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Design and Thermal Analysis of Motor Bike Exhaust Silencer- A Review

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***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. The problem identified for this dissertation work is to assess the uniform heat flow along the passage of hot gases and design the passage or passage surface such has to minimize the harmful effects of hot-spots over the length of the silencer, especially at the outer body of silencer.**

Keywords*— Exhaust system, Local heat transfer coefficient, Effective heat transfer area, dimple pattern.

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 (Muffler) is engineered as an acoustic sound proofing device designed to reduce the loudness of the sound pressure created by the engine by way of acoustic quieting. Internal combustion engines are typically equipped with an exhaust muffler to suppress the acoustic pulse generated by the combustion process. A high intensity pressure wave generated by combustion in the engine cylinder propagates along the exhaust pipe and radiates 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.

Silencer is also used in many other engines and generators. The size, shape and construction vary according to the type and size of the engine. 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.

The exhaust system of automobile or any IC engine consists of three components such as exhaust manifold, catalytic converter and resonator (i.e. silencer or muffler). So all the gaseous generated have to pass through this complete exhaust system. But because of functional requirement exhaust gaseous staying longer time in resonator (i.e. silencer section) in order to reduce noise level which also results in thermal failure of resonator and shorter life span. There are many authors worked in heat exchanger field and use different technique to enhance heat transfer rate, technique they used is passive and some are active one. In passive technique they change the design of actual component by adding some extra features. Those responsible to enhance heat transfer rate from the same surface. They using shallow spiral, dimple pattern, surface roughness, fins, and twisted tape or different type of insert wise features and in active techniques they try to make flow more turbulent by adding swirl generator, nozzle and multiphase flow. But out of those techniques only few are possible to adopt on the surface of silencer body but rest are only possible to adopt in the flow or inside of silencer. So to enhance heat transfer rate from the surface of silencer body we have to adopt such features which possible to build on the surface of it. Again some of them are possible and some are not. Those are listed in Table 1.

It is mentioned in the table that some techniques are inboard type and some are outboard. The inboard technique are those which can located at inner side of silencer and outboard are those which can located at outer side. But inboard techniques are responsible to generate back pressure as it directly present in the flow field. So it may build back pressure on engine as it located inside of silencer. So from the table dimple pattern are the best enhancement features in case of silence.

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Table 1

Comparison of different heat transfer technique [6]			
Feature	Inboard (inner side of silencer)	Outboard (Outer side of silencer)	Comment as per Silencer application
Fins	NA	A	It is possible but may harmful for rider
Dimple Pattern	A	A	It is possible to employ in case of silencer.
Shallow Extended Spiral	A	A	It is possible to employ in case of silencer.
Surface Roughness	A	A	It is possible to employ in case of silencer but become ineffective after deposition of mud on silencer body.

II. LITERATURE SURVEY

Chinaruk Thianpong et al. (2009) [1] Experimentally investigated the friction and compound heat transfer behavior in a dimple tube fitted with twisted tape swirl generator using air as a working fluid. The effect of the pitch and twisted ratio on the average heat transfer coefficient and the pressure loss are determined in a circular tube with the fully developed flow for the Reynolds no. in the range of 12000-44000. The experiment is conducted for 2 different dimple tubes with different pitch ratios of dimple surfaces. The Results obtained reveal that both heat transfer coefficient and friction factor in the dimple tube fitted with twisted tape, are higher than those in dimple tube acting alone and plain tube.

M L Munjal (2011) [2] In this review paper, recent advances in the theory and design of double-tuned expansion chamber and the extended concentric tube resonators, transverse plane wave analysis of short elliptical end chambers, acoustical source characterization of the intake as well as exhaust systems of reciprocating internal combustion engines, analysis of multiply- connected element mufflers, breakout noise of non-circular muffler shells, and analysis of diesel particulate filters and inlet air cleaners have been discussed. These are some of the topics in muffler acoustics that have a direct bearing on design of efficient mufflers for the intake as well as exhaust systems of IC engines. An equally important design parameter is the mean pressure drop or back pressure, which has been mentioned incidentally at a couple of instances.

Sandeep S Kore et al. (2011) [3] conducted experimental study of the flow of air in a rectangular channel with dimpled surface, subjected to uniform heat flux boundary condition. They studied the effect of varying depth which having constant print diameter on heat transfer coefficient taking the δ/a ratio ranges from 0.2 to 0.4. and they performed the testing on dimple test channel which having dimple depth 10 mm , 15 mm and 20 mm with 50 mm constant print diameter while Reynolds number ranges from 10000 to 40000. During experimentation of surface for same Reynolds number, they found that for range 0.2-03 δ/a ratio Nusselt number goes on increasing, which increases heat transfer while for range 0.3-0.4 δ/a ratio Nusselt number goes on decreasing, which decreases rate of heat transfer as shown in Fig.2. Heat transfer increases with the dimples appears to have a maximum value of approximately 2.88 and overall maximum thermal performance of about 2.63 for a depth of 0.3 and Heat transfer coefficients are low on the sharp end of the dimple and high on the trailing edge and flat area immediately downstream of the dimple and finally decrease in Nusselt number for 0.4 δ/a ratio because larger generation of recirculating flow which act as insulating pocket which ultimately reduces the heat transfer.

Satish G Kandlikar et al. (2012) [4] perform the experiment method to know the effect of roughness on rate of heat transfer. During the study they deals with the single phase flow in channel and keeping the value of Reynolds number below 2300 with smaller hydraulic diameter. During experimentation, they used two stainless steel pipes having diameter 0.62 cm and 1.032 cm in order to change the roughness of inner surface they used etching method. The surface was acid treated in such a way that ,each tube provided three differ roughness value with Reynolds number ranges from 900-3200 for 0.62 cm and 500-3200 for 1.032 cm diameter pipe respectively. Researcher obtained effective roughness (e/D) of 0.00255, 0.0029 and 0.00161 for 0.62 cm diameter tube whereas 0.0025, 0.00178 and 0.00281 for 1.032 diameter pipe and they concluded that for same range of effective roughness, rate of heat transfer for larger tube is less as compare to smaller one.

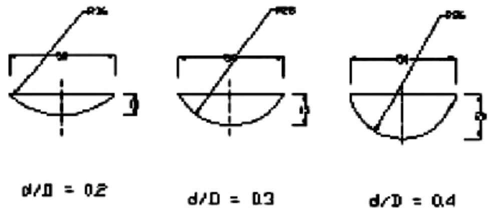

Fig. 1. Dimple Geometry

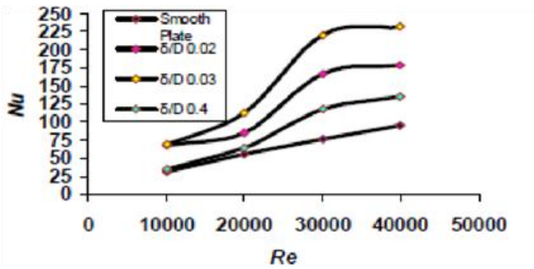

Fig. 2. Variation of Nusselt No. with dimple depths

Iftikarahamad H Patel et al. (2012) [5] carried out experiment to determine the effect of dimples on heat transfer over a flat surface under forced convection condition, for proposed study researcher employed two aluminum plates of dimension 400x72x6 mm3 with different types of dimple pattern, first plate having dimple density 204 in number with inline arrangement while second plate having dimple density 187 in number with staggered as shown in Fig. 3. On the basis of experimental result they plotted a graph between Reynolds number and Nusselt number, and found that staggered dimple pattern plate having more surface effectiveness for heat dissipation problem as compared to aligned dimple pattern plate and the use of dimples on the surface effects in heat transfer increase in forced convection heat transfer with lesser pressure drop penalty. Researcher concluded that because of dense vortices formation, Nusselt number is higher in case of staggered dimple pattern plate which ultimately higher rate of heat transfer. But in aligned pattern of dimple, there is formation of denser boundary layer as air flow in straight path without creating any disturbance.

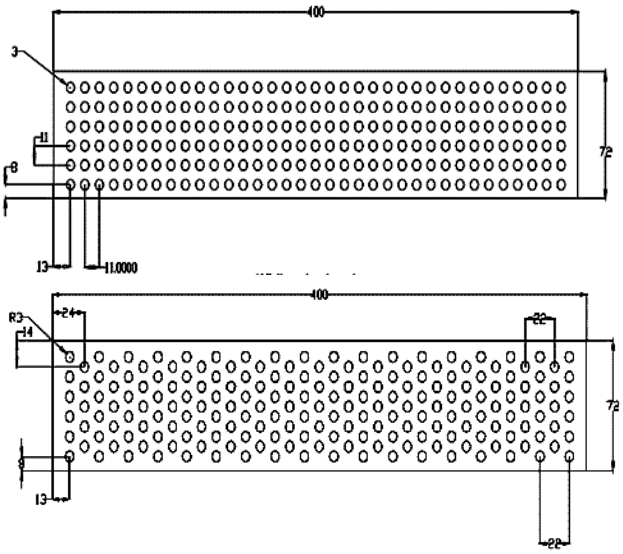

Fig. 3. Schematic of test plate with 204 inline and 187spherical staggered dimples

S M Gaikwad et al. (2012) [6] performed computational investigation of convective heat transfer in turbulised flow past a dimpled surface for aluminum plates of dimensions 400x38.1x12 mm^3 was considered as test surfaces. Variation of Nusselt numbers with Reynolds numbers are investigated, with various parameters combinations. Effect of dimple density, dimple depth and dimple arrangement on heat transfer in terms of Nusselt number enhancement is also reported. In order to determine the effects of Reynolds number, dimple depth and Nusselt number on heat transfer enhancement parametric analysis is performed with k-ε turbulence model. Researcher computed heat transfer coefficients in a channel with one side dimpled surface. For investigation the sphere type dimple geometry was considered with δ/D ratio as 0.4 as shown in Fig 4 and Fig 5. And it was increased later to 5 mm to increase δ/D ratio to 0.5. The Reynolds number based on the channel hydraulic diameter was varied from 200000 to 360000. Due to flow reattachment, the results showed that more heat transfer was occurred downstream of the dimples whereas due to the flow recirculation on the upstream side in the dimple, the heat transfer coefficient was very low and they concluded that the overall heat transfer coefficient increased as the Reynolds number increased.

J E Kim et al. (2012) [7] carried out Numerical study on characteristics of flow and heat transfer in a cooling passage with protrusion-in-dimple surface with 4 different protrusion heights and protrusion height to channel height (h/H) of 0.05, 0.10, 0.15, and 0.20. This experiment under performed by turbulent flow and water as a working fluid. CFD analysis and Experimental method and 40% negligible pressure drop, 24% increase heat transfer, increase friction factor up to 5–6% was obtained.

Dattatray et al. (2013) [8] carried out the thermal analysis for motor bike exhaust silence to reduce hot spots through design modification. They design the muffler made with hot spot reduction and made enhancement in the life of the components of exhaust system. They used high temperature heat resistance powder coating for mufflers of automobile application with improved aqueous corrosion, high temperature corrosion which started from the formation of the hot spot at front section of muffler. They investigated the modified design of muffler for heat transfer and proposed best suitable results to reduce hot spots in the exhaust sub-system.

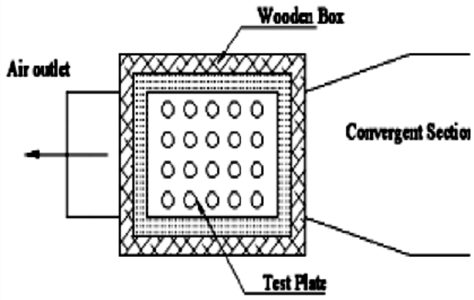

Fig. 4. Schematic of Test Section

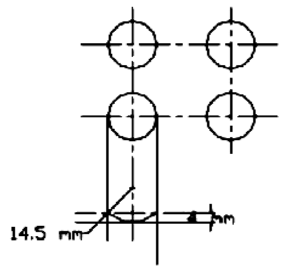

Fig. 5. Solid and perforated fin arrays

Shrirao et al. (2013) [9] conducted an investigation on the mean Nusselt number, friction factor and thermal enhance ment factor features in a circular tube having different internal threads of 120 mm pitch under constant wall heat flux boundary conditions. In the experiments, for Reynolds number range from 7000 to 14000 recorded data are taken with air as the working fluid. In the experiment three different types of internal threads viz. acme, buttress and knuckle threads are used with constant pitch. Mean Nusselt numbers obtained for test tubes with internal threads such as buttress, acme and knuckle threads are respectively, 1.46, 1.30 and 1.19 times higher than plain tube. The thermal enhancement factors are in a range between 1.12-1.04, 1.1-1.03 and 1.08-1.02 respectively for the test tubes with buttress, acme and knuckle threads.

Shewale et al. (2014) [10] performed experimental study of double-pipe heat exchanger with helical fins on the external surface of inner tube as shown in Fig 6. The length of the inner tube is one meter and the fins are provided on it for 970 mm length with uniform fin pitch of 17mm. Water is used as a cold fluid for the counter flow arrangement in the tube

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side and glycerol as hot fluid in the shell side the convective heat transfer coefficients were achieved for the stationary as well as rotating inner tube. The flow rate of hot fluid was varied but cold fluid was kept constant. For the experimental work the Nusselt number for the inner tube with helical fins is 4 times greater than that of the plain inner tube for stationary condition and the experimental results obtained are compared with the theoretical outcomes obtained by using Dittus-Boelter equation which is applied for plain tube in tube heat exchanger. The helical fins enhance area of heat transfer and rotation of the inner tube raises the turbulence which is important for the convection mode of heat transfer. Results shows that Nusselt numbers at the speed 50 rpm and 100 rpm are 36% and 64% greater than that of stationary inner tube respectively. The Nusselt numbers at 100 rpm are 21 % higher than that of 50 rpm.

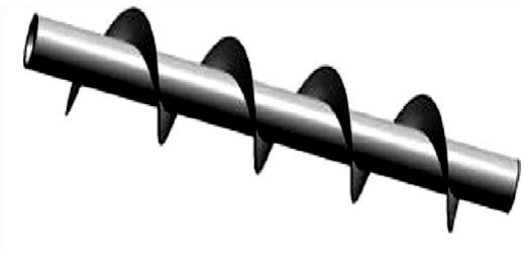

Fig. 6. Helical Fins on the Tube

Durat et al. (2014) [11] conducted experimental and CFD analysis on thermal performance of exhaust system of a SI engine; it was carried out to compare the heat transfer and CFD analysis of gas flow in the exhaust pipe. In the experiments the temperatures at inlet and outlet of the exhaust pipe were recorded and the study 3-D transient CFD analysis has been carried out for the whole exhaust pipe. The results in CFD analysis matches with those of experimental data and optimum catalyst location was determined by the CFD analysis conducted in transient regime.

N Katkhaw et al. (2014) [12] studied heat transfer performance of external air flow over the ellipsoidal dimple surface. The dimple arrangement and dimple interval are examined. In case of staggered arrangement researcher performed investigation of dimple of dimple pitch (ST/SL) 1.25, 1.11, 1.00, 1.33, 1.67 and similarly in case of inline arrangement author used dimple of dimple pitch (ST/SL) 1.00, 1.25, 1.89, 0.8, 1.00 and 1.11 as shown in Fig 7 and Fig 8. Author found that in case off staggered pattern shows considerable effect as compared to flat plate but not as that of spherical dimple of same features. It happens because in case of ellipsoidal dimple of staggered pattern because the dimple structure established the less effective heat transfer area inside it and enhances the heat transfer rate at outside area. . Hence if dimple arrange very close to each other than effective area offered by that structure is very less. In case of staggered pattern dimple rushes the plate surface so enhanced area between two dimples is very less when ST is minimum hence ST increases heat transfer rate also increases up to certain value.

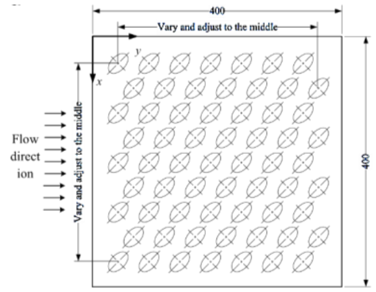

Fig. 8. Staggered array of ellipsoidal dimple

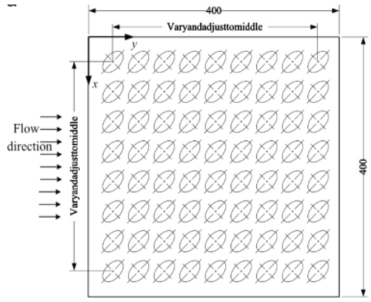

Fig. 9. Inline array of ellipsoidal dimple

Dhirajkumar K More et al. (2016) [13] proposed a study on the two-wheeler of a modern variant introduced by a top OEM in this segment, the experiment carried out over the silencer of a `live' vehicle. For the existing silencer, the readings for temperature are recorded at various chosen locations over the complete length of the silencer. They recognized problem that is to assess the heat flow during the passage of hot gases and design the passage in such a way that will minimize the destructive effects of hot-spots over the length of the silencer, especially at the front end mating with the exhaust manifold.

Kannan P et al. (2016) [14] carried out experiment on silencer for different materials for stress and strain conditions for both pressure and thermal loads, the materials they have analyzed are mild steel, stainless steel, glass fiber E-grade and carbon fiber. In the analysis of silencer they found that the carbon fiber silencer have a good strength and it have a less stress under the fixed support and force, than the other three material which are used for silencer. So the existing mild steel material can be replaced with optimized carbon fiber material because of its low deformation and elastic strain values. Compared to other optimized materials like glass fiber E-grade and stainless steel the carbon fiber has low stress value. So the suitable material for silencer is carbon fiber.

Trupti P Wani et al. (2016) [15] Modelled different designs of silencer using Catia and the analyses of the both existing and new mufflers are done by the Autodesk Simulation because its main attention is that to predict the performance of the both Mufflers. The graphs of the mass flow and volume flow of the both existing and new designed muffler are predict that by changing the design, the muffler performance will increase and noise level of the muffler is decreased. The design and analysis result for the existing and modified muffler is obtained from Catia software. From the results shows that performance of the muffler is improve and noise level reduces.

Antony luki A et al. (2016) [16] investigated that augmented surface has been achieved with dimples strategically located in a pattern along the tube of a concentric tube heat exchanger with the increased area on the tube side. Here investigation dimpled tube is used. From theoretical calculation the overall heat transfer coefficient is increased and also effectiveness of the dimpled tube with concentric tube heat exchanger is increased 8% compare to plain tube concentric tube heat exchanger. From theoretical results shows that dimpled tube heat exchanger gives better performance. Hence they suggest the dimpled tube is used in concentric tube heat exchanger in various applications will give high heat transfer.

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III. CONCLUSION

From the Literature survey we can conclude 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 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. The results obtained for the project is very encouraging and reinforce the convection modified silencer for practical, efficient and economically potential to contribute more heat transfer.

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] M L Munjal, “Recent advances in muffler acoustics”, Facility for Research in Technical Acoustics (FRITA), Indian Institute of Science, Bangalore 560 012, India, 2011.

[3] 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.

[4] 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.

[5] 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.

[6] 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.

[7] J E Kim, J H Doo, M Y Haa, H S Yoon, C Son, “Numerical study on characteristics of flow and heat transfer in a cooling passage with protrusion-in-dimple surface’’ International Journal of Heat and Mass Transfer 55 (2012) 7257–7267.

[8] 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.

[9] 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.

[10] 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.

[11] 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.

[12] 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.

[13] 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.

[14] Kannan P, Jayaseelan V, Gopalakrishnan D, Ashok M, “Design and analysis of automotive silencer for effective corrosion control”, International Research Journal of Engineering and Technology (IRJET), e-ISSN: 2395 -0056, Volume: 03 Issue: 08, Aug-2016.

[15] 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.

[16] Antony luki A, Ganesan.M, “Flow Analysis and Characteristics Comparison of Double Pipe Heat Exchanger Using Enhanced Tubes”, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X PP 16-21 www.iosrjournals.org, 2016.