

Experimental Test for Noise Attenuation in Gasoline Engine with Different Types of Mufflers

*Ehsan Sabah M. AL-Ameen
Al-Mustansiriya University
College of engineering*

Abstract

IC engines are a major source of noise pollution. An engine noise is mainly due to exhaust noise. Suppressing of an engine exhaust noise has been a subject of interest for many years. Mufflers are used to minimize sound transmission caused by exhaust gases. Thus, muffler design becomes more important in noise reduction. The present work compares between three different types of an exhaust muffler for noise attenuation of single cylinder four stroke air-cooled gasoline engine. A set of conclusions achieved about the effect of the mufflers chamber's expansion ratio, chambers length, and wall thickness. Some of them agree with former works.

Key words: Sound attenuation, Mufflers, Noise pollution

اختبار تجريبي لتخفيف الضوضاء في محرك البنزين باستخدام أنواع مختلفة من الكواتم

الخلاصة

تعتبر محركات الاحتراق الداخلي من المصادر الرئيسية للتلوث الضوضائي. السبب الرئيسي لضجيج المحرك هو ضوضاء العادم. كتم ضوضاء عادم المحرك موضع اهتمام لسنوات عديدة. الكواتم تستخدم لتقليل انتقال الصوت الناجم عن غازات العادم. لذا أصبح تصميم كاتم الصوت أكثر أهمية في الحد من الضوضاء. يقارن هذا العمل بين ثلاثة أنواع مختلفة لكاتم صوت العادم لتخفيف الضوضاء لمحرك بنزين احادي الاسطوانة رباعي الاشواط مبرد بالهواء. تم التوصل الى مجموعة من الاستنتاجات التي حول تأثير التوسع في غرفة الكاتم و طول الغرفة وسمك الجدار وتوافقت بعض من الاستنتاجات مع اعمال سابقة.

Introduction

Exhaust noise is the major contributor to noise from vehicles powered by internal combustion engine. A gasoline engine produces exhaust noise in the range from 80 to 110 dB A. Suppressing of an engine exhaust noise has been a subject of interest for many years. Mufflers are used to reduce this noise. It is an important component of the modern vehicle

exhaust system. In order to comply with the law of environmental protection, the exhaust of vehicle including the noise and the burned gas should be strictly controlled. Thus muffler design becomes more important in noise reduction. In general two types of mufflers are in use, dissipative muffler and reactive muffler.

Many tests and researches are carried on mufflers. Research into the methods used for testing the acoustic performance of mufflers and ducts gave better understanding of the experimental procedure as well as giving information on the theoretical results expected during testing.

Muthana [1], and Muna.[2,3] built a test rig and studied many design parameters affecting the muffler's performance. They also gave a survey on former works that dealt with sound attenuation tools for (I.C) engines. Studying the effect of mufflers and their design should coordinate with studying the effect of the residual noise on the environment. **Singh [4]** gave a good survey for previous works that discuss the various sources of the noise in I.C. engines and methods to achieve facilities to gain power. In his work, **Singh**, studied the relationship between compression ratio and frequency with load for a single cylinder four stroke, VCR (Variable Compression Ratio) diesel engine connected to eddy current type dynamometer for loading. **Zakhmi [5]** used single-cylinder two-stroke petrol engine in his study for generated noise at different speeds and loads with different types of mufflers. One of **Zakhmi's** conclusions is that the value of Sound Pressure Level varies linearly with respect to load and speed.

Ehsan [6] investigated the sound power generated from two different size electric generators which are operated by single cylinder four stroke gasoline air cooled engines. The sound power ((which may be considered as dissipated power)) is considered against the generating load. The comparison was between new and old (used) generators; and found that used generators make noise much more than factory specifications and this noise lower with load increment, in contrary in brand new generators, noise grow with load increment. **Munjal [7]**, stated "for muffler system to be of high performance, it should be a combination of reactive and dissipative muffler to reduce high frequency sound and active attenuation to reduce low frequency sound." **Jadhav [8]** used three models of mufflers. They are fitted on the exhaust pipe of a single cylinder water cooled diesel engine and their performance measured at constant speed through the entire load range of the engine. He found that combined reactive and dissipative muffler give better results in sound attenuation point of view. In other hand, he discovered that the multi-chamber reactive muffler is better in performance characteristic. **Biswas [9]** designed a combination and a reactive muffler of same volume for a single cylinder four stroke 8 BHP diesel engine and evaluated performance experimentally through measurement of noise level and brake specific fuel consumption time of engine. He proved that in small volume combination muffler is possible and it's more effective than reactive one.

In this work, three models of mufflers are used to investigate their effect on noise attenuation and fuel consumption in a single cylinder four stroke air cooled gasoline engine.

Experimental Setup

The schematic diagram of the experimental setup is shown in (Figure 1). All noise data were taken on a relative basis in the closed space of the laboratory and in the presence of other engines and instruments in the close vicinity of the muffler exit. The background noise was recorded before experimentation. In order to keep background noise to a minimum, all other engines and machines in the laboratory were shut down during recording of the background noise.

A single cylinder, four stroke air cooled, constant speed (3400 rpm) gasoline engine was used for testing the performance of three mufflers. The engine is loaded using an electric generator with variable load. Fuel consumption is measured by using burette and stopwatch. A sound analyzer (RION) type (Figure 2) is used to measure the sound pressure level.

Three sets of three different model mufflers of circular cross section are fabricated from 24 gauge mild steel plate (which is 1.05 mm thickness). The first mufflers set made with expansion ratio (ER) 12 and 400 mm length (L), the second set have (ER) 12 and 550 mm length while the third set have (ER) 14 and 550 mm length. A fourth set fabricated from 18 gauge mild steel plate (which is 1.4 mm thickness) with the same dimensions of the first set.

Each muffler was made to fit on 26.67 mm exhaust pipe of engine. These mufflers are fitted onto the exhaust pipe of the engine and for each setup the SPL is measured at a distance of 0.5 meter from the muffler outlet end and at an angle 45° to the horizontal axis of the muffler. SPL is also recorded at a distance 0.5 meter from the exhaust pipe outlet and at angle 45° to the horizontal axis of the exhaust pipe after disconnecting the muffler. The difference between the two readings is taken as the noise attenuation produced by the particular model.

The inlet and outlet are arranged eccentric by 20 mm with the center axis of the chamber to increase transmission loss. The perforated section is given about 5% porosity by drilling holes on the surface.

The three types of mufflers used in this work are:

T₁: Multi-chamber Reactive Muffler. Contains a double expansion chamber of unequal length. Inlet and outlet tube extended in chambers and arranged with eccentricity of 20 mm.

T₂: Concentric-tube Resonator Muffler. Muffler is simply constructed through the use of an axially located perforated tube passing through the chambers and forming the inlet and outlet.

T₃: Combined Reactive and Dissipative Muffler. Structures loosely packed with sound absorbing material (fiberglass wool) are incorporated into the reactive design protected by a perforated metal sheet. Exhaust and tail pipes are arranged with eccentricity of 20 mm and extended in first expansion chamber.

After starting the engine the measurements were taken at 3400 rpm, and different loads starting from no load to 4.4 kw. This measurement gives us the insertion loss (IL) of muffler, noise level and fuel consumption.

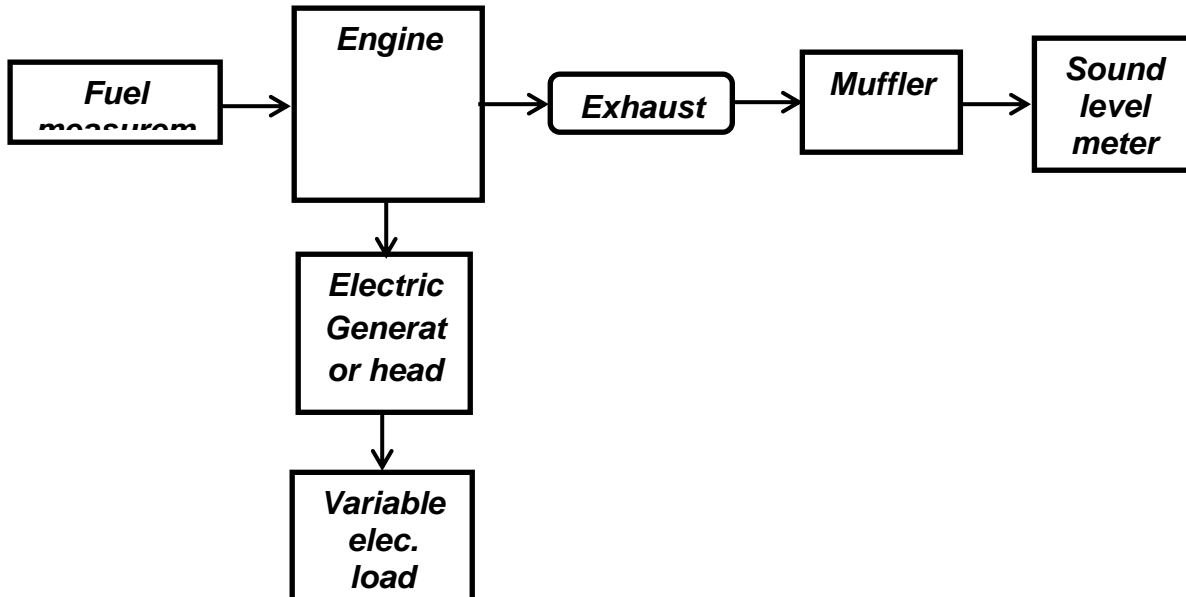


Figure 1: Experimental setup



Figure 2: (RION) Sound level meter

Results and Discussion

(Figures 3 – 5) represent the graphs of BHP against fuel consumption, sound pressure level and sound attenuation respectively for the first set of mufflers which have E.R.(12) and L (400) mm. (Figure 3) shows fuel consumption versus brake horse power and (Figure 4) shows the graph of SPL versus brake horse power. The graph represents variation of SPL with different loads with and without mufflers. As load increases, torque of an engine increases so,

SPL of an engine increases. (Figure 5) shows the graph of sound attenuation versus brake power. The graph shows that the SPL decreases at all engine test conditions. This is due to the different muffler configurations having reactive, concentric-tube resonator and combined reactive and dissipative structure.

A sound attenuation of 11, 12 and 13.5 (dB A) achieved with T₁, T₂ and T₃ respectively in the first set. According to sound attenuation, the sequence of muffler model is (T₃ - T₂ - T₁).

(Figure 3) shows an increase in fuel consumption with mufflers. This is due to the back pressure exerted on an engine. There is nominally increase in fuel consumption for each of the three models through the entire load range compared to that without muffler. The sequence of muffler models according to fuel consumption is (T₁ - T₂ - T₃).

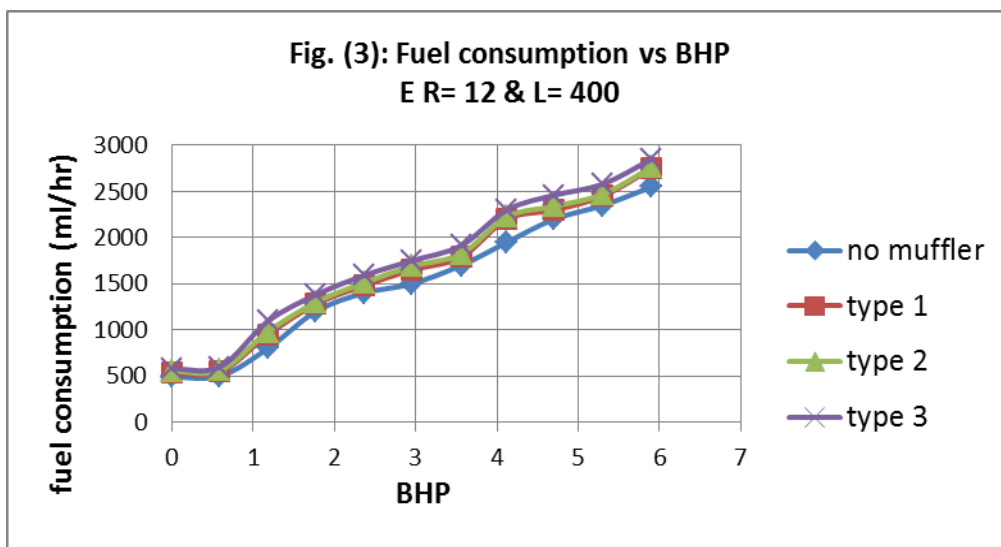
(Figures 6 – 8) represent the graphs of BHP against the mentioned above parameters for the second set of mufflers which have (ER) 12 and (550) mm length while (Figures 9 – 11) represent the results for the third set where (ER) 14 and L (550) mm.

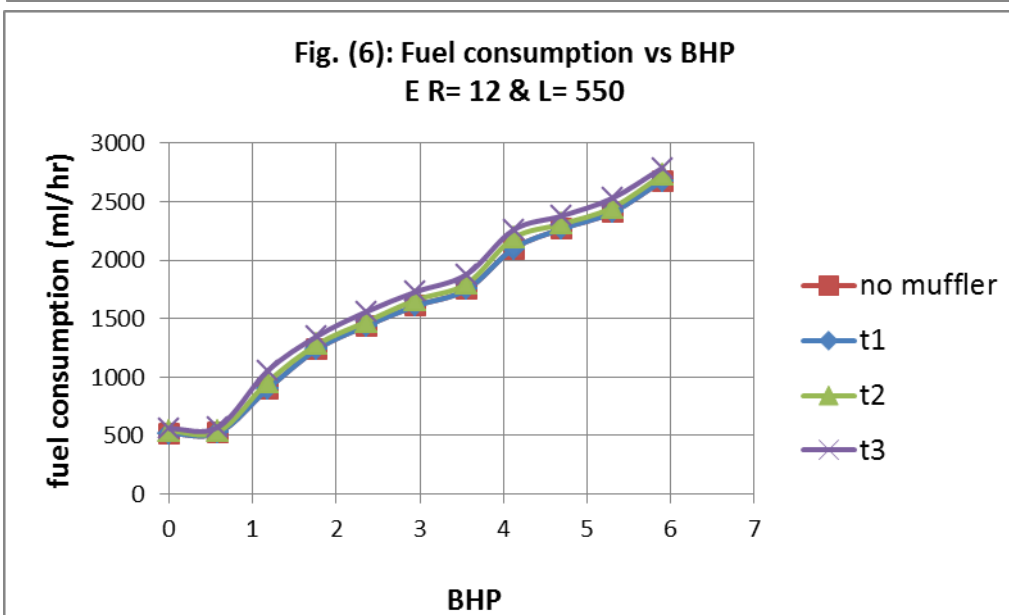
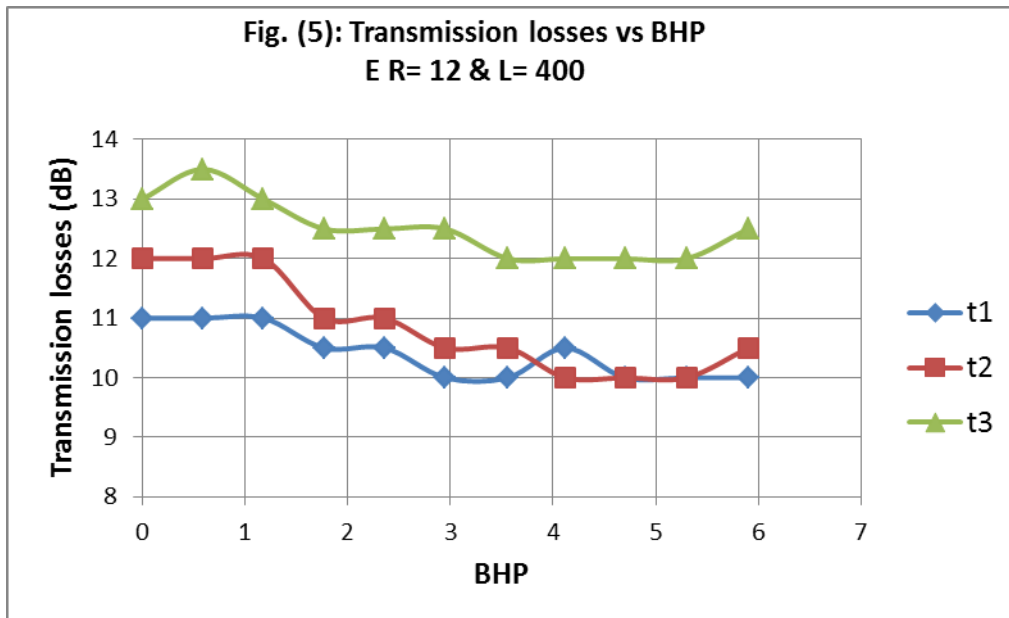
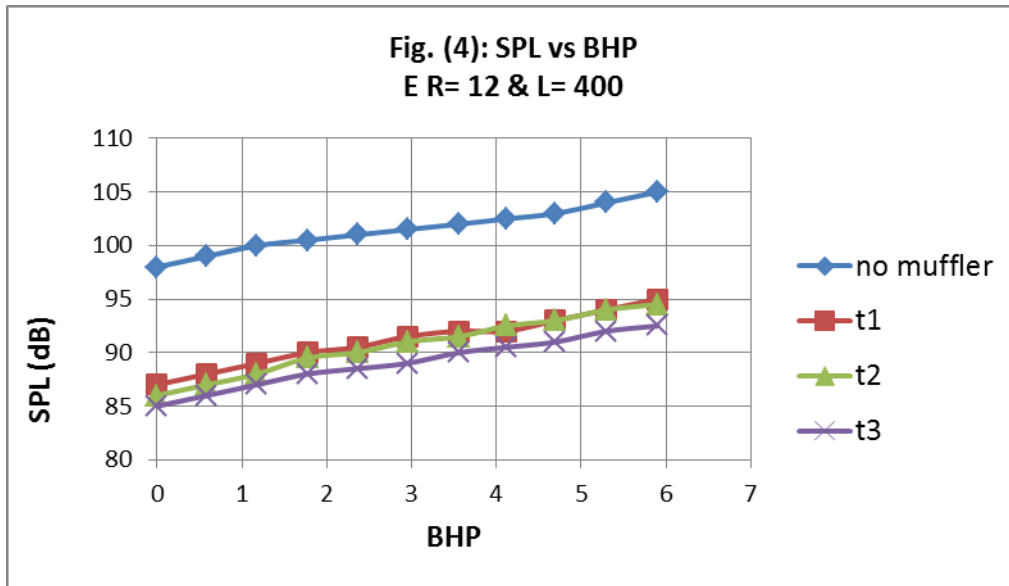
The second set produces sound attenuation of 12, 13.5, and 15 dB A and the third set gave 12.5, 15, and 16 dB A.

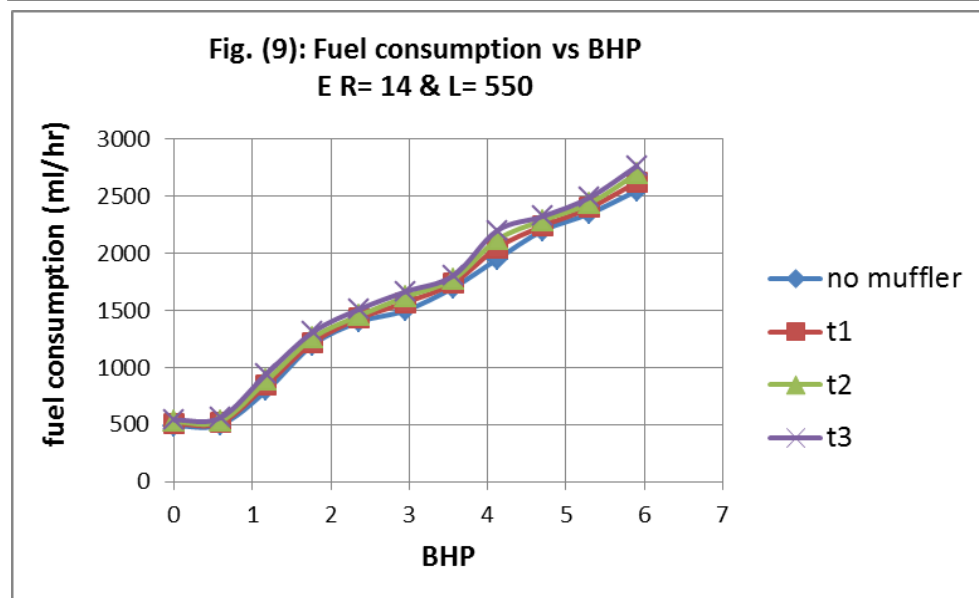
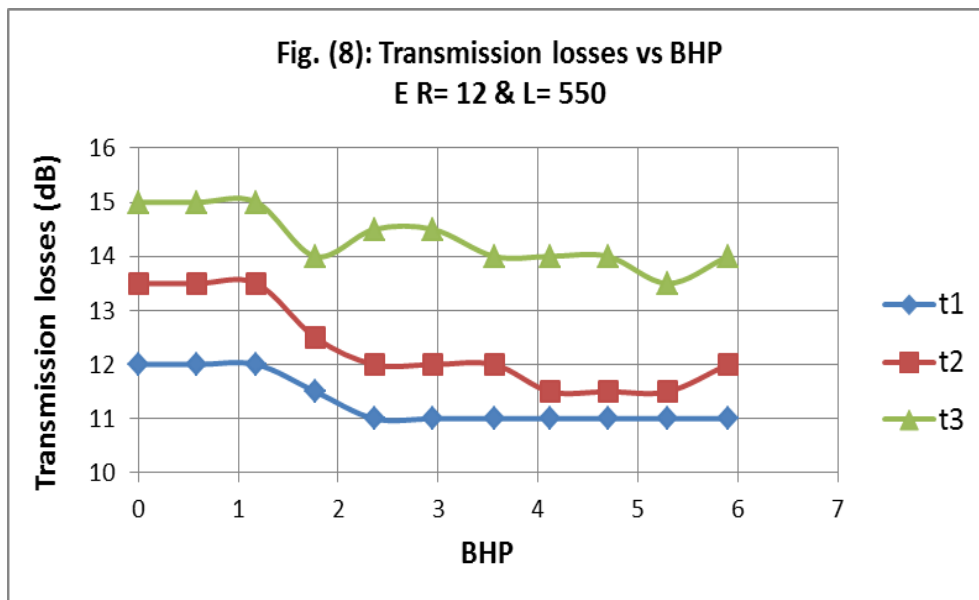
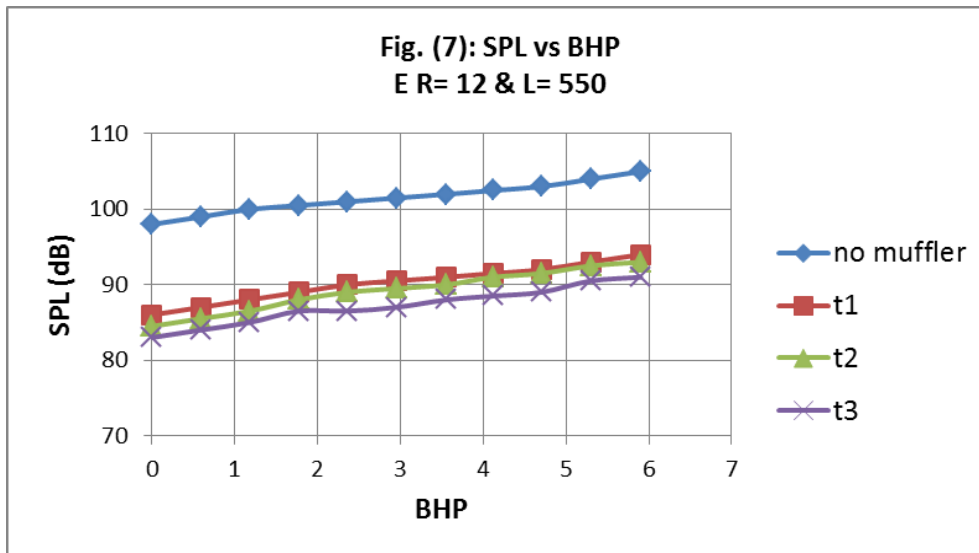
Comparing the values of fuel consumption in (Figures 3, 6, and 9) it can be noticed that these values increase with the increment in noise attenuation for different muffler types with the same design parameters (ER) and L and also it is clear that the values drop with the increment of (ER) and L.

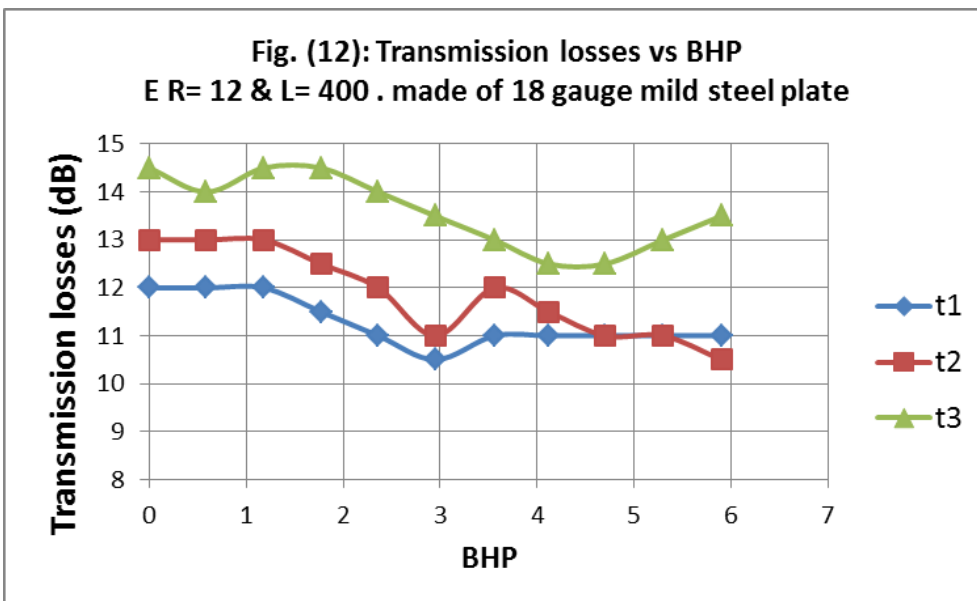
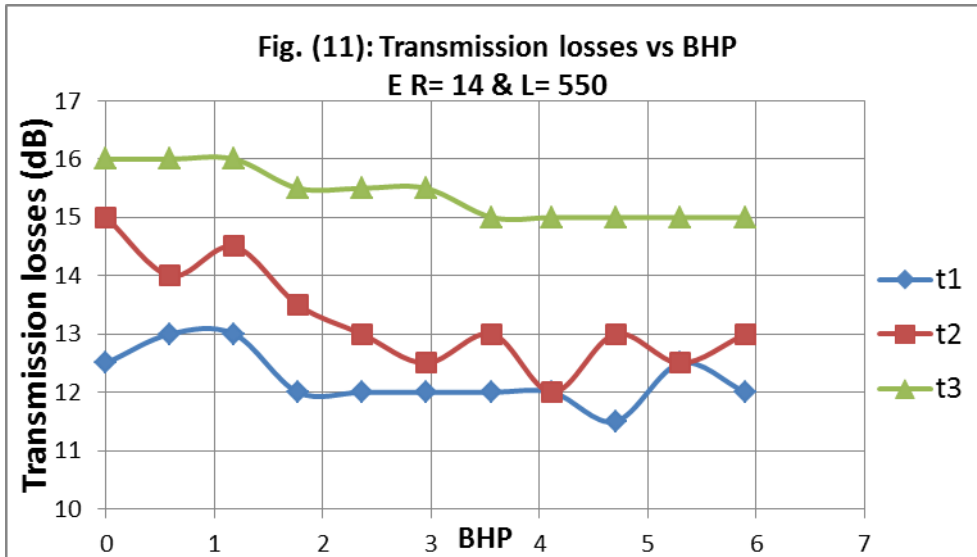
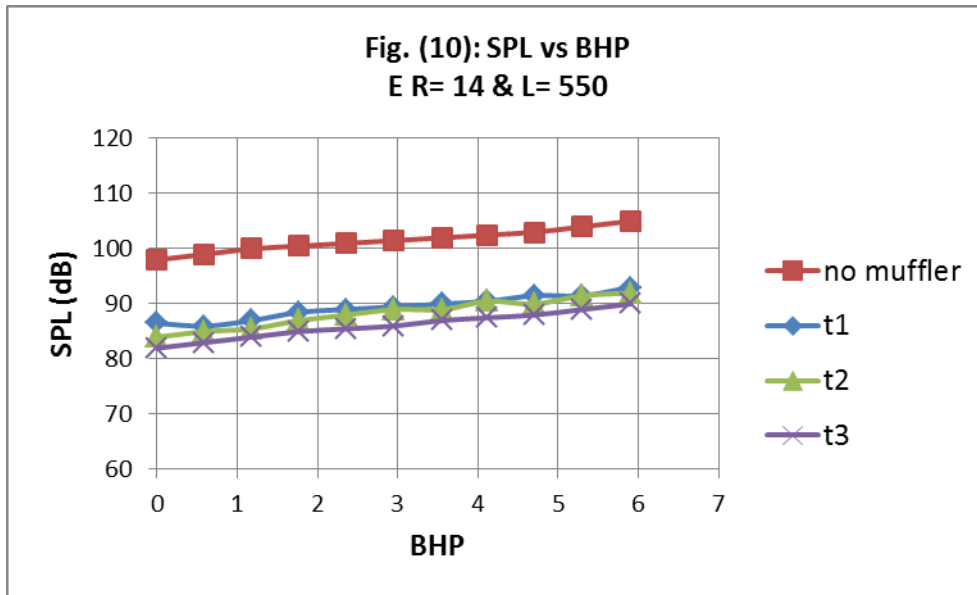
Another comparison for the noise attenuation shows that the insertion loss values increase with the increment of (ER) and L in (Figures 5, 8, and 11).

(Figure 12) shows the insertion loss achieved within the fourth set that is made from 18 gauge mild steel sheet. Comparing the results in (Figures 5 and 12) it can be noticed that the increase in wall thickness gives a limited increment in transmission losses









Conclusions

Noise attenuation of the engine is carried out using different types of mufflers. These mufflers were fitted on exhaust pipe. Fuel consumption in (ml per hp per hr) as well as acoustic performance is measured for entire load range. The following conclusions are derived:

1. Sound attenuation of 12.5, 15 and 16 dB A is achieved with T_1 , T_2 and T_3 mufflers.
 2. The greater expansion ratio the greater transmission losses.
 3. The length of muffler's chamber proportionate with sound attenuation.
 4. The higher muffler's chamber wall thickness the greater transmission losses.
 5. Fuel consumption increase in the presence of mufflers. This is due to the back pressure exerted on the engine.
 6. According to engine performance muffler T_1 is better than T_2 and T_3 mufflers.
 7. There is nominal increase in BSFC for all the three models through the entire load range compared to the case with no muffler.
 8. Muffler T_3 is better than T_1 and T_2 mufflers from sound attenuation point of view.
- The last four conclusions agree with reference [8].

References

- 1- Muthana K. Al-Doory, Muna S. Kassim & Ehsan S. M. Al-Ameen "The Effect of Orifice Shape On Noise Reduction in a Muffler Experimentally". Proceedings of the 5th Scientific Conference, WASIT University, WASIT, IRAQ December 13-14/ 2011.
- 2- Muna S. Kassim, Muthana K. Al-Doory, and Ehsan S. Al-Ameen "Experimental Investigation for the Effect of Inlet & Outlet Pipe Lengths on Noise Attenuation in a Muffler". Engineering and Development Journal, 2012.
- 3- Muna S. Kassim, Ehsan S. Al-Ameen, Hayder M. Mohammed, "Effect of Orifice Shape and Bore-Area on Noise Attenuation in a Reactive Muffler". Presented to publish. 2012
- 4- Rinkle Singh "Study of Noise Generated by Kirloskar Single Cylinder Four Stroke I.C. Engine" A thesis submitted in partial fulfillment of the requirement for the award of Degree of Master of Engineering in CAD/CAM & Robotics THAPAR University 2009.
- 5- Sonal Zakhmi "Study of Noise Generated By Single Cylinder Two Stroke Petrol Engine". A thesis submitted in partial fulfillment of the requirement for the award of Degree of master of engineering in CAD/CAM & Robotics THAPAR University 2009.
- 6- Ehsan S. Al-Ameen "An Experimental Investigation for the Relationship between Acoustic Power and exerted Load in Single Cylinder Four Stroke Air-Cooled Gasoline Engine" Engineering and Development Journal, approved to publish 2012.
- 7- Munjal M. L., Acoustics of Ducts and Mufflers, John Wiley and Sons, New York 1987.
- 8- Vijay S. Jadhav and Dhanaji M. Ghatage "Noise Attenuation Of Diesel Engine With Different Types Mufflers" Mech. Eng. Dept. Govt. COE, KARAD - INDIA. 2002.
- 9- S. Biswas "Combination Muffler is More Effective than Reactive Muffler Even in Small Size." Tata Motors Ltd. IEEE explores, jan.2012.