Two wheeler silencer study and thermal analysis- A review

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ABSTRACT

Two wheeler silencers are used to silence the noise generated by engine while throwing out hot flue gases from the combustion chamber. The technique of silencing the noise is to pass flue gases through the silencer and reduce the flow speed. Hence the noise gets silenced. It also helps to discharge hot flue gases into atmosphere. Inside the silencer the flue gas allows to flow through different sections. During this flow the nature of flow needs to study well to understand the silencing phenomenon. CFD Analysis will help to learn this flow. Practically it is very critical to study flue gas flow inside the silencer. Hence CFD method is very popular and widely used in research and development of silencer.
In this review paper, we have studied literature of two wheeler silencer. The temperature distribution, pressure variation, velocity gradient and the turbulence etc. are studied well to know the phenomenon of silencing the sound produced due to exhaust gases. Also the improvements in design can be suggested based on the CFD analysis.

Keyword: - *CFD Analysis1, Silencer2, Temperature Distribution3, Heat transfer4.*

1. INTRODUCTION

Vehicle's exhaust system is designed to take care of toxic emissions automobiles produces. It will direct harmful hydrocarbons away from the driver and passengers, and reduce the air pollutants automobiles releases into the environment, helping keep the air clean. An additional benefit is that the exhaust system significantly reduces the amount of noise automobiles produce. An exhaust system in working order will keep automobiles sounding pleasant as it runs and will reduce noxious gases. In most motorcycles all or most of the exhaust system is visible and may be chrome plated as a display feature. Aftermarket exhausts may be made from steel, aluminium, titanium, or carbon fiber.

Fig-1 Two wheeler silencer or Muffler

Motorcycle exhaust system also known as muffler is made to route exhaust gases away from the engine. As fuel burn inside the engine gases and fumes are produced, so this gases and fumes need to be taken out from the engine. The exhaust system does the work. The muffler also captures some of the harmful toxins in the gases before they are

released into the atmosphere. It also helps regulating engine noise. Some are made to create specific sounds to certain motorcycles. Silencer has to muffle the vibrations of the exhaust gases, reduce their velocity and thus reduce the amount of noise emitted from the engines. The pulsating low from each cylinder's exhaust process of an automobile petrol or diesel engine sets up pressure waves in the exhaust system-the exhaust port and the manifold having average pressure levels higher than the atmospheric. This varies with the engine speed and load. At higher speeds and loads the exhaust manifold is at pressures substantially above atmospheric pressure. These pressure waves propagate at speed of the sound relative to the moving exhaust gas, which escapes with a high velocity producing an objectionable exhaust boom or noise. A suitably designed exhaust silencer accomplishes the muffling of this exhaust noise. Which means that the exhaust gases from an internal-combustion engine are passed to attenuate (reduce) the airborne noise of the engine. To be efficient as a sound reducer, a muffler must decrease the velocity of the exhaust gases and either absorbs sound waves or cancel them by interference with reflected waves coming from the same source.

A typical sound absorbing material used in a muffler is a thick layer of fine fibers, the fibers are caused to vibrate by the sound waves, thus converting the sound energy into heat. Mufflers that attenuate sound waves by interference are known as reactive mufflers. These devices generally separate the waves into two components that follow different paths and then come together again out of phase (out of step), thus cancelling each other out and reducing the sound.

All internal combustion engines produce noise, some more or less than the others. The intensity and magnitude of the noise will vary greatly depending upon engine type i.e. naturally aspirated or turbocharged, horse power developed, means of scavenging, type of fuel used, number of cycles whether 2 cycle or 4 cycle engine etc. Among the pre-dominant sources that makes up the engine noise are the engine intake and exhaust. For the purpose of noise control on engines, it is common practice to use silencers at intake and exhaust for treating the airborne noise.

In cases where standard construction silencers do not meet the particular application, the special silencers can be designed to suit specific requirements. In silencing internal combustion engines, the most widely used silencers are the reactive type, or chamber construction silencers. This type is largely dependent on area change to reflect sound energy back to the source and utilizes the attenuation properties of expansion chambers and perforated tubes.

2. LITERATURE REVIEW

Ravindra S Girge, Nitesh Rane, [1] carried out the thermal analysis in their paper "Analysis of two wheeler exhaust silencer with thermodynamics principle and Computer Aided Design". In this they observed the hot gases from engine passes through the exhaust system of the automobile at very high temperature. Exhaust system of an automobile consist of three parts such as exhaust manifold, catalytic converter and silencer out of those silencer having very short life span as there is lot of restriction provided to the flow of hot gases due to complex geometry in order to reduce the noise level hence gases staying more time in this section as compare to other two part of exhaust system. Hence silencer needs to be focused for thermal analysis in order to increase its life span. For this improvement in life span the uniform distribution of heat over the entire exhaust system which consequently enhanced life of the elements in the exhaust system is necessary. The problem recognized for this proposed study is to assess the heat flow during the passage of hot gases and design the passage in such a way that it will minimize the destructive effects of hot-spots and localized heating due to heat transfer barriers over the length of the silencer, especially at the front end mating with the exhaust manifold.

Pradyumna Saripalli, K. Sankaranarayana,[2] in their analysis describes the exhaust pollution has become one of the important problems of environment pollution with applications in automobile industry, and the exhausted muffler has been paid attention to improve the performance of engines. Computational Fluid Dynamics (CFD) method was used to explore the aerodynamic performance of the muffler. Resistance muffler research relates with the fields of acoustics, fluid dynamics, heat transfer and mechanism design. The project report simulates the field by numerical method with Cosmos Flow and analyses the effect which the internal flow field has on the performance of the muffler. With this method the pressure distribution in the muffler is simulated and the pressure loss is predicted for the structure modification. The experiment results verify that the assembly performance of the muffler modified is better than the original muffler.

Sidharam Ambadas Basargi, G.S Joshi [3] in "Design and Development of Automobile Silencer for Effective Vibration Control" describes a silencer is a part of the exhaust system of an automobile that plays a vital role. It needs to have modes that are located away from the frequencies that the engine operates at, whether the engine be idling or running at the maximum amount of revolutions per second. Their paper postulates the first stage in the

design analysis of an exhaust system. With the specified properties of the material, the exhaust system is modelled by using a conventional FEM package. The results are compared with the reading taken on FFT analyzer, so as to distinguish working frequency from natural frequency and avoid resonating condition.

Sweta Baruah, Sushowan Chatterjee,[4] describes about C.I. engine in "CFD analysis on an elliptical chamber muffler of a I.C. engine" they desribe highest pressure and temperature are developed inside the combustion chamber of Compression Ignition (C.I.) engine. As the outlet of the exhaust system is the atmosphere, there might be adverse pressure gradient in the exhaust system which can be analysed for the purpose of attenuation of pressure wave in case of conventional silencer system. This hot exhaust gas coming out through the silencer pipes in the exhaust system of automobiles can be a scope of study for Computational Fluid Dynamic (CFD) simulation. In their work, an elliptical chamber muffler model of a MAHINDRA C.I. engine is studied based on CFD analysis of the exhaust gas flow through the muffler chamber. Two designs for the aforementioned muffler are analyzed one of which consists of perforated inlet, outlet and central pipes which, if implemented in actual practice could bring about better and improved sound attenuation. Transmission loss is calculated for both the muffler models based on pressure distribution obtained from CFD analysis results. Comparative study of the two muffler models, one without the presence of any perforation and the other after incorporation of perforation, is carried out in ANSYS FLUENT 14.5

Vijay M Mundhe, Eknath R Deore[5], in their paper "Design and analysis of perforated muffler in automobile exhaust system" stated the exhaust gas noise level depends upon various factors. Muffler geometry, extension in inlet and outlet valves, number of whole perforations and its diameter are the factors which affects noise from engines. The objective of their study is to reduce exhaust gas noise level. The performance of the muffler is assessed by analyzing pressure variation, exhaust gas flow pattern, length of expansion chamber, transmission loss. The K-epsilon method is used to obtain desired outputs by inputting sinusoidal nature of pressure wave. The modeling of muffler is done by using modeling software CATIA V5 and performance parameters are estimated using Star CCM+ software. This study helps to improve reduce the noise level and environmental noise pollution. The results obtained from software are compared with analytical method and they are found close agreement with each other.

Mohamed Filsuf M. A, S. Sankar[6], in their study i.e. in "Design and development for exhaust back pressure reduction with noise control for Motorcycles" explains 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. Their 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.
Dattatray Dilip Giripunje, Vilas B. Shinde,[7] in their paper "Thermal analysis for motor-bike exhaust silencer for ensuring reduction in hot spots through design enhancement" describes the exhaust sub-system is exposed to high temperatures as they form the passage for the hot gases released upon combustion of fuel to be released to the atmosphere. While there are other prominent areas to be focused during design phase, the uniform distribution of heat over the entire exhaust system (including the silencer) is of importance for ensuing enhanced life of the elements in the sub-system. The problem identified for their dissertation work is to assess the heat flow during the passage of hot gases and design the passage such as to minimize the harmful effects of hot-spots over the length of the silencer, especially at the front end mating with the exhaust manifold.

Tejas J. Kalange, Sameer L Shinde[8] in their paper "Design and analysis of muffler for two wheeler". Describes noise from automobiles is one of the components for noise pollution to environment. Exhaust noise is one of the main sources of vehicle and exhaust systems are developed to attenuate noise meeting required levels and sound quality emissions based on environment norms. Muffler is important part of engine system and commonly used in exhaust system to minimize sound transmission caused by exhaust gases. So to deal with this problem, muffler should be modified. But again there is one problem that is selection of type of muffler either reactive or absorptive. Absorptive muffler has more weight than reactive type as it is consisted of wound material over perforated pipes. So in their study they have taken reactive type muffler and modified it for 110 cm3 four stroke engine of two wheelers. But maximum noise reduction affects backpressure of engine. Also pressure drop is one of the parameter which influences backpressure of engine as minimum pressure drop indicates minimum backpressure. Depending on space

availability for muffler on vehicle body, external dimensions of new muffler are kept same as that of existing one. In their paper, a muffler is analyzed for varying porosity of pipes and its effect on pressure drop by simulation.

Ganesha B B, Bharath M N[9], in their paper "Design and thermal analysis of motor bike exhaust silencer- A review" studied hot spot on the silencer surface due to non uniform distribution of heat over the surface can significantly reduce by changing the profile of the silencer tube either by providing different perforations or by providing dimples on the surface. Hotspots on the silencer body create high temperature oxidation that could leads to corrosion and mechanical breakage of silencer. By changing design that is by providing dimple patterns on the outer surface of the silencer the temperature distribution is uniform and we found there is decrease in the temperature in the outer surface of the silencer. It is also proved that providing dimples will not have such influence on building back pressure that could affect silencer performance.

Jashanpreet Singh, S. P. Nigam, L. K. Bhagi [10] in their paper i.e. "A Study on Effectiveness of Muffler on a Two-wheeler vehicle Noise" described harmful effects of noise on human being, in their study they stated the major cause of noise pollution is due to the traffic noise. Traffic noise from highways creates problems in surrounding areas, especially where there is high traffic volume and at high speed. Noise pollution has hazardous effect on human health. In traffic noise, the major cause of noise is two wheeler vehicle noise. In order to minimize two-wheeler noise, study of two-wheeler motorcycle with different types of mufflers has been analyzed. Acoustic power and sound pressure level at different engine speed with and without different types of mufflers have been studied and variations between them are investigated experimentally.

Mr. Vishal M. Shrivastav, Prof. S. B. Bawaskar[11], in their paper "Design and analysis of exhaust system for the two wheeler using FEA" have focused on the exhaust mufflers of two wheeler vehicles. In their work flow analysis on the two wheeler exhaust system is performed. It is found out that approximately 70 % pressure drop can be reduced if length of exhaust pipe at starting reduced by 50 mm and restriction to the flow in D chamber is removed. It can be seen that first 3 iterations show slight increase in the pressure drop across the exhaust system which will result in to increased work for the two wheeler engine to overcome the resistance by exhaust system. In iteration 4 design pressure drop across the exhaust system drop down by 12.3 KPa and it is observed to be 5 KPa which reduces the required work by the engine to force exhaust gases out of the system drastically. This will result in increased engine efficiency and low fuel consumption for similar work production by engine. Their Study include CFD analysis and Fluid structural interaction analysis performed on the current design of the exhaust muffler with boundary conditions as per engines. Design of the muffler generated according to requirements. Exhaust gas temperatures, Velocities and back pressure evaluated and verified through Finite Element Analysis package ANSYS. Also the modal analysis is performed to study the effect of geometric change on natural frequency of system. Actual testing performed by manufacturing modified exhaust muffler and tested on the two wheeler engine test rig for back pressure and noise.

Kabral, R.; Rämmal, H.; Auriemma[12],in their paper "A novel design for cruiser type motorcycle silencer based on micro-perforated elements". It has been demonstrated that the micro perforated elements can successfully be used to achieve high attenuation of IC-engine noise in strictly limited circumstances. A technical description of the design and manufacturing of the prototype silencer is given and technological issues are discussed. The acoustical and aero dynamical performance of the silencer is characterized by transmission loss and pressure drop data. The influence of the two-stage system valve operation has been analyzed by studying the acoustics data and engine output characteristics.
In addition to the experimental investigations, numerical 1-D models were developed for the optimization of the silencer geometry and the results are compared in a number of operating conditions.
The studies have resulted in development of a silencer system for a small series cruiser type motorcycle. The first silencer prototypes have been tested on the motorcycle. While maintaining acceptable pressure drop characteristics, it has proven to comply with standard noise criteria without incorporating fibrous materials.

3. OUTCOMES FROM LITERATURE SURVEY

1) CFD Analysis with different velocities is to be examined for studying its effect on silencer.
2) Authors have focused on design and construction of muffler during their studies.
3) More concentration of studies is needed in virtual experimentation of muffler.

4) Effective Temperature distribution and flow management can reduce noise from engine.

4. CONCLUSIONS

After studying above literature work it is observed that the velocity of flue gas inside the silencer decreases while at the outlet it increases. Hence the noise control is done effectively. Each section of silencer works properly to manage flue gas flow. Noise control is also done properly. Therefore the silencer design is well enough to discharge flue gases in environment without making loud noise. Hence design change is not required for silencer.

6. REFERENCES

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