Investigation of Heat Dissipation between Dimple and Normal Silencer made of Chrome Steel

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***Abstract*: The purpose of the exhaust system in all automobile vehicle is simply to channel the fiercely hot products of fuel combustion away from the engine or generator and the car's occupants and out into the atmosphere. The main purpose of the exhaust system is to reduce the noise. The gases that are getting exhausted from the engine will be at high speeds. Because of the opening and shutting of the exhaust valves in each cycle of combustion, the gas pressure changes from high to low, this cause vibration and hence produces heavy sound. Due to the continuous operation of the engine the silencer becomes too hot. It will injure seriously if anyone touches it with naked body.**

The dimple silencer will have increase in the rate of heat dissipation, because of the dimples provided on the surface of the silencer. The dimples on the silencer will perform a function similar to that of the cooling fins of an IC engine. The dimples act as the extended surface over the surface of the silencer & provides better heat transfer rate. In this work clear Analysis is made using Ansys software for Normal & Dimple Silencer and Results are compared with the rate of Heat dissipation.

***Index Terms*: Exhaust system, silencer, cooling fins, dimples**

I. INTRODUCTION

Background

A generic Dimple Silencer collects hot exhaust gases from the engine and discharges them to the environment as quietly and efficiently as possible. Normally the exhaust arrangement (Silencer) plays the main role in reducing the noise, So heat exposure will be more on the surface of the silencer[1-2]. To reduce the heat exposure, an alternative design for silencer is required. Dimple silencer would be best for for that. The main objective of Dimple Silencer is to reduce the heat exposing over the surface of the silencer. Therefore controlling level of the parameter is quite essential for effective working of Dimple Silencer which can be done by making use of dimples on the outer surface of the silencer. In order to make reducer effective the temperature of it should be reach up to 900˚C which is possible in four wheel drive and heavy duty vehicles. The size, shape and construction of silencer vary according to the type and size of the engine. Some aftermarket silencer claim to increase engine output and/or reduce fuel consumption by dint of reduced back pressure.

Objective

Since the beginning of the 20th century the number of vehicles on the road are increasing tremendously. Not only the vehicles but also the number of IC engines (Internal Combustion). These IC engines are not only used for automobiles but also for many other applications such as running electrical generators etc. The IC engine is a device which internally converts the chemical energy of the fuel to the mechanical energy. During this energy conversion process a lot of flue gases are generated & the temperature of this flue gas is high enough that it can cause burn injuries. The hot flue gases include carbon dioxide, Carbon monoxide (CO) & nitrous oxides. These flue gas passes from the silencer and the silencer becomes hot.

The main purpose of this project is to increase the heat dissipation, so that the heat over the surface of the silencer is reduced. The reduction of the heat over the silencer surface will reduce the cause of fire accidents & some burn injuries.

Scope

The scope of this project was to design and develop a Dimple Silencer in order to increase the heat dissipation. The main purpose of the silencer is to reduce the noise emitted by the exhaust of an internal combustion engine.

Silencers are installed within the exhaust system of most internal combustion engines. The muffler is engineered as an acoustic device to reduce the loudness of the sound pressure created by the engine by acoustic quieting[3-4]. The noise of the burning-hot exhaust gas exiting the engine at high velocity is abated by a series of passages and chambers lined with roving fiber glass insulation and/or resonating chambers harmonically tuned to cause destructive interference, wherein opposite sound waves cancel each other out.

An unavoidable side effect of this noise reduction is restriction of the exhaust gas flow, which creates back pressure, which can decrease engine efficiency. This is because the engine exhaust must share the same complex exit path way built inside the muffler as the sound pressure that the muffler is designed to mitigate.

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Some aftermarket silencer claim to increase engine output and/or reduce fuel consumption by dint of reduced back pressure. This usually entails less noise reduction (i.e., more noise).

Dimple Silencer

The Dimple Silencer usually consists of projection-like dimples all over the exterior of the silencer. Dimples are intended to reduce the heat generated by dissipating the heat by increasing the area of the surface.The dimple silencer will have increase in the rate of heat dissipation, because of the dimples provided on the surface of the silencer. The dimples on the silencer will perform a function similar to that of the cooling fins of an IC engine. The dimples acts as the extended surface over the surface of the silencer & provides better heat transfer rate.

The purpose of the exhaust system is simple: to channel the fiercely hot products of fuel combustion away from the engine or generator and the car's occupants and out into the atmosphere. The exhaust system has a secondary purpose- to reduce the amount of noise made.

The exhaust gases leave the engine at incredibly high speeds. Moreover, with the opening and shutting of the exhaust valves with each cycle of combustion for each cylinder, the gas pressure alternates from high to low causing a vibration- and hence sound. Due to the continuous operation of the engine the silencer becomes too hot.

Specification Of The Dimple Silencer

- Mechanism- Heat exposure
- Target Customer- Majority of the automobile industries & IC engine manufacturers.
- Material : Chrome steel
- Software used- Ansys, Solidworks

Silencer Used

The Silencer that we use here for our fabrication is a classic Royal Enfield (bullet) silencer. This silencer is quite different from the other conventional silencers that it has long inlet and outlet lining extending from the main body. This type of silencer is generally suitable for overhead valve single cylinder four-stroke motor cycles just like Royal Enfield bullet motor cycle.The following are the available Enfield silencers in the market:

- Rocket Type (Right and Left)
- Honda Type (Right & Left)
- 500 CC Silencers
- Gold Star
- Single Filter
- Full open Silencers
- OE Type Filter
- Thunder Bird Silencers

Our fabrication is completely based on the Classic Exhaust type of silencer which is enlisted among the above silencers that are available in the market samples are shown in Figure 1.The efficiency and the functioning of the silencers are predominantly based on the type of silencers that are equipped.

Figure 1: Typical RE Silencers

The Classic Exhaust type of silencers are often considered as the most suitable type of silencer for easier dissipation of heat both during static and dynamic conditions, hence we have preferred this type of silencer for our fabrication work. The modern Characteristics and features of the silencers that are compatible with the Enfield automobiles are:

1) Long Bottle: Gives slow Strong and long Strokes. Bass is heavy and strong treble is recessed. Physically it is very long and protrudes out of chassis.

2) Short Bottle: Most close to Original Cast Iron beats, it's very pleasant and balanced out tune, very soothing for ears, not loud. Just right, very natural.

3) Wildboar: Emphasises specially on Bass, The bass is deep, heavy and thumpy. Sound seems artificial and hurts ears when in Higher RPM's

4) Goldstar: Gives a very Techno- Bassy tune. The sound upon hearing seems very artificial and not very soothing for ears. Treble is boosted.

5) Falcon: Heavy tune, authentic and balanced tune interval. Non fatiguing tune.

6) Monster: Looks tiny, but gives heavy beats, and has deepest Bass of all.

7) Megaphone: Loud, fast beats, emphasized on Bass, sound is much more continuous without interval.

8)Dolphin: Looks like mouth of dolphin,large sound with high bass.

9)Red rooster:It will increase engine power by reducing the back pressure of the factory exhaust system.

Figure 2: Silencer used

Technically any silencer change will affect engine's performance, shelf life, wear-tear, efficiency[5-8]. On that basis we have concluded that this classic exhaust silencer shown in Figure 2 will be suitable more for heat dissipation and also for achieving our main objective of the dimple silencer. General specifications shown in Table 1.

Table 1: General Specifications

Brand	Royal Enfield
Model	Angular Off roader Upswept Free Flow Exhaust Silencer Chrome For Royal Enfield Standard 350 cc
Material	Chrome Steel
Reducer diameter	96mm
Length	825mm
Thickness	2mm
Weight	2.4kg

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.

Complete modelling of existing and modified silencer models are done by using SOLIDWORKS software.

II. FABRICATION

Fabrication of the Dimple Silencer

The dimple silencer is having a simple cross section as similar to a ordinary silencer, except those that of the dimples. The reducer from the ordinary silencer is replaced with a dimpled one. The surface over the ordinary silencer is removed & replaced by a surface with dimples, this is replaced with the help of welding.

The electric arc welding using a steel electrode AISI 317, AISI 317L., these electrodes are used for stainless steel of similar composition, clad fabrication, joining of stainless steel to carbon steel and low alloy steel, acid storage tank and vessels etc.

Initially the design was done in SOLIDWORKS 2017. And analysis was done using Ansys. While performing the analysis work the temperature at the inlet of the silencer is taken to be 116.5°C, which is standard for the Royal Enfield Bullet when operating at ideal conditions. The silencer is made up of chromium steel (or) chrome steel. The thermal conductivity was found to be (k) =16.5 W/m^{2}K. The convective heat transfer coefficient has calculated manually. Initial model was made for inlet shown in Figure 3.

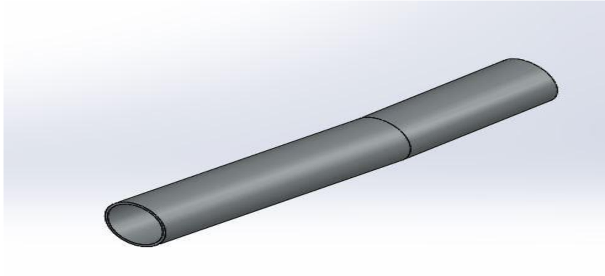

Figure 3: Inlet of Silencer (or) Exhaust pipe IN

Reducer

- The length of the reducer is 350 mm.
- It is 2 mm thick.
- The diameter of the reducer is 96mm.
- The reducer has enclosed three mufflers in it.
- It is made up of chromium steel.

The reducer is shown in figure 4 is the reducer which is used in two wheeler, where as in 3(or)4- wheelers & all, this reducer is replaced by catalytic converter. The dimples can also be added to the catalytic converter. Figure 4 shows the reducer without dimples.

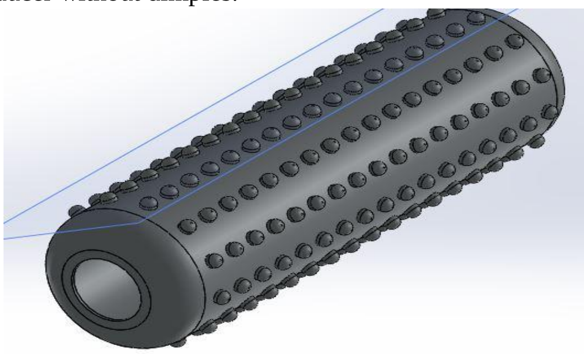

Figure 4: Reducer with dimples

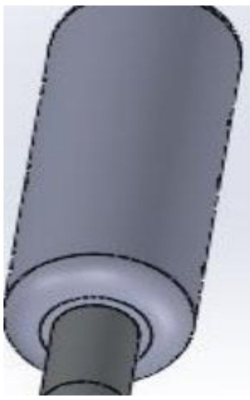

Figure 5: Reducer without dimples

Muffler

- Mufflers shown in figure 6 are something which reduces the noise.
- These mufflers are placed (or) arranged alternatively such that the hot flue gases from the engine passes in a spiral manner reducing the noise.

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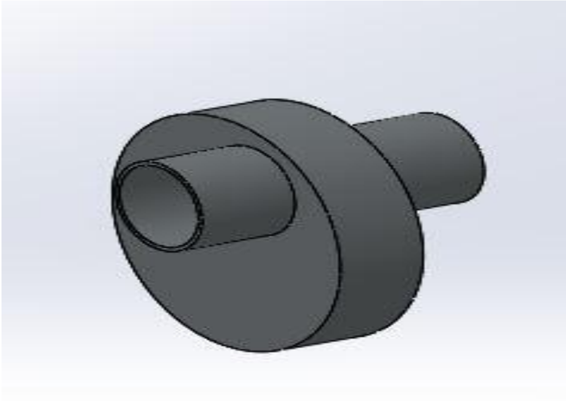

Figure 6: Muffler

Outlet

- The length of the outlet is 165mm.
- It is made up of chrome steel (or) chromium steel.
- It bent at an angle of 20°.
- Figure 7 shows the outlet portion attached towards the reducer.

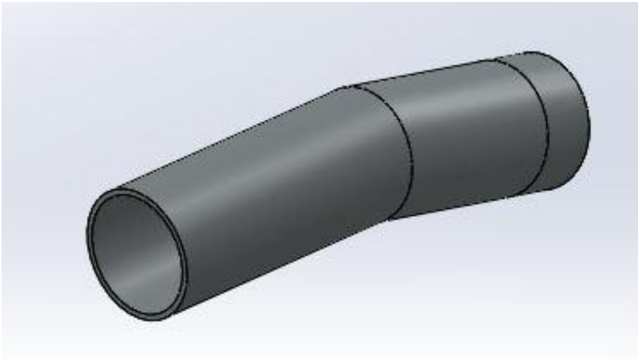

Figure 7: Outlet

Dimples

- These are tiny projections on the surface of the silencer as in figure 8.
- The dimples play a vital role for increasing the surface area, hence better heat dissipation.
- In-order to reduce the stress concentration at the top of the dimple, instead of making them sharp, it is modified to dome like structure.

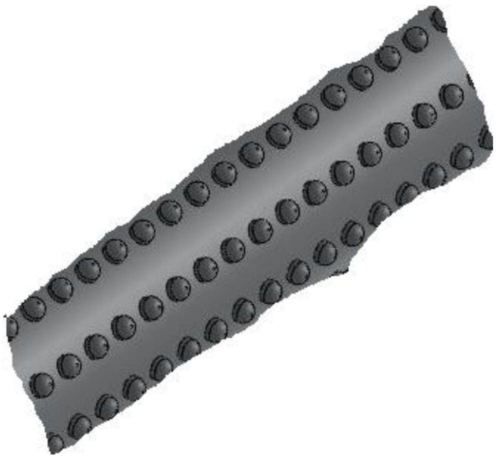

Figure 8: A simple view of Dimples

Working

- The dimple silencer in Figure 9 is replaced with the normal silencer in Figure 10.
- The motorcycle is started & is operated at desired avg. speed for sometime.
- The silencer of the bike becomes hot.
- The dimples on the silencer will act as an extended surface, similar to that of the fins on IC engines (or) fins on any electrical appliance.
- As heat dissipation can be increased by increasing the surface area, hence by the use of dimples the heat on the surface of the silencer is reduced.

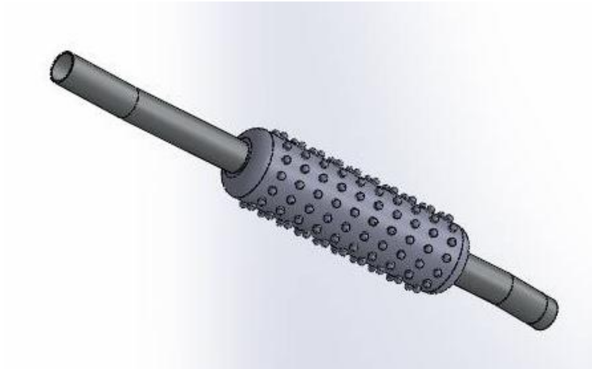

Figure 9: Dimple silencer

Figure 10: Normal Silencer

III. ANALYSIS

Calulation For Heat Transfer Coefficient

Assume ideal speed of the bike (u) = 60KMPH= 16.66m/s

At normal operating speeds the inlet temperature of the exhaust T_w =115.56°C

= 388.56 K

Normal atmospheric temperatureT_∞ = 30°C = 303K

The film temperature (T_F) =($T_w + T_\infty$)/2

=(388.56 + 303)/2

= 345.78K

h= 62.03 W/m^2

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Steady state Thermal Analysis of Existing Silencer done using Ansys software in shown in Figure 11. Geometry details and thermal data that are used during analysis are shown in Table 2 and 3 respectively. Material data and stress distributions are shown in table 4 & 5 respectively.

Analysis of Existing silencer using ANSYS-

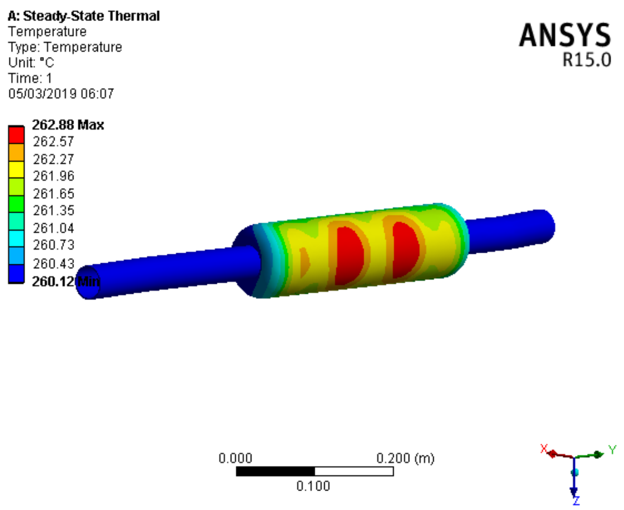

Figure 11: Steady State Thermal Analysis of Existing Silencer

Table 2: Geometry

Object Name	*Geometry*
State	Fully Defined
Definition	
Type	Iges
Length Unit	Meters
Element Control	Program Controlled
Display Style	Body Color
Bounding Box	
Length X	0.1133 m
Length Y	0.81918 m
Length Z	9.6×10^{-2} m
Properties	
Volume	8.3689×10^{-4} m³
Mass	6.5696 kg
Scale Factor Value	1.
Statistics	
Bodies	6
Active Bodies	6
Nodes	12494
Elements	5692
Mesh Metric	None
Basic Geometry Options	
Solid Bodies	Yes
Surface Bodies	Yes
Parameters	Yes
Parameter Key	DS
Attributes	No
Named Selections	No
Material Properties	No
Advanced Geometry Options	
Use Associativity	Yes
Coordinate Systems	No
Reader Mode Saves Updated File	No
Use Instances	Yes
Analysis Type	3-D
Mixed Import Resolution	None

Table 3: Thermal Data

Object Name	*Total Heat Flux*	*Temperature*
State	Solved	
Scope		
Scoping Method	Geometry Selection	
Geometry	All Bodies	
Definition		
Type	Total Heat Flux	Temperature
By	Time	
Calculate Time History	Yes	
Suppressed	No	
Results		
Minimum	4.1472×10^{-5} W/m²	260.12 °C
Maximum	3864.8 W/m²	262.88 °C
Minimum Occurs On	Part 5	Part 6
Maximum Occurs On	Part 6	
Minimum Value Over Time		
Minimum	4.1472×10^{-5} W/m²	260.12 °C
Maximum	4.1472×10^{-5} W/m²	260.12 °C
Maximum Value Over Time		
Minimum	3864.8 W/m²	262.88 °C
Maximum	3864.8 W/m²	262.88 °C
Information		
Time	1. s	
Load Step	1	

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Table 4: Material Data (Chrome Steel)

Density	7850 kg m^{-3}
Coefficient of Thermal Expansion	1.2x 10^{-5} C^{-1}
Specific Heat	434 $Jkg^{-1}C^{-1}$
Thermal Conductivity	60.5 W $m^{-1}C^{-1}$
Resistivity	1.7x10^{-7} ohm m

Analysis of Dimple silencer using ANSYS

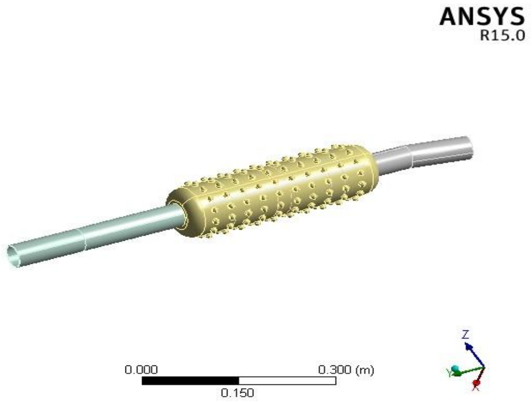

Figure 12: Dimple Silencer

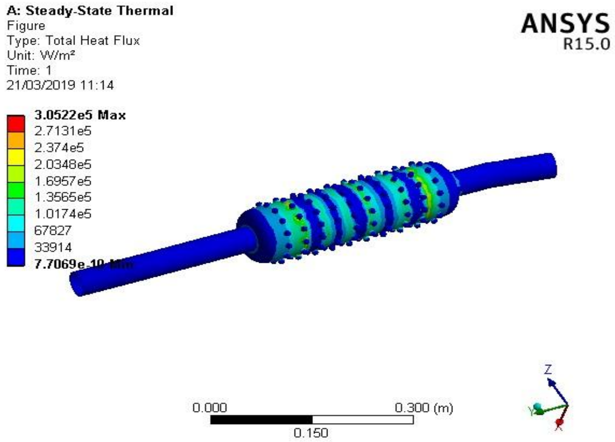

Figure 13: Heat Flux over Dimple Silencer

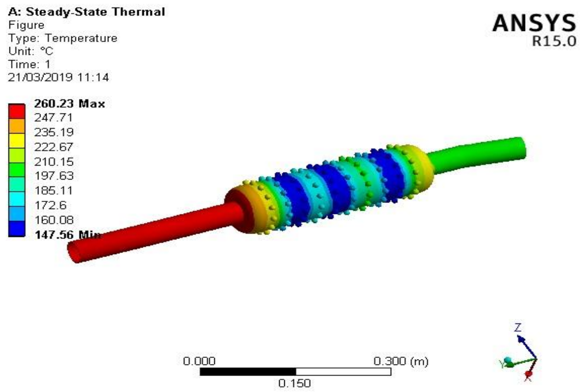

Figure 14: Steady State Thermal Analysis for dimple

Table 5: Stresses Cycle in Dimple Silencer

Alternating Stress (Pa)	Cycles
3.999 x 10^9	10
2.827 x 10^9	20
1.896 x 10^9	50
1.413 x 10^9	100
1.069 x 10^9	200
4.41 x 10^8	2000
2.62 x 10^8	10000
2.14 x 10^8	20000
1.38 x 10^8	1 x 10^5
1.14 x 10^8	2 x 10^5
8.62 x 10^8	1 x 10^6

IV - RESULT &DISCUSSION

Due to the increase in area of cross-section of the surface of the silencer by the addition of dimples, the heat dissipation rate increases and hence the heat that is produced in the fabricated dimple silencer is subsequently minimal as compared to the heat that is produced in the conventional silencers. In other words, the dimples are the main significant factor in the dissipation of heat which helps in absorbing a considerable amount of heat which is generated through the silencer.

Hence the main objective of increasing the heat dissipation rate is accomplished and the heat over the surface of the silencer is reduced. The reduction of the heat over the silencer surface will reduce the cause of fire accidents & some burn injuries.

The result comparison is clearly shown in table 6. From the results obtained 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 figure 12 on the outer surface of the silencer the temperature distribution is uniform shown in figure 13 & 14 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.

Before carrying out the execution of the concept, following steps were done:

- Study of exhaust system
- list out the Performance parameters
- Study of design of existing silencer

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- Analysis of existing silencer for 'thermal' (heat dissipation)
- Geometry modelling of existing silencer
- Demonstrating a relation between exhaust gas temperature and stress caused due to it.

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.

Table 6: Result Comparison

EXISTING SILENCER	DIMPLE SILENCER
The surface of the silencer is uniform throughout.	The surface of the silencer is having the dimples throughout the surface of the reducer
Less area of cross-section.	More area of cross-section.
Heat is almost equally distributed throughout the surface of the silencer.	Heat is unevenly distributed throughout the surface of the silencer due to the dimples.
The inlet & outlet temperatures are same	The inlet & outlet temperatures are different, the outlet temperature is less then inlet temperature.
Heat exposure is more.	Heat exposure is less.
No stress concentration is possible.	There may be a possibility of stress concentration due to the presence of dimples
Inlet Temperature:260^{0}C	Inlet Temperature:260^{0}C
Outlet Temperature: 260.8 ^{0}C	Outlet Temperature: 196.63^{0}C
Average body Temperature: 261.35^{0}C	Average body Temperature: 203.5 ^{0}C
Max. Temperature: 262.88^{0}C	Max. Temperature: 260.23 ^{0}C
Min. Temperature: 260.12^{0}C	Min. Temperature: 147.56^{0}C

V - FUTURE SCOPE

Considering the current state of the silencers that are used in automobiles, it is very much safe to say that the future scope of the dimple silencer is quite high. As the current silencers dissipate heat slowly(almost no heat gets reduced while coming out of the outlet) which is the reason for most accidents(minor) all over the city, this concept of dimple silencer will surely be welcomed with open hands by the automobile community.

The execution and implementation of this concept is also quite simple and seems easily possible within a required span of time. This concept of dimple silencer will surely be one of the simply fabricated component that will work effectively and efficiently in finding a solution for the long-existing problem of highly heated silencer surface which is obviously dissatisfying the automobile users.

This concept of dimple silencer can further be improvised and modernised depending upon the response of the automobile community and also depending upon the needs and requirements of the automobile-specialized personnels. Hence the possibilities of implementation of this concept of dimple silencer in current automobiles is held high by its standards of application and its heat absorbing characteristics.

Therefore, this concept of dimple silencer is surely going to be one of the simple ideas that is capable of eliminating the barrier of automobile user's comfort that is, the intense heat generated on the silencer's surface during the working time of an automobile.

REFERENCES

1. M. H. ShojaefardAutomotive Engineering Department , Iran University of Science and Technology , Tehran, Iran,A. R. Noorpoor,D. A. Bozchaloe &M. Ghaffarpour , 24 Feb 2007, Pages 627-644, Transient Thermal Analysis of Engine exhaust valve.
2. Sweta Baruah, Sushovan Chatterjee, Structural analysis for exhaust gas flow through an elliptical chamber muffler under static and dynamic loading condition, Advances in Modelling and Analysis B Vol. 61, No. 2, June, 2018, pp. 92-98
3. Avinash Kumar Agrawal, Shrawan Kumar Singh, Shailendra Sinha1 and Mritunjay Kumar Shukla June 2004,effect of EGR on the exhaust gas temperature and exhaust opacity in compression ignitionAccepted for Publication, August 2010. (ISSN # 0306-2619).
4. Kavita H. Dhanawade, Vivek K. Sunnapwar and Hanamant S. Dhanawade, 07 January 2014.Thermal Analysis of Square and Circular Perforated Fin Arrays by Forced Convection Heat dissipation is a drastic issue to tackle due to continued integration, miniaturization, compacting and lightening of equipment.Accepted 07 January 2014, Available online 01 February 2014, Special Issue-2, (February 2014)
5. Juhi Sharaf, Jul-Aug 2013, Exhaust Emissions and Its Control Technology for an Internal Combustion Engine, ISSN: 2248-9622, Vol. 3, Issue 4, Jul-Aug 2013, pp.947-960
6. Dhirajkumar Dr. Prashant, D. Deshmukh, June 2016, Thermal Analysis of Two Wheeler Exhaust Silencer using Computer Aided Engineering,June 2016, Volume 4, Issue 6, ISSN 2349-4476. 87
7. Ong kok seng, C.F. Tan, Koon Chun Lai, Kia Hock Tan, September 2016 , Heat spreading and heat transfer coefficient with fin heat sink.
8. Mahesh S. Vasava, P. V. Jotaniya, Heat transfer analysis in automotive exhaust system, Vol. 4, Issue 6, June 2015.
9. Karthick, S., Devi, E.S., Nagarajan, R.V. "Trust-distrust protocol for the secure routing in wireless sensor networks", In Proceedings of 2017 International Conference on Algorithms, Methodology, Models and Applications in Emerging Technologies, ICAMMAET 2017, 2017-January, pp. 1-5, 2017. DOI: 10.1109/ICAMMAET.2017.8186688

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10. Arul Teen, Y.P., Nathiyaa, T., Rajesh, K.B., and Karthick, S. "Bessel Gaussian Beam Propagation through Turbulence in Free Space Optical Communication", Optical Memory and Neural Networks (Information Optics), vol. 27, no. 2, pp. 81-88, 2018. DOI: 10.3103/S1060992X18020029
11. Vijayan, V., Parthiban, A., Sathish, T., Siva Chandran, S., Venkatesh, R. "Performance Analysis in End Milling operation", International Journal of Mechanical Engineering and Technology, Vol. 09, Issue. 11, pp. 2263-2271, 2018.
12. Sathish, T., Jayaprakash, J. "Optimizing Supply Chain in Reverse Logistics", International Journal of Mechanical and Production Engineering Research and Development, Vol. 07, pp. 551-560, 2017.
13. Sathish, T., Periyasamy, P. "Modelling of HCHS system for optimal E-O-L Combination section and Disassembly in Reverse Logistics", Applied Mathematics and Information science, Vol. 13, No. 01, pp. 1-6, 2019.
14. Sathish, T., Muthulakshmanan, A. "Design and simulation of connecting rods with several test cases using AL alloys and high Tensile steel", International Journal of Mechanical and Production Engineering Research and Development, Vol. 08,Issue 1, pp. 1119-1126, 2018.
15. Sathish, T., and Karthick, S. "HAIWF-based fault detection and classification for industrial machine condition monitoring", Progress in Industrial Ecology, vol. 12, no. 1-2, pp. 46-58, 2018

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