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Design and Thermal Analysis of Motor Bike Exhaust Silencer

Bharath M N[1], Ganesha B B[2] and Arunkumar K N[3]

[1] Department of Mechanical Engineering, VVCE, Mysuru, Karnataka, India

[2] Department of Mechanical Engineering, VVCE, Mysuru, Karnataka, India

[3] Department of Mechanical Engineering, VVCE, Mysuru, Karnataka, India

Abstract— ***The hot gases which generate from combustion of fuel passes through the exhaust system of the automobile as they form the passage for the hot gases and released to the atmosphere, Hence they are subjected to 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 that area needs to be focused during design phase. The uniform heat distribution over the entire exhaust system is important for ensuing enhanced life of elements in the sub-system. This problem is important to identify and to assess the uniform heat flow along the passage of hot gases and design the passage or passage surface to minimize the harmful effects of hot-spots over the length of the silencer, especially at the outer body of silencer.***

***Keywords*— Exhaust system, Convective heat transfer, Dimple pattern, Heat transfer coefficient, Hot spots.**

I. Introduction

Automobile Silencer is a device used to reduce the noise produced by the engine. Silencer can also be termed as a Muffler or Resonator. The Silencer is well known as an acoustic sound proofing device aimed to reduce the noise of the sound pressure created by the exhaust gases by way of acoustic quieting. Internal combustion engines are usually equipped with an exhaust silencer to suppress the acoustic pulse generated by the combustion process. A high intensity pressure wave produced by combustion in the engine cylinder propagates along the exhaust pipe and releases from the exhaust pipe termination. Components of silencer absorbs high pressure sound waves and converts it into heat energy, hence designing of the Silencer for uniform heat distribution is of major concern.

The primary function of the silencer is to reduce engine noise emission. Construction wise silencer is classified into two types first is reactive and second is dissipative or absorptive silencer. A reactive silencer generally consists of a series of resonating and expansion chambers that are designed to reduce the sound pressure level at certain frequencies. The inlet and outlet tubes are generally offset and have perforations that allow sound pulses to scatter out in numerous directions inside a chamber resulting in destructive interference, whereas an absorptive or dissipative silencer uses absorption to reduce sound energy. Sound waves are reduced as their energy is converted into heat in the absorptive material. For both the types of silencers, uniform distribution of heat is desirable. Another kind of silencer is Combination Reactive and Dissipative (absorptive) silencer which has both the effects of reactive and dissipative silencer.

II. Literature Survey

Before modifying the existing model, the work of different author done on dimple pattern is studied and it is mentioned in table I. So design assumptions are made on the basis of table I.

TABLE I: AUTHORS WORK ON DIMPLE PATTERN

Author name	Tested structure	Changing Parameter	Constant parameter
Chinruk Thianpong et. al. [1]	Dimple tube (spherical dimple)	P/D=0.7,1	PD, D, H
Sandeep S Kore et. al. [2]	Square channel (spherical dimple)	PD/H=5, 3.33, 2.5	PD
N Katkhaw et. al. [10]	Square channel (ellipsoidal dimple)	S_T/S_L	PD, H
Iftikar ahamad H. Patel et. al. [4]	Square duct (spherical dimple)	Inline and Staggered pattern	P, H, PD

III. Objectives

1) Study of design of existing motor bike silencer
2) Geometry modeling of existing bike silencer
3) Thermal analysis of the Silencer by ANSYS CFD Analysis.
4) Modification in the existing geometry.

5) Enhancing the heat transfer rate by changing the profile of the Silencer thus Improve the life of the silencer by reducing non uniform heat distribution.

IV. METHODOLOGY

A. Study of design of existing silencer

The Silencer opted for the project is Reactive Type of Silencer i.e. the silencer of 153 cc displacement motor bike with 14 bhp at 7500rpm. The silencer is made of Aluminized steel and consists of gas expansion chamber and designed on the basis of optimized back pressure, the Transmission loss noise specified for this silencer is 30dB and allowable back pressure of 10% exhaust gas pressure.

B. Geometry modeling of existing silencer using UG NX 8.0

Complete modeling of existing and modified silencer models are done by using UG NX 8.0 software. Fig.1shows 2D model of Top view of Silencer and 2D model of Front and bottom sectional view of the model.

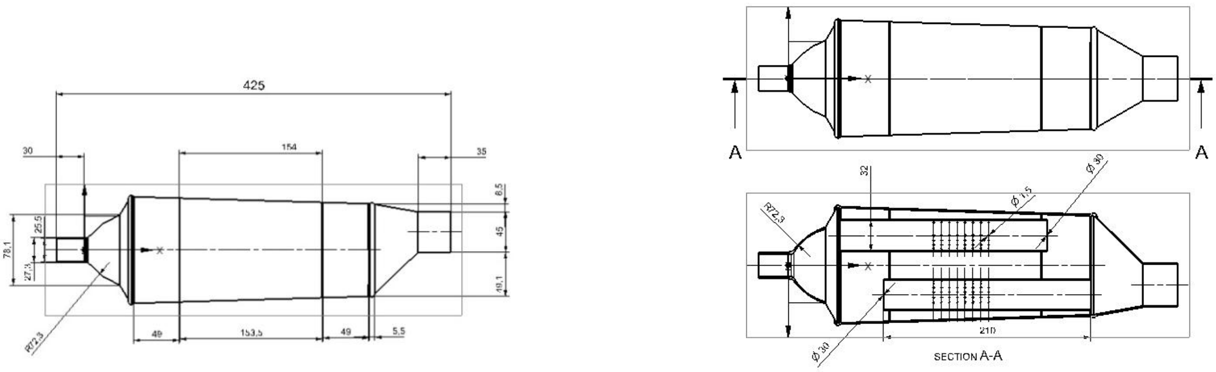


Fig. 1 Two Dimensional model of Existing Silencer (Top View) and 2D model of existing silencer (Front and Sectional view)

As shown in Fig. 1, Bike silencer mainly consists of three section inlet tail pipe, silencer body and outlet pipe. Thickness of the model is 1.5mm and all the dimensions of above figures are in mm.

C. CFD analysis of existing silencer for thermal analysis (heat dissipation) using Ansys workbench

Geometry modeling of complete silencer is done on UG NX 8.0 software. After that it is imported to Ansys workbench 14.5 software. Firstly preprocessing i.e. meshing and fluid definition is made, when all the preprocessing is completed the model is solved using Ansys Fluent. Before Doing CFD analysis some of the assumptions has been made they are

1) Flow is considered to be steady
2) Air is considered as fluid1for computations
3) Flow is considered as turbulent
4) Inlet considered as velocity inlet
5) Outlet considered as pressure outlet

D. Decided modification in the geometry and recommendation of best suitable solution

From the CFD Analysis results for the existing silencer we found hot spots on the silencer outer surface due to non-uniform1heat distribution as shown in Fig. 7 (a) Hence as mentioned earlier we decided to use dimple pattern in staggered arrangement on outer surface of the silencer.

Assumptions are made before design modification

1) Pitch between dimple patterns should be constant
2) The ratio of Print diameter (PD) to height of dimple should be maintaining 2:1
3) Surface area of dimple along the x and y axis should be uniform (i.e. $D_x/D_y=1$)

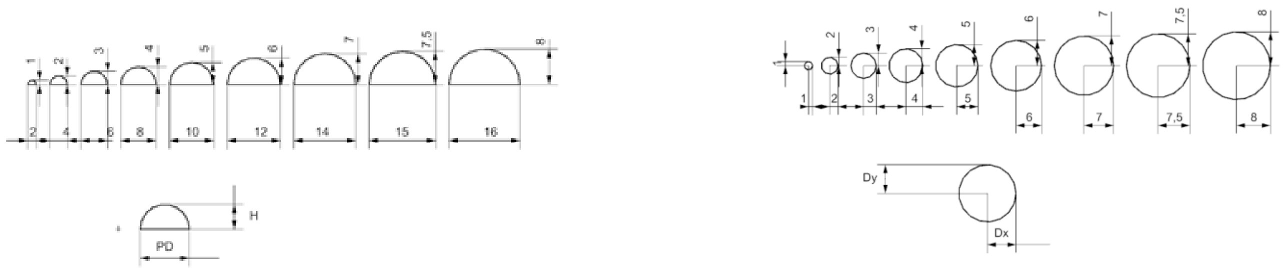


Fig. 2 (a) Dimension of Dimples (b) Dimension of dimple (D_x/D_y ratio)

As shown in Fig. 2 (a) the ratio of Print diameter to height (PD/H) of dimple is 2:1 for all dimples. But according to the assumption if we keep constant pitch between two dimples then diameter to pitch ratio (PD/P) for different dimple features are goes on increasing as diameter increases. The number of dimples used for different trial is shown in Fig.2

(b). For selection of dimple dimensions, pitch we referred the experiment done by Dattatray Dilip Giripunje et. al. The model used by them for analysis is shown in Fig. 3 (a) and boundary conditions as follows

1)For inlet: Velocity Inlet

Inlet flow velocity = 11.2 m/s, Inlet temperature = 303 K, Turbulence intensity = 10%, Hydraulic diameter = 0.12 m

2)For outlet: Pressure outlet

Gauge Pressure = 0 Pa, Back flow turbulent intensity = 10%, Back flow hydraulic diameter = 0.12m

3)For Wall: HTW (Heat Transfer Wall)

Material name = Aluminum, Aluminum, Convective heat transfer coefficient = 0, 120 w/m^2-k, Temperature = 300, 300 K, Free stream temperature = 300, 660 K

Temperature recorded during the analysis of different diameter of dimple with same boundary condition is shown in Fig.3 (b).

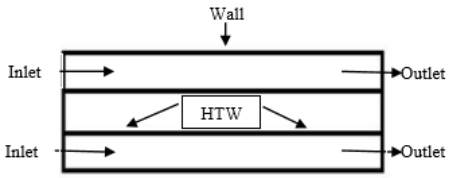
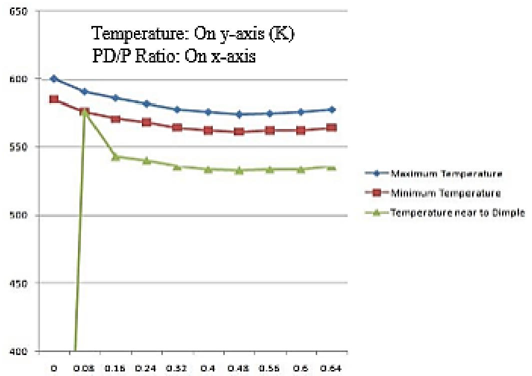


Fig. 3 (a) Schematic Diagram for the CFD analysis



(b) Comparison of result between plain and different dimple surface of silencer body from CFD

From the Fig.3 (b) we can conclude that temperature near to dimple surface goes on decreasing as the ratio of print diameter to pitch increases up to 0.48. But as the ratio of PD to pitch increases above 0.48 it start to show its inverse effect on temperature drop. Hence dimple diameter of 12 mm and 25 mm pitch is decided, Since silencer model has taper cross-section from 120 mm major diameter to 104 mm minor diameter, for effective modification fourteen numbers of dimples are selected for 25mm pitch for staggered arrangement with transverse pitch 25 mm.

E. Design details

Fig 4 and Fig 5 Represents 3D modeling of Existing and Modified Silencer done using UG NX 8.0 software. It is then analyzed using Ansys 14.5 software.

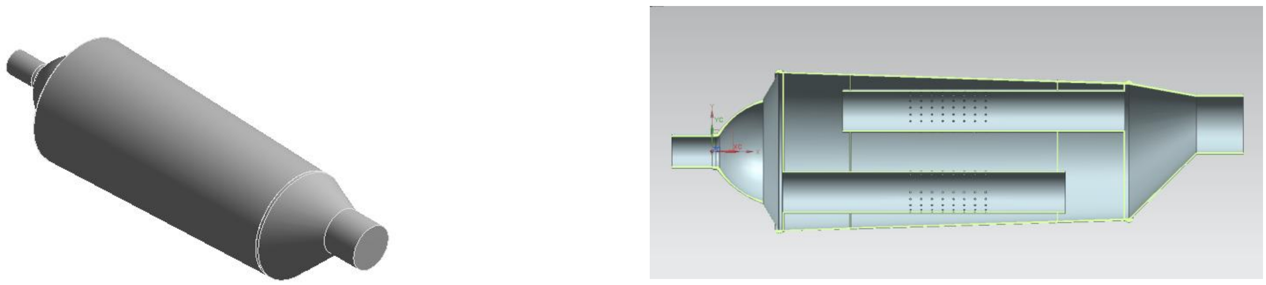


Fig. 4 Isometric and Sectional View of existing silencer

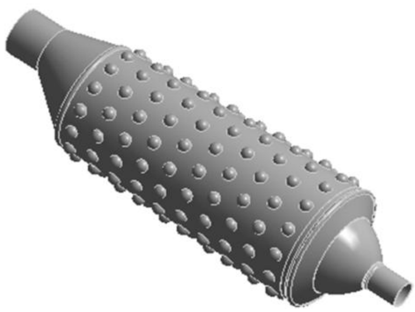


Fig. 5 Modified model having staggered dimple pattern on outer surface

F. Analysis results and discussion

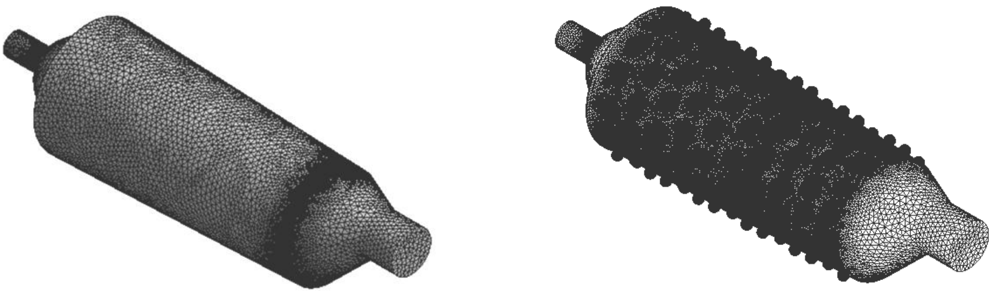


Fig. 6 Meshed model of existing and modified staggered model

From the above Fig. 6, the meshing employed is Tetrahedral meshing and results shows that number of nodes = 134112 and number of elements = 748095 for existing model and number of nodes = 859340 and number of elements = 4797889 for modified Staggered model. Boundary conditions for CFD analysis is given in table 2.

TABLE II: BOUNDARY CONDITION USED FOR CFD ANALYSIS

Material	Aluminum
Temperature of exhaust gas (k)	403 k
Velocity of exhaust gas (m/s)	3 m/s

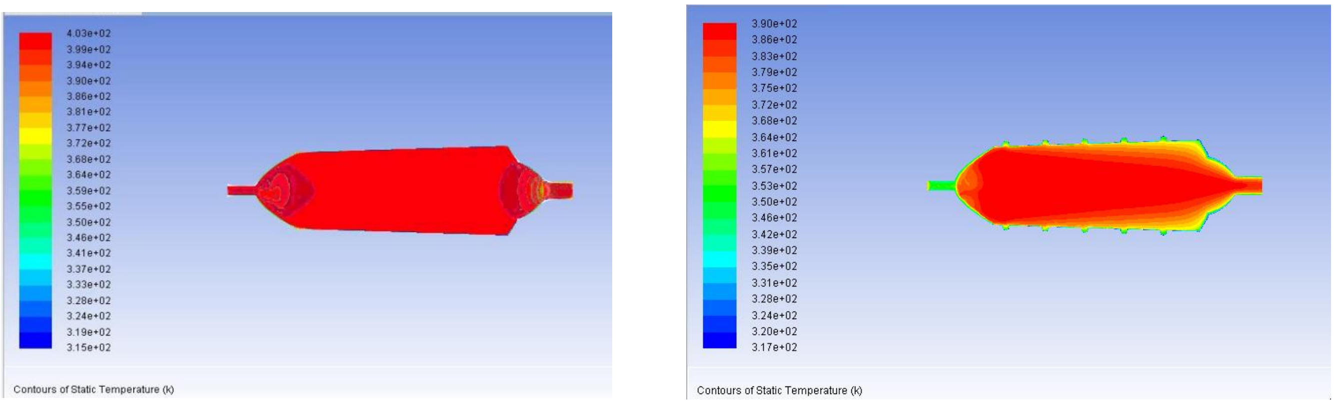


Fig. 7 (a) Static Temperature results of Existing model (b) Static analysis results of Modified model

CFD Analysis has been carried out for existing model and we found non uniform heat dissipation on the outer surface of the silencer body fig.7 (a) for a boundary condition as mentioned in table 2, i.e. formation of hotspots at inlet as well as outlet sections. To overcome this problem modification is done by providing dimple patterns on the outer surface of the silencer body and dimple patterns of 12 mm diameter with 25 mm pitch is decided for effective modification and CFD analysis is carried out for the same boundary conditions and results showing uniform heat dissipation is shown in fig.7 (b) and even there is reduction in maximum temperature from 403k to 390k compare to existing model.

V. Conclusion

From the results obtained we can concluded that hot spots 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 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 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.

Weight of the existing model is 1.2126 kg, Weight of staggered model it is 1.611 kg. Even though weight of the silencer is increased by modification, we got good results in temperature distribution and weight increment is very small.

Acknowledgment

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References

[1] Chinaruk Thianpong, Petpices Eiamsa-ard, Khwanchit Wongcharee, Smith Eiamsa-ard, "*Compound Heat Transfer Enhancement of a dimpled tube with a twisted tape swirl generator*", International Communications in Heat and mass transfer, pp. 698-704, 2009.

[2] S S Kore, S V Joshi, N K Sane, "*Experimental investigations of heat transfer enhancement from dimpled surface in a channel*" IJEST, pp. 34-41, 2011.

[3] S G Kandlikar, S Joshi, S Tian, "*Effect of channel roughness on heat transfer and fluid flow characteristics at low reynolds number in small tube*" 35th National Heat Transfer Conference , California , ASME., pp. 34-39, 2012.

[4] Iftikarahamad H Patel, S L Borse, *"Experimental investigation of heat transfer enhancement over the dimpled surface*", International Journal of Engineering Science and Technology (IJEST), pp.67-74, 2012.

[5] S M Gaikwad, Iftikarahamad H Patel, R B Gurav, J D Patil, A A Ramgude, "*Computational investigation of convective heat transfer over a dimpled surface*", pp.56-63, 2012.

[6] Dattatray Dilip Giripunje, Vilas B Shinde, Swapnil S Kulkarni, "*Thermal analysis of motor bike exhaust silencer for enhancing heat transfer rate by adding dimple as enhancing features*", International Journal of Scientific Research and Management Studies (IJSRMS) ISSN: 23493771 Volume 2 Issue 2, pg: 125- 135, 2013.

[7] P. N. Shrirao, R. U. Sambhe and P. R. Bodade, *" Convective Heat Transfer Analysis in a Circular Tube with Different Types of Internal Threads of Constant Pitch*", International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-2, Issue-3, February 2013.

[8] O M Shewale, P A Mane, "*Experimental investigation of double pipe heat exchanger with helical fins on the inner rotating tube*", IJRET, pp.98 -103, 2014.

[9] Mesut Durat, Zekeriya Parlak, Murat Kapsiz, Adnan Parlak, Ve Ferit Fiçici, "*CFD and Experimental analysis on thermal performance of exhaust system of a spark ignition engine*", Journal of Thermal Science and Technology, TIBTD Printed in Turkey ISSN 1300-3615, 2014.

[10] N Katkhaw, N Vorayos, T Kiatsiriroat, Y Khunatorn, "*Heat transfer behavior of flat plate having 45˚ ellipsoidal dimpled surfaces*" case studies in thermal engineering" pp. 67–74, 2014.

[11] Dhirajkumar K More, Prashant D Deshmukh, R O Gawande, "*Thermal analysis of two wheeler exhaust silencer using computer aided engineering*", International Journal of Engineering Technology, Management and Applied Sciences, Volume 4, Issue 6, ISSN 2349-447, 2016.

[12] Trupti P Wani, Raja R, M S Ganesha Prasad, "*Design and analysis of muffler for reducing the vibration*" International Journal of Research in Aeronautical and Mechanical Engineering, ISSN: 2321-3051, Vol.4 Issue 1, Pgs: 120-130, 2016.