation between the exhaust gas temperatures and stresses developed, modified design is stated.

### III.A NEW CONCEPT OF THEORY OF WEDGE SYSTEM

After numerous levels of design considerations, it has arrived at a stage of reduction of noise as well as back pressure literally. Initially for free flow we have to provide a open channel flow for the transfer of exhaust gas to move to atmosphere and in accordance with the reduction of angular plates which enables carbon contents to slide through the slanting plates but for space we have to reduce the cross-section of the open section for the control of exhaust gases to pass through. So it had come to an idea of Wedges, which not only enables the Air to pass through but also enables to reflect the sound waves to reflect through.

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But now let us keep the Back Pressure aside and study about the reflections of sound, which has been studied on the coming topic of noise reduction strategy, that reflections of sound have the tendency of attenuation of sound wave of different phase angle that recombines to the process of Destructive Interference, this process states that when a sound wave is allowed to recombine by splitting the waves through a system after a particular length, we found that sound waves tends to reduce its power showing that it gets destructed on some ratios, which will be discussed n the upcoming chapter of Reactive muffler system.

And also not only but also, these waves are allowed to reflect the system and are redirected to the sound or noise reducing materials called Glass Wool which has a property of absorbing sound waves by converting the noise redirected towards by reflection through Wedge System introduced. The material included has a property of absorbing sound waves and has the ability to convert it into heat energy, to a certain instant. Therefore, absorption system also helped in the process of Noise Reduction which will be discussed in the upcoming Chapter.

Therefore, by the introduction of Reactive as well as the Absorptive muffler system, we can simultaneously call this process as a Hybrid muffler system.

Now let is consider about the Back Pressure that we have kept aside earlier before. Back pressure which earlier blocked the system of exhaust now gets reduced due to the straight chamber introduction, but to a certain extent of pressure need for the next turning moments of the engine crank rotation. Then now with the introduction of wedges we can not only enabled us to reflect sound but also can slide air from exhaust manifolds which passes through the chamber, which simultaneously control the back pressure inside the system. The introduction of the Wedge System enables the exhausts to pass through.

Next we have a 3 Wedge System in which each wedges are arranged n such a way that the corresponding magnitudes of air strikes the wedge are simultaneously reflected to absorbers a part, reacted a part in each stages of wedge chambers making all the air coming out of the exhaust air to hit the wedge.

Finally, it had been given with a Pressure Retainer Valve for regulating the pressure inside the chamber. And may think that why we want Back Pressure again. Yes, back pressures must be kept constant for different RPM because when we are riding our motorcycles on low speed too much of low pressure at outlet scavenges or sucks air out resulting in too much fuel loss inside the system and not only but also there may be too much fresh air and fuel mixture that takes liberal time for reaching its point of combustion, so Back Pressure has to be kept.

And when are moving with a speed of higher RPM's we literally don't need too much Back Pressure cause it may cause the increase in temperature, power loss therefore high Fuel Consumption. And therefore it has designed with an moving pressure regulator which moves in angular position with respect to the pressure sensed before and after the muffler.

Here the design is proposed on movement of the Pressure Retainer Valve for 1500RPM and 7500RPM and has been analysed with the help on ANSYS18.2 ACADEMIC VERSION, and the results has been proven for the same. Design modelling was done on CATIAV5 for different models.

The steps followed to complete the project work are in the form of flow chart.

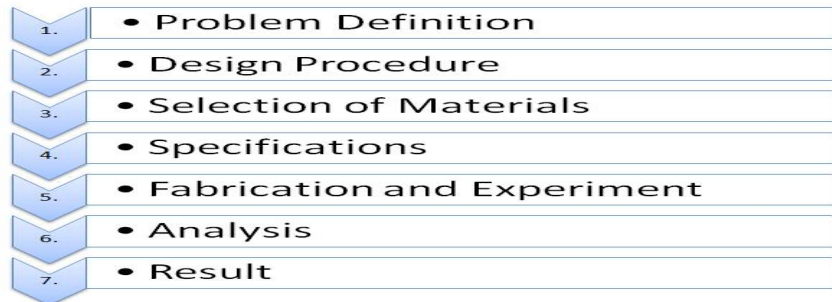
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Chart 1 Thesis Process



## PROBLEM DEFINITION

The problem here faced is the reduction of the performance of mid range motorcycles due to high back pressure, because of the problem of compulsion of attenuation of exhaust noises in the system.

## DESIGN

Design and its assembly are done on Catia V5 and the analysis is done on ANSYS 18.2 Academic version. Further the measurements are taken from the existing muffler and the modifications are incorporated on required fundamentals. Designing procedure performed as part of this research are:

- Selection of particular Engine and its following Muffler.
- Sketching solid model of respective existing muffler using CATIA V5
- Performing CFD analysis of existing muffler using ANSYS 18.2
- Calculation the results obtained denoting outlet velocity and pressure drop.
- Designing solid model of new muffler using CATIA V5
- Run CFD analysis of new muffler using ANSYS 18.2
- Calculation the results obtained denoting outlet velocity and pressure drop
- Compare back pressure of existing muffler with the back pressure of new muffler.

## SELECTION OF MATERIAL

The current material used in automobile muffler is Mild steel where we are going to compare the load and thermal stresses. The material that we are going to use is Stainless steel. We have selected stainless steel because it is the material which shows high resistant to corrosion and can be reinforced into muffler with ease.

## SPECIFICATION

### Engine Specification:

Engine - 4 stroke single cylinder.  
Displacement- 153cc  
Bore- 58centimetre  
Length- 57centimetre  
Compression ratio- 9.3:1  
Maximum power- 13.80 BHP at 7500 rpm  
Maximum torque- 13.60 Nm at 6000 rpm

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## Exhaust gases

Temperature = 300 k  
Density = 0.525 kg/cubic metre  
Specific heat = 1.151 kJ/kg-k  
Viscosity = 2.833168e-05  
Thermal conductivity (k) = 0.0466 w/m-k  
Inlet velocity = 20 m/sec

## Stainless steel

Density = 7700 kg/cubic metre  
Specific heat = 420 J/kg-k  
Thermal conductivity = 11.2 w/m-k  
Outlet pressure = 1 bar

## Noise reduction Process

There is lot of theories on how sound waves Go forth and the path that sound waves displaces through mufflers, but can inscribe how formulas are used in pointing the chambers and tubes inside the muffler. Channels and chambers of a muffler are created for a reason. Some sound waves are eliminated and others are opened to pass through. The most effective thing is that others find in an automobile the right way is the sound that the bike creates. Formulas used in pointing certain sound frequencies are mostly based on the number of cylinders of the engine and the cylinder firing order of the engine that a researcher is designing silencer for. Internal design relay on volume. Both the sum of space that is open in the space and the volume of the muffler want for the engine size and rpm are a must in calculating where channels and baffles have. Each type of muffler has its design formulas and physics theory to acknowledge and to when designing a muffler for a new application.

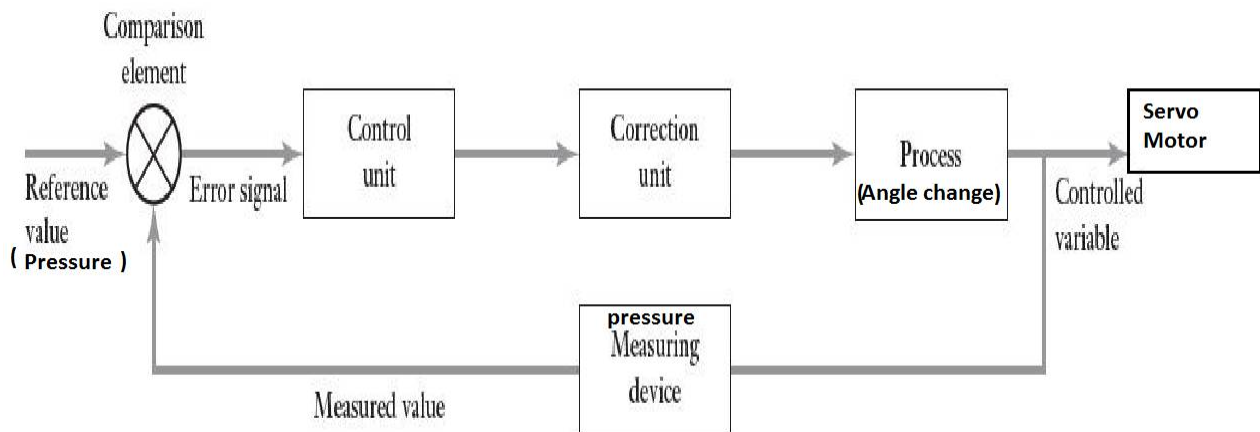


Figure 1 Automatic Pressure Maintainer Block Diagram

## Boundary conditions given for the analysis:

Entry Mass flow rate at 1500RPM = 0.0297732456905 Kg/S  
Entry Mass flow rate at 7500RPM = 0.148866234525 Kg/S  
Exit pressure = Atmospheric Pressure (1Bar)

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## Existing Design Model

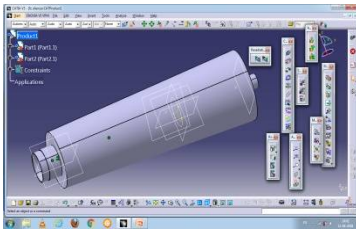


Figure 2. Model

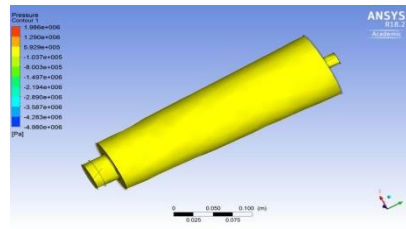


Figure 3. Pressure at 1500RPM

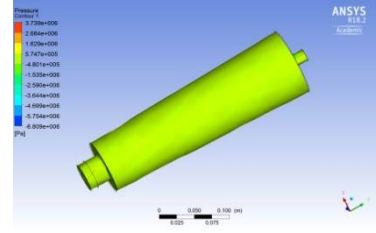


Figure 4. Pressure at 7500RPM

Existing model has been taken from the motorcycle and has been explored to get the dimensions and for getting a design depth of knowledge about it.

## Modified Design Model

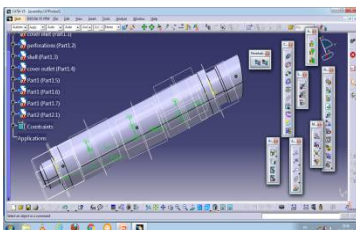


Figure 5. Model

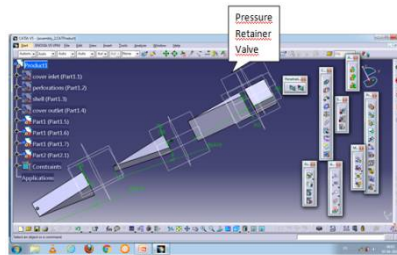


Figure 6. Wedge System

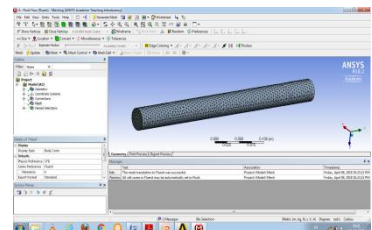


Figure 7. Meshing

## At 0 Degree Pressure Retainer Valve

Modified model is as shown, has been modified based on the requirements of the performance of the vehicle and with the method of Wedge System for maintaining the Noise levels outside the system. The noise levels has been measured by means of a Sound Level Meter by keeping the Sound Level Meter 1m away from the tail pipe by the help of a 1m length pipe . This is done so as to reduce the external noise coming from various sources.

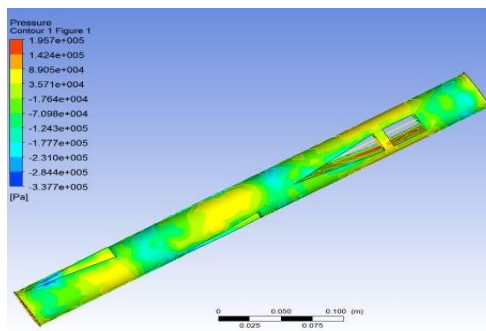


Figure 8. Pressure at 1500RPM

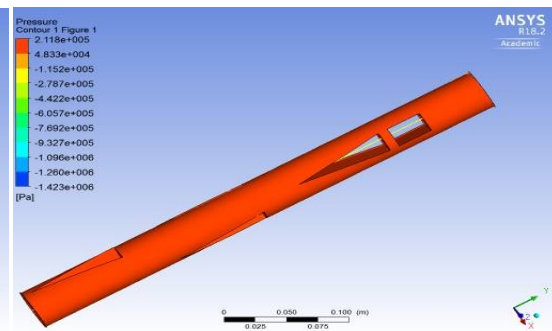


Figure 9. Pressure at 7500RPM

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Initially the pressure retainer valve has been set to fully open position (0 degrees) so as to measure the highest pressure generation.

Then it has been set to at most partial closing position (90 degrees) with vents for reducing high pressure generation.

At 90 Degree Pressure Retainer Valve

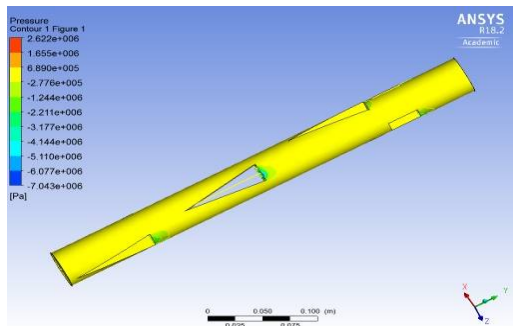


Figure 9. Pressure at 1500RPM

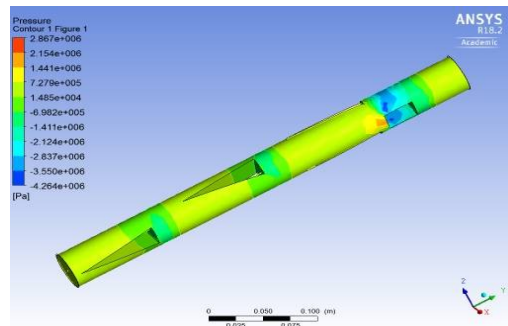


Figure 10. Pressure at 7500 RPM

Both the positions of the Pressure maintainer valve has been tested at different mass flow rates based on their speed (RPM).

## IV. EXPERIMENTAL RESULTS

Finally the results found to be positive based on the analysis done by ANSYS 18.2, in which the model has analysed:

Table 1 Comparison for Existing and Modified

Speed (RPM)			1500	7500	
Mass flow rate (Kg/s)			0.0297732456905	0.148866234525	
Existing Muffler			1.986e+06	3.739e+06	Maximum Pressure Value (Pa)
Modified Muffler	Angle (θ)	0 Degree	1.957e+05	2.118e+05	
		90 Degree	2.622e+06	2.876e+06	

## V. CONCLUSION

Finally in this Thesis it had been concluded and stated that for getting a stable back pressure we can control the valve that has been provided with the final wedge section. Further not only but also the noise has been controlled by means of the new wedge system.

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