International Journal of Advance Research in Science and Engineering
Volume No. 13, Issue No. 04, April 2024
www.ijarse.com
IJARSE
ISSN 2319 - 8354

NOISE ATTENUATION OF TRACTOR SILENCER

Kiran Chavan[1], V. B. Ghagare[2], D. P. Chavan[3]

[1]*PG Scholar, Department of Mechanical Engineering, Trinity College of Engineering and Research,Pune, Maharashtra, India*

[2]*Professor, Department of Mechanical Engineering, Trinity College of Engineering and Research, Pune, Maharashtra, India*

Abstract*:* It is really challenging for automotive sector to reduce the engine exhaust noise. Tractor mufflers which consist of perforated ducts, baffle plate, perforated baffles and expansion chamber for noise attenuation are commonly used. The present work consists of optimization of muffler configuration. Mufflers are classified as reactive and absorptive types. Unburned particles gets accumulated in acoustic lines of absorptive muffler due to which they loss their performance. Reactive muffler works at short range of frequency. Absorptive muffler works at high range of frequency. So the current work aims to develop combine muffler which is very good in performance and works in wider frequency range. Three muffler were develop in this study. Each mufflers expansion chamber was wrapped with different absorbing materials like glass wool, glass fiber, etc. and baffle plates were used. The results were compared with existing muffler model Fuel consumption time for three mufflers was recorded to predict the exhaust back pressure indirectly.

Key words **- Muffler configuration, Combine muffler, Expansion chamber, Absorbing Material, Fuel Consumption**

I. Introduction

Indian agriculture is developing very rapidly with the mechanical power being used in various operations. Basic farm cultivationin first half 20th century was done by bullock cart. However, with the advancement of technology machine power took the placeof animal power. Since as tractor is used more frequently for farm operation it has created an uncomfortable working environment for operator by means of noise. Noise Source Identification study carried out by Yadav et al. concluded that exhaust noise is thehighest ranked noise source [7]. Noise is one major factor which affects operators health and his working efficiency. Noise results in hearing loss, stress, backache, heart failure, blood pressure. So this mechanical equipment should be made better to provide safe and comfortable working environment for operator. Tractors exhaust is one of the major source of the noise. Silencers presently used in automotive industry to attenuate noise are either reactive or absorptive type. By varying the length and diameterof the chambers transmission loss of muffler can be increased Praveen R et al. [9]. Parametric study for different absorbing material, different chamber lengths and different perforation hole diameter was done by Sibin Babu et al.[10]. Investigation wasdone on the effect of baffle configuration on transmission loss and back pressure by Ahmed Elsayed et al.[11]. Reactive mufflersattenuates only low frequency noise and absorptive muffler attenuates only high frequency noise. Thus, to take the advantage ofthis two type of mufflers and overcome their disadvantages combine mufflers are used. Basically, the current works is based on noise attenuation of tractors

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silencers.

II. METHODOLOGY

An experiment was carried out in open field. The experiment site was free from obstructions like rocks, walls, tall trees and otherobjects. The experimental site did not have any sound absorbing materials like tall grass and standing crop.

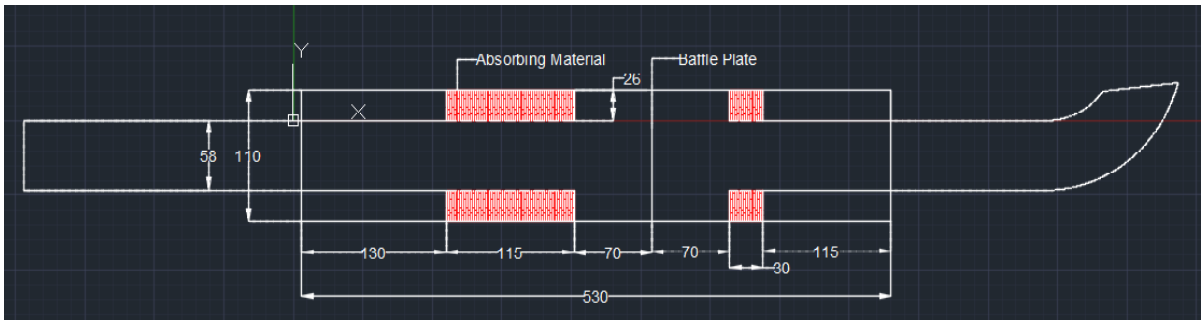

Figure: 1 CAD model of developed muffler

(a)

(b)

Figure: 2 (a) Different mufflers developed for study. (b) Existing muffler of test tractor.

Three different mufflers were developed by wrapping the chamber walls, perforated pipes (Figure 2: a) with

different absorbingmaterials like glass wool, wire mesh, glass fiber. The thickness of the absorbing material layer is 26 mm. Multiple hole baffle plate with 25mm center hole diameter and eight equally spaced surrounding holes with 7 mm diameter is used at the center of muffler (Figure 2:a). This three developed mufflers and the existing muffler of the test tractor were considered for the study. The details of the developed model mufflers are given in Table 1. The technical specifications of the test tractor were of 42 break horse power, four cylinder, direct injection and water cooled engine.

Table 1 Specifications of developed mufflers.

Sl No.	Particular	Muffler A	Muffler B	Muffler C
1	Absorbing Material	Glass Fiber	Wire Mesh	Glass Wool
2	Baffle plate center hole diameter	25 mm	25 mm	25 mm
3	Thickness of absorbing material	26 mm	26 mm	26 mm

Experimental Design

The experimental design Table 2 was created to conduct the test for sound pressure level and fuel consumption timing. Three different engine speeds were selected for the experiment (1000 rpm to 2000 rpm with difference of 500 rpm). The gear box was in neutral position to keep the engine in no-load condition. Sound pressure level at each engine speed was recorded near theexhaust. Time taken to burn the 100 ml fuel was determine to examine the effect of noise attenuation by each muffler on engine.

Table 2 Experimental Design to conduct test.

SL NO.	Parameters	
1	Tractor break horse power, Ps	42
2	Tractor engine speed, rpm	1000, 1500, 2000
3	Gear Condition	Neutral
4	Different Mufflers	4

Instrumentation

Sound level meter 2250 type of B&K make was used to record sound pressure level of test tractor. It consist of microphone, 24V battery for power supply, touch screen display to record sound pressure level.

Sound Pressure Level and Fuel Consumption Measurement

An experimental test was done to evaluate four different mufflers (Figure 2) for sound pressure level where engine

was kept under no-load condition and at different engine speeds. Fuel consumption timing was determined to observe the effect of exhaustback pressure on fuel consumption. Sound pressure level was measured at the muffler outlet with the help of sound level meter at different engine speeds.

An supplementary tank with 100 ml fuel was used to measure fuel consumption timing. The supply line to the fuel pump was given from supplementary tank and the over flow pipe of fuel injector was put in tank.

III. RESULTS AND DISCUSSION

Based on the capacity of tractor, design parameters of the exhaust system and muffler as area expansion ratio, chamber size, inletand outlet positions, duct extension, porosity and open area ratio, noise attenuation and exhaust back pressure may fluctuate andexhaust back pressure readings at idle on most automobiles engines should generally be less than 10 KPa (Shrivastava *et al.*, 2014)[17].

In Figure 3 it can be seen that the sound pressure level increases with increase in engine speed for each muffler as the engine speed increases pressure wave increases. The sound absorbing material in muffler absorbs sound energy and converts that energyinto heat energy. Thus when sound waves passes through the small space between the tightly packed, small diameter fibers in theabsorbing material, the viscous friction results in the dissipation of sound energy as small amount of heat. As the multiple hole baffle plate is used at the center of muffler the space in the chamber will be reduced. So, when the high speeds sound waves willtravel in this small space the reflection of this sound waves will increase with the muffler walls and this will help to reduce noise.Multiple hole baffle plate is used as it will allow the flow in parallel pathway which will assist to minimize the back pressure.

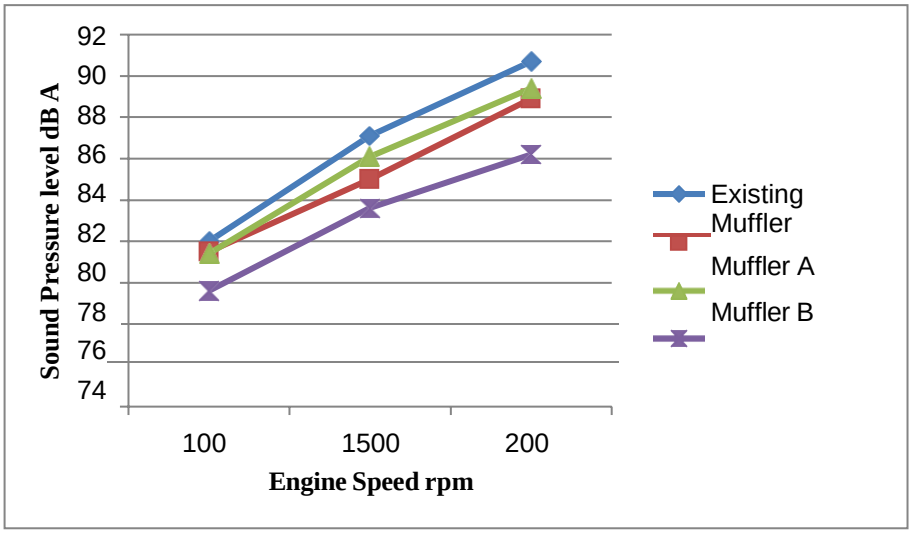

Figure: 3 Sound pressure level at different engine speeds.

It was found that muffler C (glass wool muffler) attenuated the sound more than muffler A and muffler B. Also, it is important to note that glass wool has smaller fiber diameter as compared to glass fiber and wire mesh. Thus glass wool provides more tortuous path and high surface area for the sound waves which in turn glass wool become more capable to absorb the sound energy and convert that into heat energy than glass fiber and wire mesh. The sound pressure level using muffler C was 86.2 dB A near rated engine speed (2000 rpm). And that of muffler A was 88.9 dB A and of muffler B was 89.4 dB A.

Figure 4 shows the time taken by engine to burn 100 ml fuel using each muffler. Time taken to burn the 100 ml

fuel using the muffler C was 1.40 min. which was close to the existing mufflers time taken 1.52 min. It can be concluded that the design characteristics of muffler C helped in low exhaust back pressure by means of consuming less fuel as compared to muffler A andmuffler B with highest noise attenuation. Muffler C has three chambers of 130 mm, 280 mm, 115 mm lengths. 2nd chamber wasincorporated with perforated tubes at inlet (115 mm) and outlet (30 mm), the baffle plate was fitted at the center of middle chamber. Glass wool was used to wrap the chamber wall which helped in noise reduction by converting sound energy into heat.

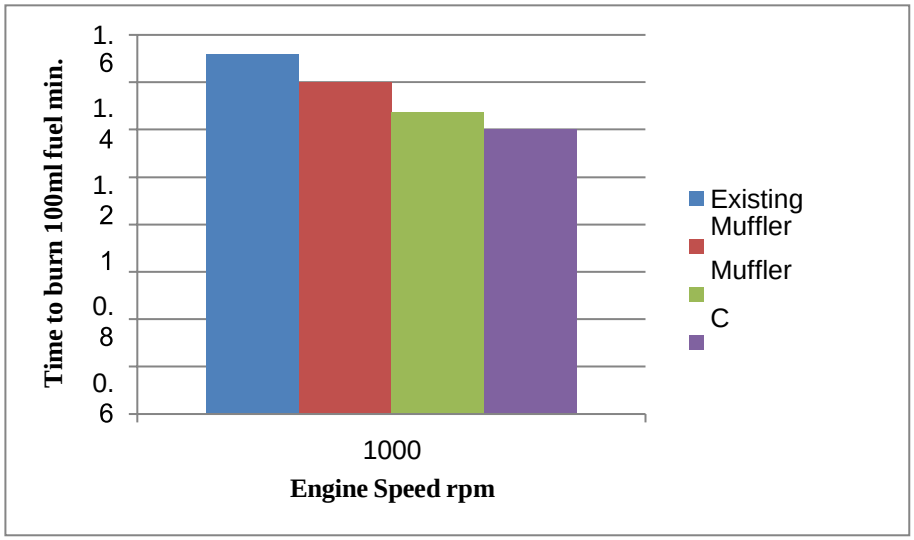

Figure: 4 Fuel consumption at 1000 rpm.

The combination of area discontinuities and sound absorbing material like glass wool, steel wool are used to control noise over broader frequency range of 20 Hz to 3000 Hz (Panigrahi *et al.* , 2005 ; Lee *et al.* , 2015). From the above discussion, muffler C was found to be best as compared to muffler A and muffler B, due to its more noise attenuation and efficient fuel consumption timing.

Table 3 Sound Pressure level near exhaust by using muffler C.

Particular`	Engine Speed(rpm)	pressure level(dB A)
Muffler C	1000	75.6
	1500	78.6
	2000	80.2

IV. CONCLUSION

An experiment was conducted to evaluate three different mufflers with different absorbing materials for sound pressure level atdifferent engine speeds at no-load condition. To check the effect of noise attenuation on engine,

fuel consumption timing was recorded. As the engine speed is increased sound pressure level increases. At different engine speeds with muffler designs thereis significant effect on sound pressure level at 10 % level. Muffler C (three chambers of 130 mm, 280 mm, 115 mm baffle plateat the center of middle chamber with 25 mm center hole diameter, glass wool wrapped around expansion chamber wall) was predicted to be optimum among the tested mufflers at it reduces noise to 80.1 dB A with better fuel efficiency. Typically,material with smaller fiber diameters and greater surface area to flow area has better noise attenuation capability (glass wool). The study shows that higher attenuation results in higher back pressure and lower fuel efficiency. Hence, improved muffler design would maintain balance between noise attenuation and exhaust back pressure.

V. ACKNOWLEDGEMENTS

I would like to express my gratitude towards my parents and my guide Prof. V.B.Ghagare and members of TCOER,pune fortheir kind co-operation and encouragement which help me in completion of this project.

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