ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

STUDY OF NOISE BEHAVIOR ON MUFFLERS FOR IC ENGINE: A REVIEW

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ABSTRACT

The aim of this paper is to analysis the Muffler for four stroke diesel engine. Muffler or silencer is a device which is used for reducing the amount of noise emitted by the exhaust of an internal combustion engine. After burning the fuel the many poisonous exhaust gas such as CO2, SO2, NO2, are generate. Such types of harmful exhaust gases are generate noise and air pollution. Exhaust noise from IC engines is one of main factor of noise pollution to the atmosphere. Day to day, noise pollution increases in our surroundings due to increase of number of vehicles and automobiles. Mufflers are installed within the exhaust system of most I C engines, although the muffler is not designed to serve any primary exhaust function. The muffler is an acoustic soundproofing device designed to reduce the noise of the sound pressure created by the engine. The majority of the sound pressure produced by the engine is to reduce approximately 10db to 15db after passing the exhaust gas through muffler.

KEYWORDS: muffler, exhaust gases, noise pollution, sound pressure.

INTRODUCTION

Mufflers are installed within the exhaust system of most internal combustion engine although the muffler is not designed to provide any primary exhaust function. The muffler is an acoustic sound proofing device designed to reduce the loudness or highly intensive sound of the sound pressure created by the engine by way of acoustic quieting. The maximum amount of the sound pressure produced by the engine is emanated out of the vehicle using the same piping used by the silent exhaust gases absorbed by a series of passages and chambers lined with roving fiberglass insulation and resonating chambers harmonically tuned to cause destructive interference where in opposite sound waves cancel each other . An unavoidable side effect of muffler use is an increase of back pressure which decreases engine efficiency. This is because the engine exhaust gases must share the same complex exit pathway built inside the muffler as the sound pressure that the muffler is designed to mitigate. Some vehicle owners remove or install an aftermarket muffler when engine tuning in order to increase power output or reduce fuel consumption because of economic or environmental concerns, recreational pursuits such as motors port and hyper milling and/or for personal aesthetic acoustical preferences. Although the legality of altering a motor vehicle's OEM exhaust system varies by jurisdiction, in most developed parts of the world, modification of a vehicle's exhaust system is usually highly regulated if not strictly prohibited.

A modern exhaust muffler is normally manufactured by a combination of an expansion chamber, perforated pipes and perforated boards [13-14]. This noise resistance as the combustion gases flow through the pipe holes and boards but the combustion gasses cause exhausts resistance as a side effect [15]. The two most important design objects for a muffler are to obtain noise reduction greater than the required lower value and also back pressure lower than the maximum permissible value [16, 17]. An exhaust muffler is usually considered when talking in terms of energy [15,19], fuel consumption [15,18,19,21], noise [17,18,20,22–24], damping [22,25], good conditions of environmental designs [19,21,26–27], vibrations from the I C engine sand roads [26], even burn injuries when in contact to skin [27] or their painting [28] but rarely as a hot spot for fatigue and/or creep damage. They can burn the skin when it is contact to skin. Lee and Ih are explaining the design of a muffler and its fatigue life [16]. Similarly Wangetal.[31] report that in most of the cases cracks occurred at the welded joints when a muffler bust in use .Martins et al. [30] write about cracks that propagate from weld toes of butt and fillet weld joints on a marine gas turbine. Subbiaha et al. [26] studied the effect of muffler mounting bracket design on the basis of durability and observed development of crack sat weld locations. Increasing requests for weight reduction and improved performance of exhaust systems, their n long term

guarantee and strict environmental regulations demand enhanced materials [26]. An exhaust muffler is generally made of stainless steel [13, 14, 19, 27]. Modern day newer materials such as titanium alloys [30] and composite materials, e.g. carbon fiber epoxy [31, 32], are being used, the main reasons for the continued use of stainless steel are cost and good corrosion resistance [14, 27].

Types of mufflers

Mufflers can be classified in reflective, absorptive and hybrid mufflers depending on the working principle.

Reflective muffler:

Reflective mufflers are those mufflers that uses for sound attenuation by changing cross sections in the duct. Reflection mufflers attenuate the sound by reflection and interference. The important tools of Reflective mufflers are analytic modeling and evaluation of network theory. The reflective muffler is shown in Fig1.1.using silencer no.2.[12].

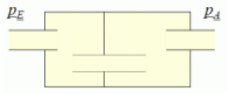

Fig.1.1 Reflective Muffler.

Reflective muffler in closed condition

Reflective muffler in cut condition

Absorptive Muffler:

Absorptive mufflers are those mufflers that uses for sound attenuation by sound absorbing materials. They dissipate the acoustic energy into heat energy through the use of porous materials as mineral fiber. The important tools of Absorptive mufflers are absorber modeling and numerical computation. The absorptive muffler is shown in Fig1.2. silencer no.3.

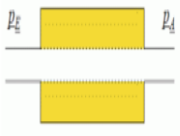

Fig.1.2 Absorptive Muffler

Absorptive muffler in cut condition

Absorptive muffler in cut condition

Hybrid Mufflers:

Mufflers that combine the working principle of a reflective muffler and an absorptive muffler are called hybrid mufflers. This type of muffler is the best muffler to reduce the noise.

In this study, three different types of mufflers are used out of which two are Reflective mufflers and one is Hybrid muffler. Silencer No. 1 is Hybrid type of muffler shown in fig. 1.3 and fig. 1.4.

Fig. 1.4 Hybrid muffler in cut condition

Fig1.3Hybrid muffler in closed condition

LITERATURE REVIEW

Studies on perforated tube of mufflers

Taylor W. Le Roy in his thesis has considered the effect of perforated tube on transmission loss of the silencer. They added a perforated tube to the single expansion chamber. From the results obtained he concluded that addition of perforated tube increases the transmission loss of muffler at higher frequencies. The addition of perforated tubes improves the transmission loss by 4.5 dB to 6 dB. The perforated tube is more beneficial when expansion chamber is not used effectively [1].

Haluk Erol and Ozcan Ahmetoglu investigated the effect of amount of perforation and porous material thickness on the transmission loss of the muffler. They concluded that at lower value of frequency transmission loss is independent of the number of perforated hole but at higher value of frequency, the transmission loss is depend on the number of perforated holes it increases with the increase in number of perforated holes[2].

F.D Denia et al. studied the acoustic manners of perforated dissipative type circular mufflers. They considered the complex characteristic impedance, wave number, and perforation impedance to calculate the axial wave number in the fibrous material and perforated pipe. They showed that the use of empty extensions leads to quarter wave resonances which enhanced the acoustic performance of the muffler at low to mid frequencies. He showed that the use of perforated tube leads to quarter wave resonances which improved the acoustic performance of the muffler at low to mid frequencies [3].

Ovidiu Vasile and Nicolae Enescu investigated the acoustic performance of reactive muffler by using numerical and experimental techniques. He conclude that five lines of perforated holes of muffler configuration gives higher transmission loss in comparison to single line or three lines of perforated holes.[4].

Ayse Dincer in his thesis discussed the effect of perforated hole pattern on transmission loss of the muffler. The author studied linear and staggered pattern of hole on the tube and concluded that pattern of holes do not have much effect on the transmission loss of the Muffler [5].

Zhuoliang Li observed the effect of perforated tube on transmission loss of muffler. After their analysis author concludes that when perforated tube is replaced by solid tube, at all frequencies the transmission loss of the muffler reduced [6]**.**

Studies on length and diameter of perforated tube on mufflers

Fangsen Cui et.al studied the effect of porosity, length and diameter of perforated tube on the transmission loss of muffler. The result shows that transmission loss for large porosity is good for low frequency and small porosity is good for high frequency. Also the transmission loss increase with length of tube at high frequency but for small frequency effect of perforated tube length is not monotonous [7].

Nawaf H. Saeid performed the numerical simulation to examine the effect of perforation on acoustical performance of muffler. The author studied the effect of perforated hole diameter and length of perforated tube on transmission loss. In his work he considered three different perforated tube of hole diameters 6 mm, 9mm and 12 mm. He also varied the length of tube to analyze the effect of tube length on transmission loss. He concluded that transmission loss is dependent to perforated hole or length of perforated tube. The transmission loss is increases with increase in either perforated hole or length of perforated tube [8].

Nitin S. Chavan in his research paper explains the effect of length to diameter ratio of perforated tube on the transmission loss of muffler. He conclude that transmission loss increases as ratio of length to diameter of tube increases [9] The exhaust noise, which falls into low-frequency noise, is the dominant noise source of a diesel Engines and tractors. It is a direct and effective way to reduce the exhaust noise by using an exhaust muffler. However, the traditional exhaust muffler, which are normally constructed by combination of expansion chamber, and perforated pipe or perforated board, are with high exhaust resistance, but poor noise reduction especially for the low-frequency band noise. Normally, there is a contradiction between the noise reduction and the exhaust resistance for an exhaust silencer, so it has a great significance in studying the theory or principle of the exhaust muffler with high-efficiency noise reduction and energy saving [1].

Wonnacott E.J. used the recommendations and established theory to analyze and manufactured a series of efficient mufflers for general vehicle and stationary engine use. The recommended design step has generally been found to be flexible in its application and the silencers thus designed appear to have distinct advantages over their current counter parts in relation to design simplicity, easy to manufacture and consistent attenuation performance throughout their useful life. [34].

Nakra B.C., Said W.K. and Nassir A. experimented on reactive types of muffler and their combinations with absorption type muffler, in order to find out their noise attenuation characteristics. Tests were performed on a test rig, with highly intensive sound (loud speaker) as a input source as well as a four stroke four cylinder diesel engine. The frequency spectrums of attenuation levels, obtained experimentally, were compared with corresponding theoretical calculations. The effect on the performance of the engine itself was studied. The effect on the performance of the engine was marginal. It was seen that the combinational mufflers offer a good solution when high noise attenuation is desired.[35]

Higgs Benjamin and Rupke Ryan designed the muffler. The primary objective of this project is to develop a muffler system to fulfill the demanding needs of a Formula SAE prototype race car. This development of the FSAE standards as they related to noise control system. [36]

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PURPOSE OF MUFFLER

Mufflers are assembled along the exhaust pipe as a element of the exhaust system of an IC engine to reduce or minimize its exhaust noise. Mufflers use efficient technology to cancel out the noise. The muffler minimizes exhaust noise by dampening the pulsations in the exhaust gases and allowing them to expand slowly. It was usually made of sheet metal of steel, coated with aluminum to reduce corrosion and deterioration. Some mufflers are made of stainless steel.

A muffler contains perforated pipes, baffles and resonance chamber space. Many type of sound-absorbing material also contain such as fiberglass or wool cloth. The muffler reduces flow the gases and breaks or splits up the pulsating sound waves, and so minimize the noise. It must cause as small restriction as possible. Poor design can cause unnecessary back-pressure that will slow down the escape of the exhaust gases and minimize engine performance.

Some mufflers combine baffles and pipes to change the flow of gases without limitation them. Gases enter through the inlet and must reverse their mode of flow before they exit through the outlet. This flow is called a reverse-flow muffler. Some mufflers are using as double outer-skins to reduce heat and noise transmission. Few exhaust systems use a resonator as well as a muffler. It looks like a muffler but it typically has a straight-through design and it also contains some sound absorbing material. It is designed in such a way to remove types of sound that mufflers can't remove. Silencers or mufflers cover a wide range of noise reduce devices and must be considered one of the most powerful weapons available to minimize noise produced from cars, trucks, motor cycles, boats.

PRINCIPLE OF THE MUFFLER [10]

The principle of the new muffler is shown in Fig.*. The exhaust gases are introduced in inlet and passes by a cone, flowing into the space between inner and outer pipes, and then distributed or circulated automatically, coming into the chamber space through the radial rectangular slits using a U-type shaped pipe. In each assembly, the coming exhaust gases are divided into two parts which has the same magnitude and 180º phase (angle) difference, when these two parts gases are made to gather at centre-line of the chamber, they are cancelled to each other, foremost that gas flow rate is relatively low. And also the expansion chamber in the middle of the muffler helps to reduce the noise. Since the two openings chambers placed to each chamber are big rectangular slits and also the gas flow speed is lowered by the cancelling, the value of pressure loss is much lower when gas passes through the muffler meaning at the backpressure of the muffler is lower.

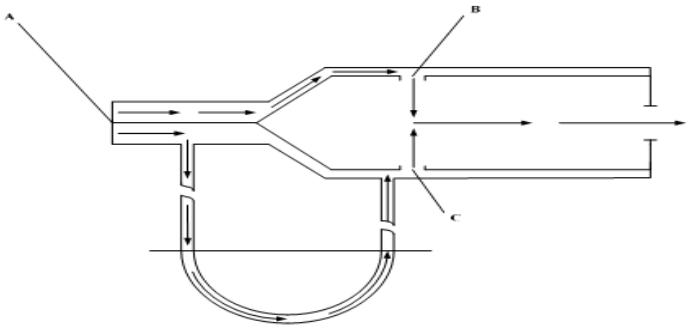
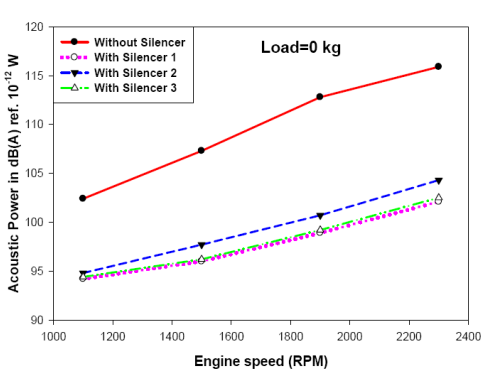


Fig. Principle of the muffler using reversed-phase cancelling [10]*

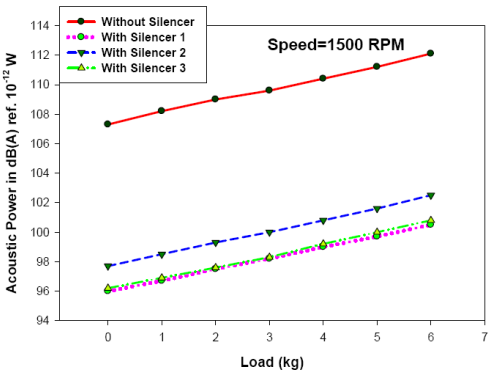
EFFECT OF MUFFLERS ON THE IC ENGINE

Analysis of sound parameter on engine

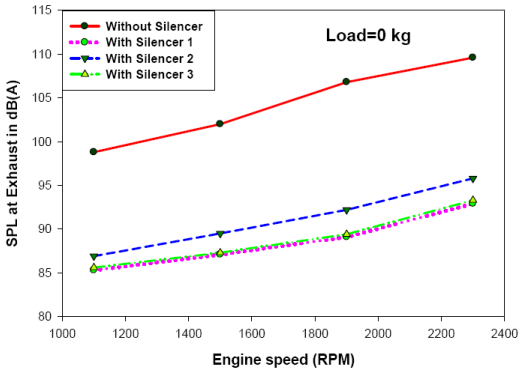
By using muffler or silencer the various observations is taken as shown in fig. at constant load the acoustic power can be reduce 10 db (A) to 15 db (A) and also reduce the sound pressure level 8 db to 12 db as compare to without silencer. [12]



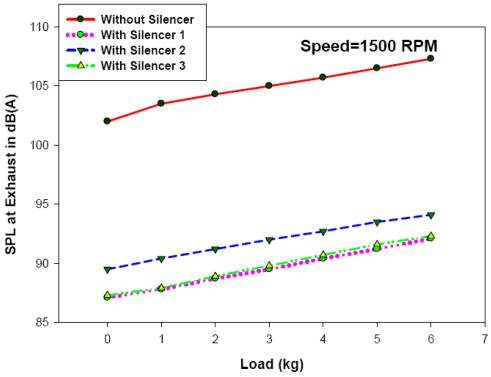
Acoustic Power Vs Engine speed



Acoustic Power Vs Load



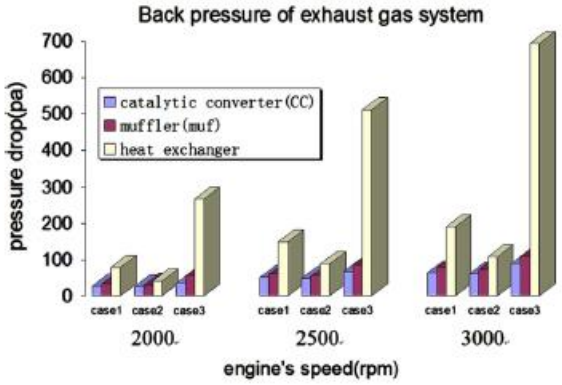
SPL at Exhaust Vs Engine speed



SPL at Exhaust Vs Load

Analysis of back pressure

The experimental system was composed of the 2.0-L naturally aspirated engine, a dynamometer (maximum power input 160 kW, maximum speed 6000 rpm). In the bench test, the experiment conditions such as room temperature, wind speed.[33].



CONCLUSION

Mufflers are one type of duct, or hollow cylindrical tube which exhausts gases passes. By using mufflers we can save the power and reduce the knock in the IC engine. We can also save the large amount of sound pollution and heat energy through muffler. Exhaust gases are utilized by mufflers in the form of heat energy, mechanical and electrical energy in I.C engine. Muffler can reduce sound pressure 8 db to14 db [12]. In the current days all type of luxury vehicles are used waste heat recovery system through mufflers. Mainly mufflers are generally used to increase the engine efficiency and reduction in noise pollution and all types of exhaust emission. The biggest advantage is to improve the environmental condition of ambient. Larger the diameter of the pipe hole, low value of back pressure and hence lower will be the transmission loss which makes the vehicle highly instance sound.

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