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The Effects on Rate of Change of Thermal Behavior of Auto Muffler with Thermo Electric Module

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Abstract- Thermal quantity and external insulation to exhaust system is main factor which affects the inlet gas temperature of catalytic converters. Under normal operating conditions, catalytic converters are most effective to reduce air pollution from internal combustion engines. The exhaust gases flowing through the exhaust system need to be cooled before reaching the catalytic converter to increase performance of catalytic converter. The heat transfer analysis in automotive exhaust system is necessary because their importance in the design and optimization phases of exhaust aftertreatment system. Heat loss between the engine out and before the catalyst converter will determine the energy gain of the catalyst thus affect the temperature rise of the catalyst which affect catalyst life time. A significant number of researches have been done for exhaust manifold, exhaust piping and catalytic converter packaging design for automotive exhaust system to improve performance based on heat transfer analysis of exhaust system. The resulting heat transfer expression based on experiments and mathematical modeling used in computational models for the design of exhaust system parts and optimization phases to facilitate the selection of suitable material and designed system for better performance

Keywords- Catalyst converter, heat transfer analysis, automotive exhaust.

I. INTRODUCTION

It is a device for reducing the noise produced by the engine. In internal combustion engine the exhaust gases flow out through the muffler. In muffler there is a resonating chamber which is tuned to minimize the exhaust noise. 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 soundproofing 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 them into heat energy, hence designing the Silencer for uniform heat distribution is of major concern.

The 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. The construction-wise silencer is classified into two types first is reactive and the second is a 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 types of silencers, uniform distribution of heat is desirable. Another kind of silencer is the Combination Reactive and Dissipative (absorptive) silencer which has both the effects of the reactive and dissipative silencer.The exhaust system of an 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 requirements exhaust gaseous staying longer time in the resonator (i.e. silencer section) to reduce noise level which also results in thermal failure of the resonator and shorter life span. Many authors worked in the heat exchanger field and use different techniques to enhance heat transfer rate, a technique they used is passive and some are active ones.

In the passive technique, they change the design of the actual component by adding some extra features. Those responsible to enhance heat transfer rate from the same surface. They use shallow spiral, dimple pattern, surface roughness, fins, and twisted tape or different types of insert wise features and inactive techniques they try to make the flow more turbulent by adding swirl generator, nozzle and multiphase flow. But out of those techniques, only a few are possible to adopt on the surface of the silencer body but the rest are only possible to adopt in the flow or inside of silencer. So to enhance the heat transfer rate from the surface of the 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.

II. PRINCIPLE METHODOLOGY

Muffler is a device which usually equipped with internal combustion engines to minimize the acoustic pulse generated by the combustion process. In the engine cylinder, a very high intensity pressure waves are generated, which transmit along the exhaust pipe and emit from the exhaust pipe termination. Pulse repeats at the firing frequency of the engine. f =engine R.P.M *No. of cylinders/120 Hz (for four stroke engine) The majority of the pulse energy lies between the 0-600 Hz frequencies ranges. Exhaust muffler are designed to reduce sound levels at these frequencies. Sound waves transmitting along a pipe can be decreased by using muffler

Tailpipe Design

The tail pipe itself acts as a resonant cavity that couples with the muffler cavity. The effect of exhaust gas flow speed has a detrimental effect on the muffler performance. The length of tailpipe is important parameter in the designing of muffler.

Design of Inlet pipe

The diameter of inlet pipe is taken same as the diameter of the exhaust port of the engine muffler. The length of the inlet pipe is taken as small as possible so that muffler will occupy less space. There is no specific procedure for designing inlet pipe of the muffler.

Design of Expansion chamber

This design is most effective at low frequency i.e less the 500 c/s and m=10

Volume of expansion chamber

$$V_m = \frac{\pi}{4} D^2 l$$

Vm= volume of expansion chamber.
D = Diameter of expansion chamber
l = Length of the expansion chamber

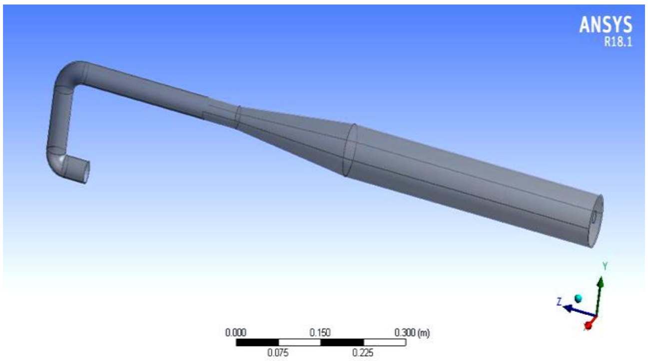

Figure 1. 3D View of design muffler

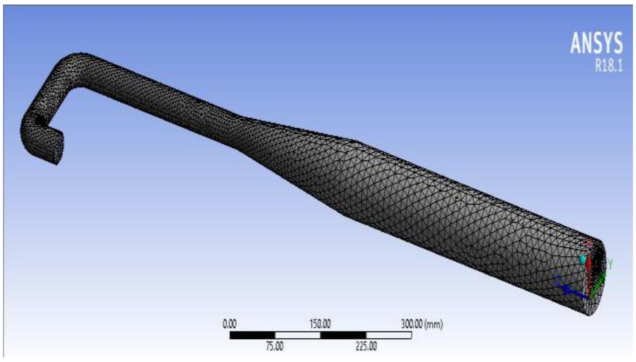

Figure 2. Meshed model

For further frequency analysis we have prepared a modified muffler with thermo electric module in the last chamber as show in the simulation diagram also.

Figure 3. 3D plot of muffler

Figure 4. Model of modified muffler.

Arrangement of the Experiment

To test the silencer used in this research with changes, it has been kept according to the arrangement shown below. In which the sound measuring device is shown by point 1, point 2, and point 3. It has been kept at a distance of 0.5 m, 2 is 0.5 m and 3 is 0.7 m as shown in the picture, in addition to this, three temperature gauges have also been installed, whose position is given in the picture number 5.

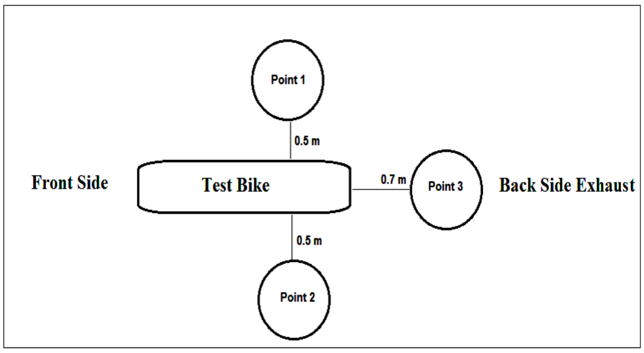

Figure 5. Arrangements of the experiment

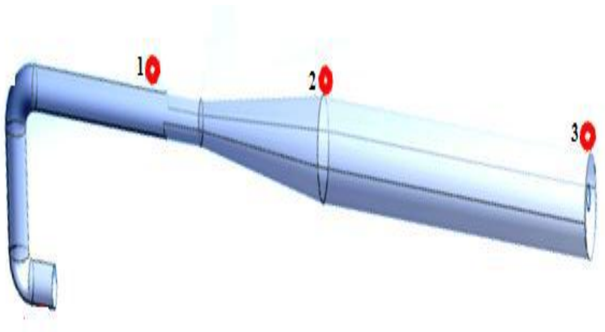

Figure 6. Position of the temperature measurement unit

III. RESULT AND OBSERVATION

After all the measurements, it is required to analyses the noise data by comparing the engine speeds with before and after modification of the mufflers. Analysis is done to find out the acoustic power of the motorcycle, sound pressure level, insertion loss, and Frequency spectra and also generated electricity.

According to our aim there are two prospective of this project, first concern with sound wave frequency variation and second is the heat exerted by normal and modified mufflers In this method, the first step is to sound pressure level is measured for every grid point at different speeds of engine. Different speeds of engine used in this work are 500, 1000, 1500, rpm. calculating the Lw from sound pressure level is given in table.

Table 1 Different speeds of engine

Description		Particular
1.	Engine	Petrol
2.	Number of cylinder	One
3.	Horse power (B.H.P)	8.6
4.	Weight (in Kg.)	112 kg
5.	Stroke	Four
6.	Displacement	97.2cc

Value of sound pressure level is measured in A-weighting. The measurements are taken with Unmodified and modified mufflers. The measurement data for sound pressure level and temperature from Table 1 and Table 2. The method for

Table 2.Thermal analysis of the muffler before modification

Speeds	Tem	Temperature at 1	Temperature at 2	Temperature at 1
500 rpm	1	139.7	100.3	71.5
	2	142.2	98.7	68.6
	3	137.2	93.6	63.2
	Average	139.7	97.53	67.76
1000 rpm	1	146.5	94.8	73.2
	2	148.2	95.2	74.1
	3	143.3	97.5	74.8
	Average	146	95.83	74.03
1500 rpm	1	158.4	100.5	84.7
	2	161.8	101.6	82.5
	3	168.2	104.4	83.4
	Average	162.8	102.1	83.53

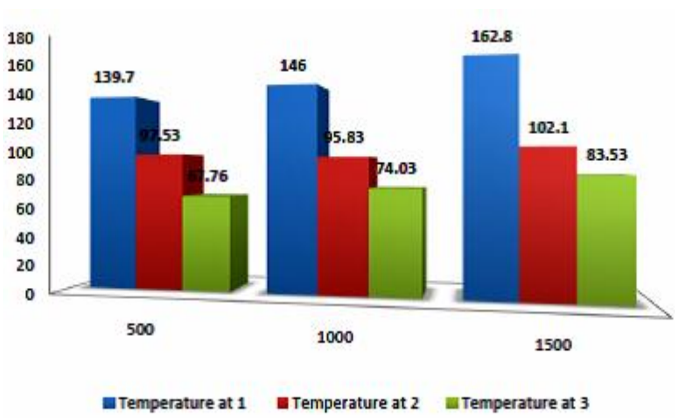

Figure 7.Temperature/ speed on the muffler before modification

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Table 3.Thermal analysis of the muffler after modification.

Speeds	Tem	Temperature at 1	Temperature at 2	Temperature at 1
500 rpm	1	135.7	95.4	68.3
	2	138.1	96.5	65.1
	3	133.3	94.3	67.3
	Average	**135.7**	**95.4**	**66.9**
1000 rpm	1	145.8	95.8	72.2
	2	146.3	94.2	71.0
	3	144.2	97.1	71.3
	Average	**145.43**	**95.7**	**71.5**
1500 rpm	1	151.5	98.9	79.7
	2	156.7	97.5	81.2
	3	154.6	96.4	78.5
	Average	**154.26**	**97.6**	**79.8**

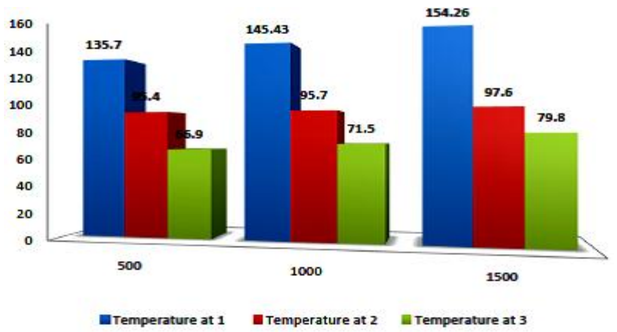

Figure 8.Temperature/ speed on the muffler before modification

Table 4. Frequency analysis of the muffler before modification

Speeds	Position	1 turn	2 turn	3 turn
500 rpm	point 1	62.8	67.9	64.5
	point 2	63.9	68.5	65.3
	point 3	65.4	67.7	62.8
	Avg.	**64.1**	**68.1**	**64.2**
1000 rpm	point 1	64.6	69.7	66.4
	point 2	63	64.4	64.1
	point 3	64.9	69.6	67.3
	Avg.	**64.2**	**67.9**	**65.9**
1500 rpm	point 1	67.6	72.5	68.6
	point 2	67.8	72.2	69.6
	point 3	67.7	73.2	69.3
	Avg.	**67.7**	**72.6**	**69.2**

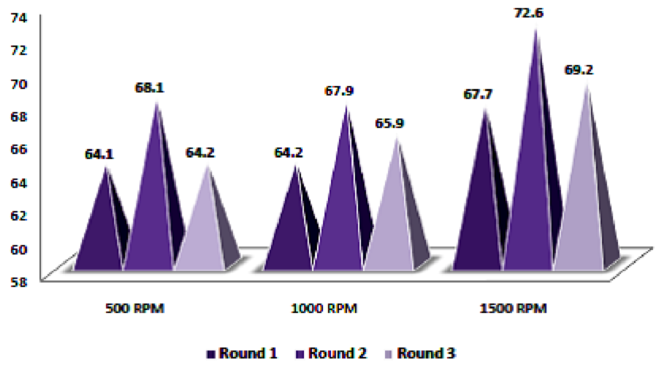

Figure 9.Speed Vs frequency analysis on muffler before modification

Table 4Frequency analysis of the muffler after modification

Speeds	Position	1 turn	2 turn	3 turn
500 rpm	point 1	61.7	65.2	61.4
	point 2	62.5	67.3	66.3
	point 3	64.2	66.8	61.8
	Avg.	**62.8**	**66.43**	**63.16**
1000 rpm	point 1	65.1	67.4	65.5
	point 2	61.2	62.3	62.6
	point 3	62.8	65.4	65.4
	Avg.	**63.03**	**65.03**	**64.5**
1500 rpm	point 1	65.9	70.2	65.8
	point 2	68.5	76.5	64.7
	point 3	64.6	74.1	67.9
	Avg.	**66.33**	**73.6**	**66.13**

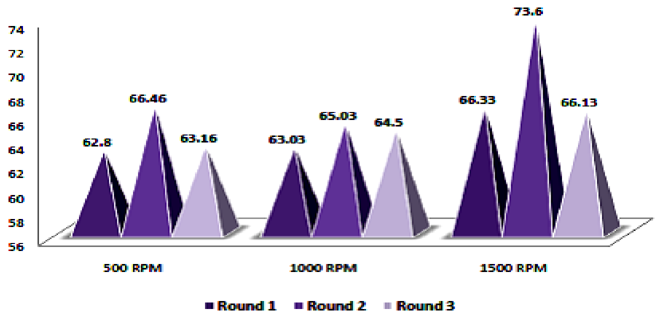

Figure 10.Speed Vs frequency analysis on muffler after modification

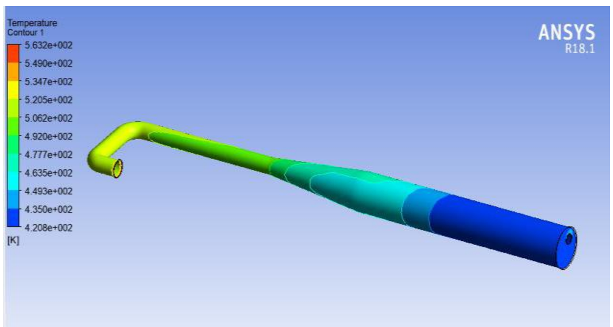

Figure 11. Temperature plot

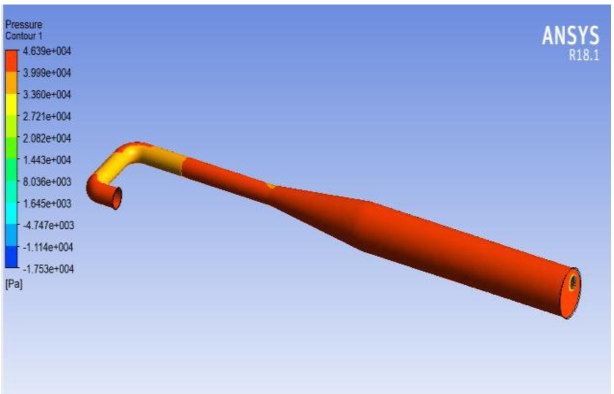

Figure 12. Pressure plot

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