IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

CETCME-2017

"Cutting Edge Technological Challenges in Mechanical Engineering"

Noida Institute of Engineering & Technology (NIET), Greater Noida

Vol. 4, Special Issue 3, February 2017

A Study on Effectiveness of Muffler on a Two-wheeler vehicle Noise

Jashanpreet Singh[1], S. P. Nigam[2], L. K. Bhagi[3]

Assistant Professor, Aryabhatta Group of Institutes, Barnala (Punjab), India[1]

Visiting Professor, Thapar University, Patiala (Punjab), India[2]

Independent Researcher[3]

Abstract: In today's world, noise pollution is the biggest problem. 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 have been analysed.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.

Keywords: Traffic noise; Mufflers; Sound pressure level; Frequency spectrum; Insertion loss.

I. INTRODUCTION

Noise is defined as an unwanted sound and is of random in nature. Noise pollution has hazardous effects on human health like effects in work efficiency, loss of hearing ability. It may cause headache and psychology strain. Two-wheelers are becoming increasingly prevalent as a means of transportation. Because of variety of vehicles intended uses, noise characteristics vary quite widely for this class of vehicles. In most vehicles the engine structure, transmission, brakes, tyres and aerodynamic flow are main contributors, under various conditions, to total vehicle noise. The major sources of noise in two-wheeler are engine exhaust noise which can be minimized by using effective muffler [1].A lot of research work has been carried out throughout the world to investigate and analyse the effectiveness of muffler on a two wheeler noise. Tandonet al. [2] studied the two-wheeler engine and their noise control and concluded that the major source of noise produced is the engine of a two-wheeler. Singh et al. [3] studied the effect of rubber damper on the engine cylinder and found that the rubber dampers decrease the radiated noise but also increase the engine temperature. Potente[4]discussed absorptive and reflective type mufflers and further calculated the insertion losses.

Sathyanarayana and Munjal [5] presented a new hybrid approach towards the prediction of noise radiation from engine exhaust. Chan and Too [6] investigated the effects of sound elimination in a cylindrical duct. In this work, a combined adaptive algorithm is adopted and results show that the hybrid system has more advantages over the traditional muffler. Yasuda et al. [7] analysed an automobile muffler with acoustic characteristic experimentally and numerically under wide open throttle acceleration and found that attenuation performances of peak and trough was related to resonance and anti-resonance frequency of the muffler. Lee and Wang [8] predicted the acoustical properties of multi-layered noise control material and found that the acoustical property of multi-layered system could be obtained by adding more layers with higher quality material treatment.

In this study Royal Enfield Bullet motorcycle (350 cc) has been used to measure the noise of two-wheeler. In this, different types of mufflers have been studied out of which two were reflective type (M1 and M2), one was free flow (M3) and one was hybrid type (M4). This M4 type muffler was prepared by using technique of reflective type and absorptive type muffler a new hybrid type muffler M4 is modified from their existing design by introducing 1 cm thick glass wool because of its absorptive nature and it also controls the external heat that takes place on the outer surface of the muffler.

II. BASIC REQUIREMENT OF MUFFLER DESIGN

Muffler 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.

Exhaust muffler is designed to reduce sound levels at firing frequencies. Sound waves transmitting along a pipe can further be decreased by using muffler. An effective muffler will reduce the sound pressure of the noise source to the required pressure of the noise to the required level at the end of the tail pipe or receiver. Some of the important design parameters for muffler are as follows-

1. Adequate insertion loss
2. Selection of size
3. Back Pressure
4. Cost and Weight

A muffler performance is generally defined in terms of insertion loss or transmission loss. Insertion loss of a sound attenuator, sound barrier, or other element designed to provide sound reduction in a specified frequency band, the decrease in sound power level measured at the location of the receiver when this element is inserted in the transmission path between the sound source and the receiver. Transmission loss is defined as the difference between the average sound pressure level occurrences at the entry to the muffler to that of the transmitted by the muffler. The muffler designer must determine the required insertion loss so that a suitable type of muffler can be designed for the automotive application.

To ensure the best specific design principles, a proper selection and sizing of the muffler is essential. The selection of the correct type of engine exhaust muffler is determined by:

a) Type of engine.
b) End use of the engine.
c) Degree of silencing required.
d) The silencer size selected must satisfy the specified volume of exhaust gas flow keeping the back pressure within the specified limit.
e) The available space has a great influence on the size and type of muffler may be used.

Back pressure is the additional static pressure exerted by the muffler on the engine through the restriction on the flow of exhaust gases. Back pressure should be kept to a minimum to avoid power losses and for better performance. Absorptive type muffler creates less backpressure as compared to other types of mufflers.
Usually the larger the muffler is, the more its weight and more will be its cost. To manufacture effectively supporting a muffler is always a design issue and the larger a muffler is the difficult it is to support. A muffler's mounting system not only needs to support the mufflers weight but also needs to provide vibration isolation so that the vibration of the exhaust system is not transmitted to the chassis and then to the inside cabin [9].

III. EXPERIMENTAL SETUP AND MEASUREMENTS

Different types of commercially available mufflers have been considered in the present work. Table 1 shows the dimensions of the Mufflers. M1 is the original reflective type muffler, M2 is reflective type muffler, M3 is free flow type of muffler and M4 is hybrid type muffler [10].The detailed drawing of all the four Mufflers is shown Fig.1.

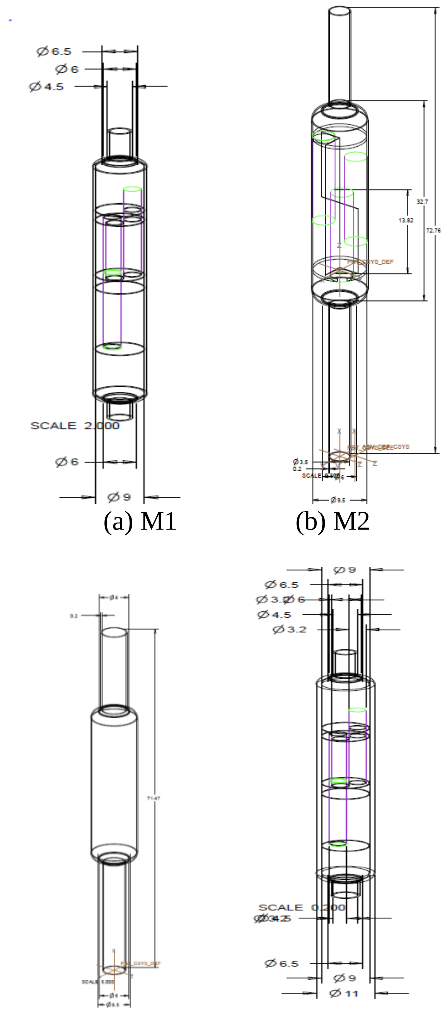
TABLE.1 DIMENSIONS OF MUFFLERS (cm)

Muffler	Full length	Muffler length	Diameter
M1	77.3	63	9
M2	72.7	32.7	9.5
M3	71.4	31	9.5
M4	77.3	63	11

A motorcycle used in this work is "Royal Enfield Bullet motorcycle". The specification of the motorcycle is presented in Table 2.

TABLE 2 SPECIFICATIONS OF MOTORCYCLE

Engine	Petrol
Number of cylinder	One
Horse power (B.H.P)	19.8
Weight (in Kg.)	175
Stroke	Four
Displacement	350cc



(a) M1 (b) M2

(c) M3 (d) M4

Fig.1Detailed drawing of M1, M2,M3 and M4 muffler

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
CETCME-2017
"Cutting Edge Technological Challenges in Mechanical Engineering"
Noida Institute of Engineering & Technology (NIET), Greater Noida
Vol. 4, Special Issue 3, February 2017

A. Modification in muffler

In the present work, a hybrid muffler (M4) is fabricated by using the techniques of absorptive type and reflective type muffler.

a. Stepwise muffler modification

A glass wool is tightly positioned between the two metallic sheets like a sandwich structure (Fig. 2).

Fig.2 View of metallic sheets of M4 muffler

The outer sheet has length 600 mm, width 340 mm and thickness 1.24 mm and the inner round hole perforated sheet has length 600 mm, width 320 mm, thickness 0.85 mm and number of holes 3000(approx.) shown in Fig. 3. The round hole perforated sheet is worked as a medium of transferring the air from the exhaust to glass wool, by which glass wool absorb noise and heat from exhaust air.

Fig.3 Metallic sheets with glass-wool

These sheets were rolled by roll bending machine and converted it into cylindrical form (Fig. 4).

Fig.4 Sheets rolled in bending machine

Fig. 5 shows the TIG welding of the rolled cylindrical sheet formed in previous step.

Fig. 5TIG welding of cylindrical sheets

Some extra glass wool was inserted and pressed into the gap between the sheets.

Fig. 6 Inner view of muffler

A reflective chamber was positioned as same as earlier in the muffler, so as to reflect the air flow from the exhaust.

Fig. 7 View of muffler

The inlet pipe and outlet pipe are welded again by TIG welding.Final hybrid muffler (M4) isready, which is the combination of reflective absorptive type muffler (Fig. 9).

Fig. 8 Ends pipe of muffler

Fig. 9 View of modified muffler (M4)

IV. DESIGN OF EXPERIMENT

To check the noise level of vehicle, Acoustic power of vehicle has been measured. Calculation of sound pressure level is done by two methods:

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
CETCME-2017
"Cutting Edge Technological Challenges in Mechanical Engineering"
Noida Institute of Engineering & Technology (NIET), Greater Noida
Vol. 4, Special Issue 3, February 2017

Hemispherical parallelepiped and Rectangular parallelepiped [1]

In this work rectangular parallelepiped method is used because the largest dimension of the vehicle is more than 1metre. In this method, first step is to make a grid according to the dimensions of the motorcycle. Length, breath and height of motorcycle are 1.9m, 0.5m and 0.95m respectively. The grid is made by placing a motorcycle at centre position and with the help of thread at required positions mark at different points. There are 17 pointsformed. Sound pressure level is measured for every grid point at different speeds of engine as shown in Fig. 10. Different speeds of engine used in this work are 1000, 1500, 2000, 2500, 3000 rpm. Value of sound pressure level is measured in A- weighting.The measurements were taken by sound pressure level meter of model "Bruel and kjaer hand held analyser type 2250" and the data was recorded in software of Bruel and kjaer in "BZ 5503 Measurement partner suite." Sound pressure level of motorcycle has been measured by using different four mufflers at 1 meter away from the tail pipe of the muffler at 45°angle. The advantages of measuring acoustic power of source over sound pressure level is that the former does not depend upon distance while later depends upon the distance of measurement.

Fig.10 Showing 17 grid points

V. RESULTS AND DISCUSSION

After all the measurements, it is required to analyse the noise data by comparing the engine speeds with different types of mufflers. Analysis is done to find out the acoustic power of the motorcycle, sound pressure level, insertion loss, and Frequency spectra.

A. Determination of Acoustic power

Evaluation of acoustic power was carried out on M1 and M4 mufflers at different engine speeds.

The graph showed (Fig. 11) the variation between acoustic power and at different speeds. The value of acoustic power increases continuously as the engine speed increases in both M1 and M4 muffler. The difference between acoustic power of M1 and M4 muffler varies between 2-4 dB(A).

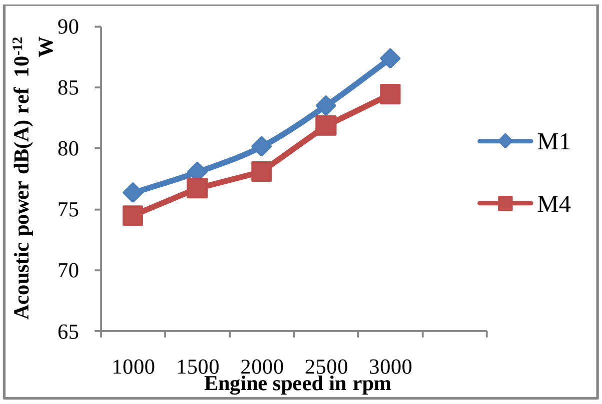


Fig.11 Acoustic power Vs. Engine speed

B. Measurement of sound pressure level

In this study, the comparison is made between sound pressure level with out and with different mufflers atdifferent engine speedsas shown in Fig. 12 to 16.

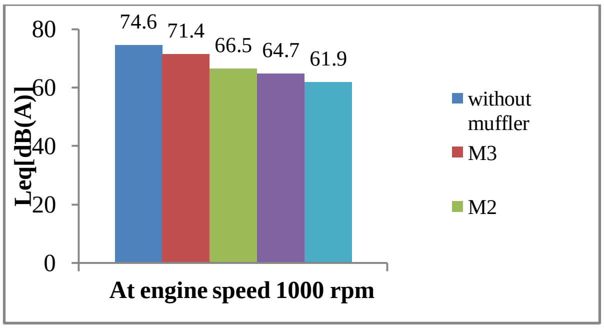


Fig. 12 Sound pressure level of different mufflers at 1000 rpm engine speed

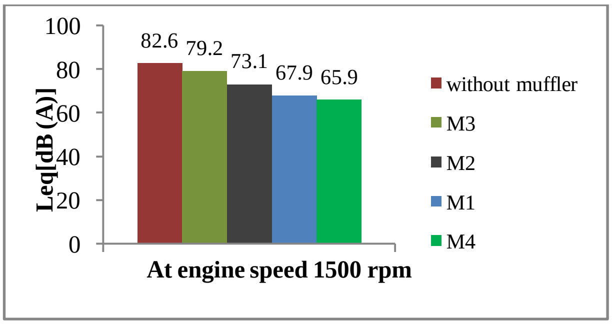


Fig. 13 Sound pressure level of different mufflers at 1500 rpm engine speed

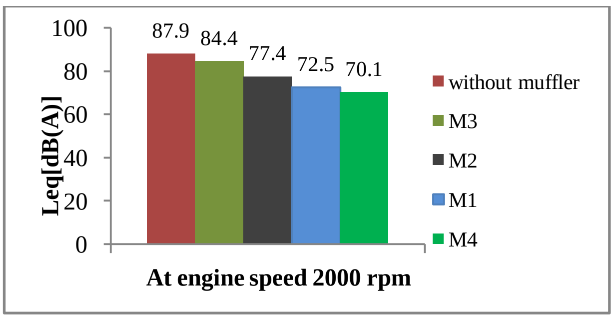


Fig. 14 Sound pressure level of different mufflers at 2000 rpm engine speed

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
CETCME-2017
"Cutting Edge Technological Challenges in Mechanical Engineering"
Noida Institute of Engineering & Technology (NIET), Greater Noida
Vol. 4, Special Issue 3, February 2017

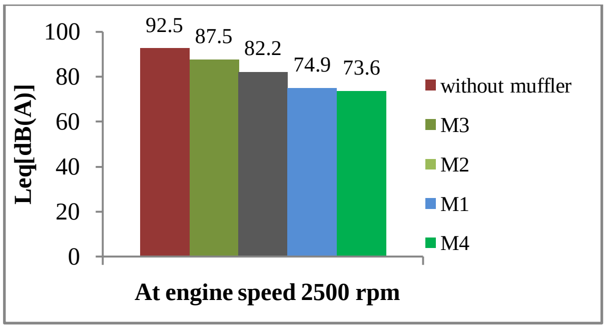


Fig.15 Sound pressure level of different mufflers at 2500 rpm engine speed

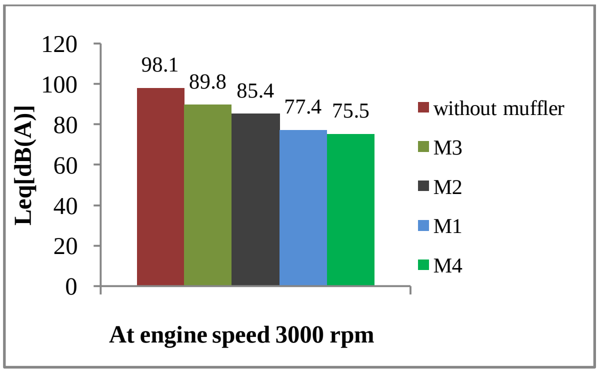


Fig. 16 Sound pressure levelof different mufflers at 3000 rpm engine speed

Above graphs show the effect of mufflers at particular engine speed on sound pressure level. At constant engine speed, value of sound pressure level is maximum without muffler and minimum with M4 muffler in all the cases. The decreasing order for each engine speed is without muffler > M3 >M2 > M1 > M4.The difference between sound pressure level of muffler M1 and M4, M2 and M3 are found to be less in each graph respectively. Value of sound pressure level without muffler is very high as compared to other mufflers in each graph. From the above graphs, it's found thatvehicle with muffler M4 has minimum noise level.

C. Analysis for frequency spectrum

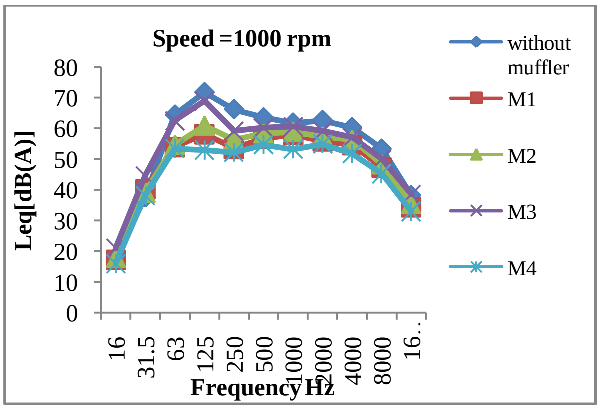


Fig.17 Sound pressure level Vs. Frequency at 1000 rpm

A frequency spectrum indicates the characteristics of the exhaust noise source. It gives idea of peak frequency which intern would decide the type of control measures. In this analysis, comparison is done between the sound pressure level and frequency for with and without mufflers. The analysis of frequency spectrum is done at1-1 octave band. The response plots are shown fromFig. 17 to 21.

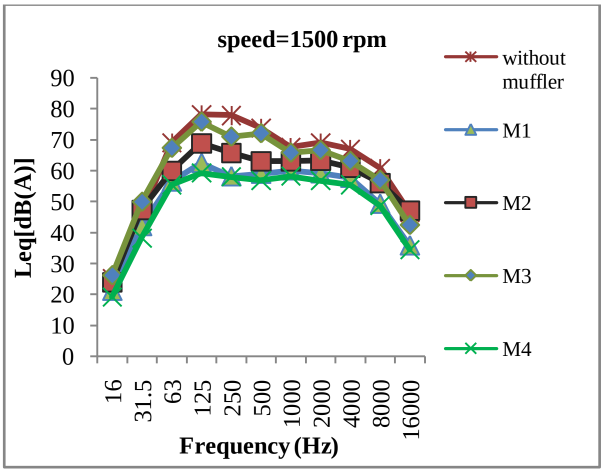


Fig. 18 Sound pressure level Vs. Frequency at 1500 rpm

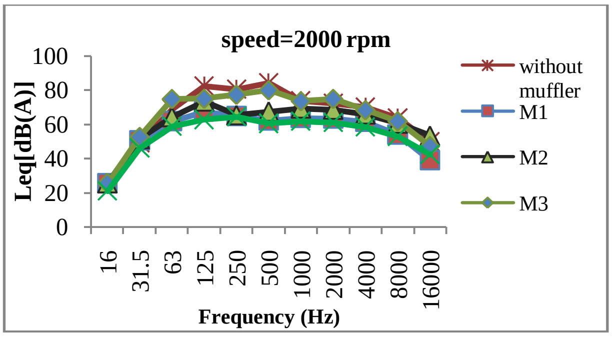


Fig. 19 Sound pressure level Vs. Frequency at 2000 rpm

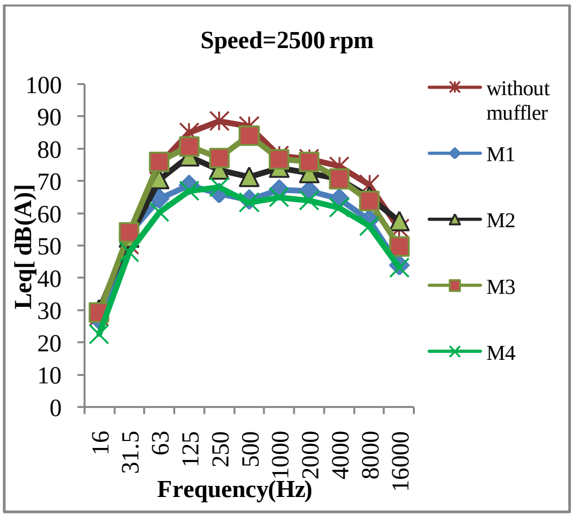


Fig.20 Sound pressure level Vs. Frequency

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

CETCME-2017

"Cutting Edge Technological Challenges in Mechanical Engineering"

Noida Institute of Engineering & Technology (NIET), Greater Noida

Vol. 4, Special Issue 3, February 2017

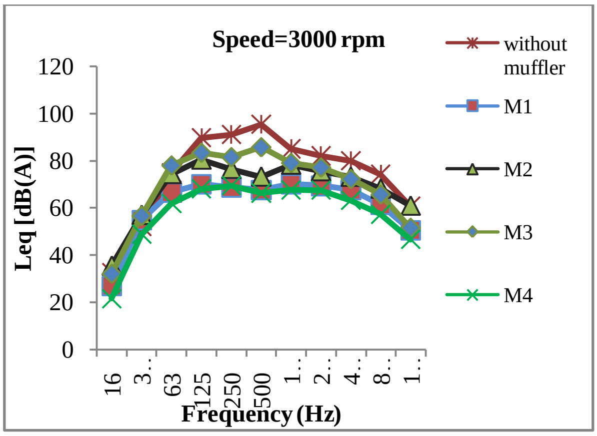


Fig.21 Sound pressure level Vs. Frequency

The figures show the comparison between sound pressure level and frequency at particular speed. As the engine speed increases from 1000 to 3000 rpm the peak value is shifted towards higher frequency level, between the ranges of 125 to 500 Hz. Sound pressure level also increases with increase in engine speed.

TABLE.3 RELATIONSHIP BETWEEN ENGINE SPEED, PEAK FREQUENCY AND SOUND PRESSURE LEVEL

Engine speed (rpm)	Peak frequency level (Hz)	Sound pressure level dB(A)
1000	63	71.7
1500	125	78.2
2000	125	84.3
2500	250	8.6
3000	500	95.4

D. Measurement of Insertion loss

The insertion loss of different mufflers is calculated by subtracting the sound pressure level without muffler and with using muffler.

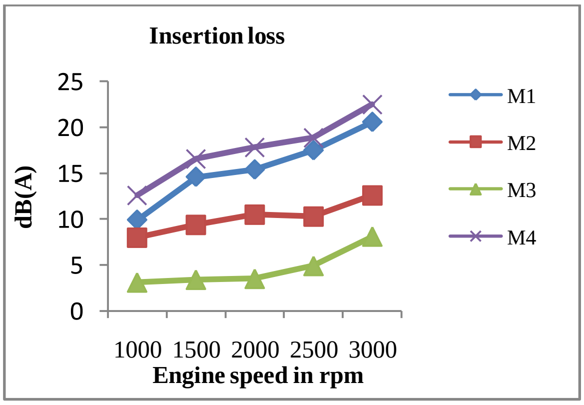


Fig. 22 Comparison of sound pressure level with different engine speeds

The above graph shows the variation in sound pressure level at different engine speed.

1. For M1 muffler initially at engine speed 1000 rpm, the value of insertion loss is 10 dB (A) and at engine speed 3000 rpm is 20.6 dB (A). The difference between initial and final is 10.6 dB(A)
2. For M2 muffler initially at engine speed 1000 rpm, the value of insertion loss is 8 dB (A) and at engine speed 3000 rpm is 12.6 dB (A). The difference between them is 4.6 dB
3. For M3 muffler initially at engine speed 1000 rpm, the value of insertion loss is 3.1 dB (A) and at engine speed 3000 rpm is 8.1 dB (A). The difference between them is 5 dB
4. For M4 muffler initially at engine speed 1000 rpm, the value of insertion loss is 12.6 dB (A) and at engine speed 3000 rpm is 22.6 dB (A). The difference between them is 10 dB
5. The value of insertion loss increases with increase in engine speed.
6. It is found that maximum value of insertion loss is obtained with M4 muffler so that it is the best muffler with respect to other mufflers.

VI. CONCLUSION

1. The acoustic power of M4 muffler is found to be less than M1 muffler at engine speed.
2. The decreasing order of sound pressure level at particular speed is found to be without muffler > M3 >M2 > M1 > M4.
3. The value of insertion loss increases with the increase in engine speed. Maximum insertion loss is found to be for M4 muffler and minimum for M3 muffler.
4. On the basis of maximum insertion loss, minimum sound pressure level, it is found that M4 muffler is the best among the other mufflers.

REFERENCES

[1] C. M. Harris, Handbook of acoustical measurements and noise control, 3rd ed.,McGraw-Hill, 1991.
[2] N. Tandon, B. C. Nakra, B. Sarkar, and V. Adyanthaya, "Noise control of two-wheeler scooter engine,"Applied Acoustics, vol. 51, issue 4, pp. 369-380, 1997.
[3] O. P. Singh, T. Sreenivasulu, and M. Kannan, "The effect of rubber dampers on engine NVH and Thermal performance,"Applied Acoustics, vol. 75, pp. 17-26, 2014.
[4] D. Potente, "General design Principles for an automotive muffler," in Proceedings of ACOUSTICS 2005, pp. 153-158, Australian acoustics society, Australia.
[5] Y. Sathyanarayana and M. L. Munjal, "A hybrid approach for aeroacoustic analysis of the engine exhaust system," Applied Acoustics, vol. 60, issue 4, pp. 425-450, August 2000.
[6] S. R. Chen, and G.-P.J. Too, "Simulations and experiments for hybrid noise control systems," Applied Acoustics, vol. 70, issue 2, pp. 247-255, February 2009.
[7] T. Yasuda, C. Wu, N. Nakagawa, and K. Nagamura, "Predictions and experimental studies of the tail pipe noise of an automotive muffler using a one dimensional CFD model,"Applied Acoustics, vol.71, issue 8, pp. 701-707, August 2010.
[8] C. M. Lee and Y. S. Wang, "A prediction method of the acoustical properties of multilayered noise control materials in standing wave-duct systems," Journal of Sound and Vibration, vol. 298, issues 1–2, pp. 350-365, November 2006.
[9] M. J. Crocker,Handbook of Noise and Vibration Control,John Wiley & Sons, 2007.
[10] R.G. Whiteand J.G. Walker,Noise and Vibration, 3rd ed., Ellis Horwood Ltd, 1982.