Progress in Engineering Application and Technology Vol. 2 No. 1 (2021) 912–923

PEAT

Homepage: http://penerbit.uthm.edu.my/periodicals/index.php/peat
e-ISSN : 2773-5303

Design and Fabrication of Noise Silencer for Grass Trimmer

Muhammad Azmir Rajali[1], Rahim Jamian[1]*

[1]Department of Mechanical Engineering Technology, Faculty of Engineering Technology,
Universiti Tun Hussein Onn Malaysia, 84600 Pagoh, Johor, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/peat.2021.02.01.087
Received 13 January 2021; Accepted 01 March 2021; Available online 25 June 2021

Abstract: Grass trimming employees work in a noisy condition every day as they hold the grass trimming machine on their back. Over several years, this everyday exposure can lead to noise-induced hearing loss. In fact, reducing the noise emissions generated by engine exhaust system poses a major problem for various industries. In this respect, mufflers have been used to reduce the emitted noise from the automobile engine into the environment. This research project was attempted to design and fabricate a noise silencer for grass trimmer. The scope was based on the existing grass trimming machine and design of muffler as a noise silencer for grass trimmer. The design of prototype model of silencer was developed with the aid of SolidWorks software based on secondary data of previous research study. The selection of final design was founded on the advantages of the muffler that can be attached at outside of the trimming engine. Then, measurement of noise level of grass trimmer was conducted using noise level meter. The equipment was set up at 0 – 10 m between the operator and engine with the operation condition of 1000 and 6000 rpm. Based on the measurement and analysis results, the noise level of grass trimmer reduced significantly with a longer distance after applying the silencer for both the condition of 1000 and 6000 rpm. The overall findings suggested that the proposed prototype model of silencer is effective to be used as an improvement opportunity to decrease the level of noise toward minimizing the harmful effect and risk of noise emitted by the engine of grass trimmer. Nonetheless, several recommendations are highlighted for further development and improvement of the research, including redesigning the silencer to suit with the characteristics of the commonly used grass trimmer.

Keywords: Grass Trimming Machine, Muffler, Noise Silencer

1. Introduction

The pace of grass growth, which is quick and continuous has produced a grass-trimming job in great demand to preserve the tidiness of the scenery and to preserve the beauty nature. The use of grass trimming machine is the only way to cut long grass along the landscape and overall farmland based on

*Corresponding author: rahimj@uthm.edu.my

different rates and complex positions which the grass will grow. In addition, a majority people still use older type of grass trimmer which is gasoline grass trimmer. Most of the existing grass trimmers suffer from high levels of engine noise. The excessive noise could potentially result in annoyance, hearing loss and fatigue of the operator and people in the surrounding area. The pressure waves escape from the engine exhaust of trimming machine with a high velocity producing an offensive exhaust noise [1].

However, any noise that is loud and lengthy too much can injure and lead to the natural transition of Noise-induced Hearing Loss (NIHL). Noise effects on hearing differ between individuals. Some urbanites ears, especially at certain frequencies, are more sensitive to loud sounds. Compared with adults, so does the issue for young children. Sound shall be measured in decibels (dB). Normal conversation is about 60 dB, loud rock concert about 120 dB and grass trimmer around 85-95 dB while in use. Sounds above 85 dB are usually dangerous, regardless of the time of exposure and maybe you are not providing protective equipment, such as earplugs. In general, the further the people exposed to a loud noise, the more it becomes harmful. Moreover, standing for two or three hours on that grass trimmer can do a great deal of harm.

There are many ways and quite simple to reduce the noise come from grass trimmer. One of it is to create a silencer or muffler and to have resource to some reasonably easy sheet metal working devices. Nonetheless, a properly designed exhaust silencer is helpful to reduce exhaust noise [2]. These days, the current pattern in grass trimmer design involves the reduction of costs, and easy for carrying [3]. Reducing the noise radiated on gasoline grass trimmer is now a matter of concern among developers. Therefore, the research project development of noise silencer for grass trimmer is launched with the aim to reduce the noise emitted by the engine of grass trimmer. This project was attempted to design and fabricate a silencer or muffler for grass trimmer. In this context, the muffler could be considered as an acoustic insulation device for reducing the noise level of engine-created sound pressure.

2. Materials and Methods

2.1 Materials

This research study utilized the original design specification for every end side of the grass trimmer. As for this project, a grass trimmer of Tanika BG328 model that complied with the scope of study was employed for further investigation as shown in Figure 1. The other fabricated part is hardened steel that covers the whole part of the silencer.

Figure 1: Grass trimmer of Tanika BG328 model

Selection of material is so important since it needs to prepare the future effects of such materials. Additionally, this will help the progression of engineering analysis over the long-term period and suggestion the best chance for the project to succeed. The material used for noise silencer for the grass

trimmer which is muffler in this project is mild steel sheet metal. In addition, muffler needs to maintain high heat and therefore has high corrosiveness. Thus, muffler material must have a high boiling point and a high resistance to corrosion.

Furthermore, mild steel sheet metal is also quite affordable to buy at the marketplace. The mild steel sheet metal can last up longer that requires less or no maintenance, repairs, or replacement because the material is durable and sustainable. Mild steel sheet can typically be joined with mechanical fixings or welded by methods including arc welding and others. It is also easy to clean the surface of the material by using alkaline water and a soft cloth.

2.2 Research design

Research design refers to an organized plan and scientific investigation into a specific problem, undertaken with the objective of finding solutions to it [4]. It is concerned with describing the shape of the blueprint for data collection, measurement, and analysis. The process of research design in this project involves five main phases.

The research project begins with the initiation phase, which focuses on defining problem and design solution. The second phase is design of a silencer, which comprises, sketching, part drawing, material selection, and design selection. The third phase is development of silencer through fabrication and assembly. Next phase is the testing and analysis of noise level measurement. The final phase is conclusion, which embraces the discussion and conclusion of findings. Figure 2 shows the process flow chart of the overall research design.

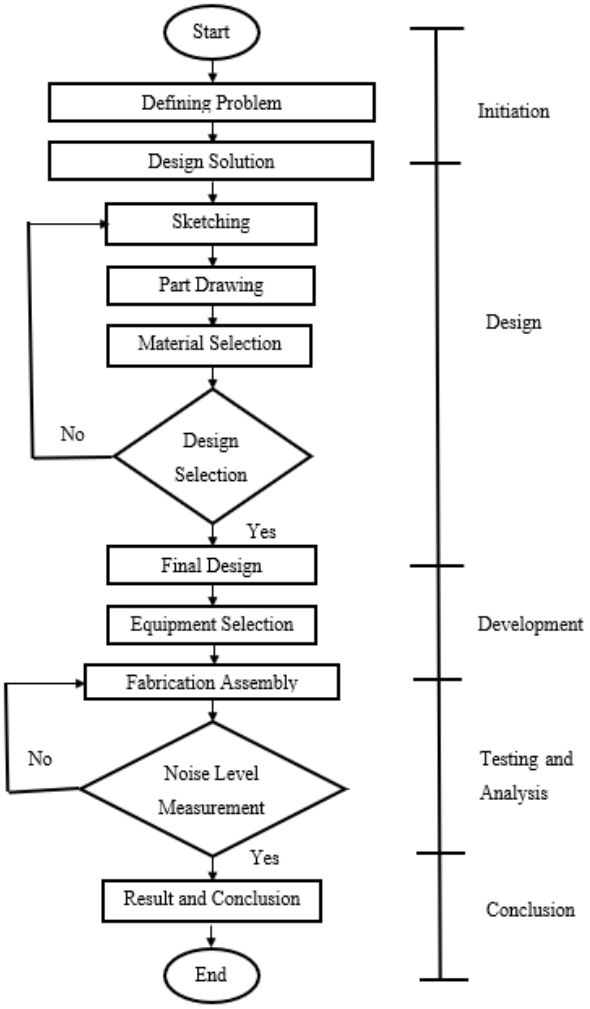

Figure 2: Research design process flow chart

2.2 Design selection

The selection of the best design of noise silencer for grass trimmer is based on their pros or advantages with comparison to their cons or disadvantages. As depicted in Table 1, the muffler in the first design concept is assemble at outside of the engine. It is because to avoid any interruption of the position each part of the engine when attach the muffler.

In addition, if the muffler builds inside, it will make the engine produce more heat that surround the machine. Therefore, the selected design concept of muffler was built outside the engine to produce lesser heat. In contrast, the disadvantages of the design concept were in terms of ergonomic aspects such as an operator of grass trimmer will struggle to avoid body contact with the muffler as well as hard to lift the machine to do the work of trimming grass.

Table 1: Pros and cons of noise silencer design

Design	Pros (Advantages)	Cons (Disadvantages)
Preliminary	• Easy to assemble after cleaning the muffler. • Modern features and more efficiency of noise reduction.	• Not ergonomic

2.3 Design of prototype model

In this study, brainstorming has been conducted to obtain idea and consensus on the noise silencer design. The design is further drawn in three dimensional (3D) modelling using SolidWorks software as shown in Figure 3.

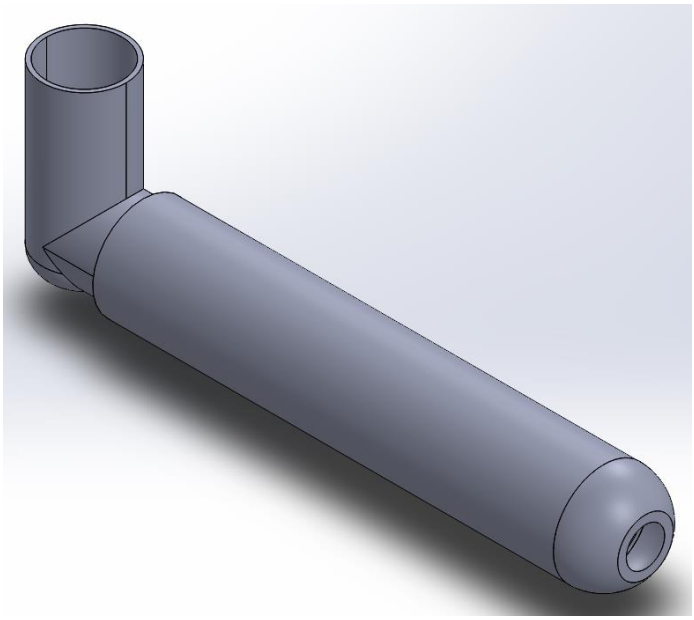

Figure 3: Design of the noise silencer

The selection of design concept that has been selected is transferred into the SolidWorks software by drawing back the sketching that has been made into specific dimensions as shown in Figure 4. The part drawing includes the inner pipe and L-shape pipe with the correct measure. In the design, the inner pipe part was mate in concentric, so it was fit to the hole of L-shape pipe. Then, the middle inner pipe with the correct measurement was assembled in concentric with the L-shape pipe.

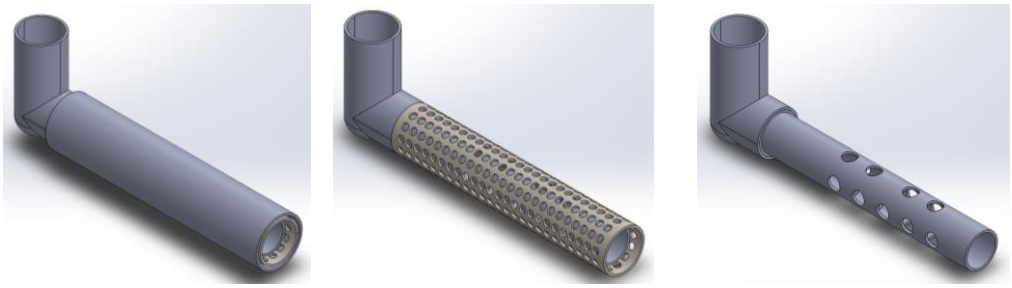

Figure 4: Section view of the noise silencer

2.4 Fabrication and assembly

In this research project, the prototype model of silencer has been developed by utilizing the tools, equipment, and machines for the purpose of fabrication and assembly operations. The equipment is selected based on the type of operations needed for fabrication and assembly of noise silencer, which inclusive of measuring equipment, cutting machine and welding machine. The final fabrication and assembly part of silencer is then installed at the outer part of grass trimmer for further testing and analysis.

2.5 Measurement of noise

The measurement of noise level for gas trimmer in this research project involved the selection of equipment, measurement and experimental set up, and determining noise exposure standard. The measuring of noise level and testing process of grass trimmer was conducted by using noise level metre. Figure 5 show that the MS6708 sound level meter used in this research. The equipment was set up to determine the value of noise level at certain distance and height for the silencer.

Figure 5: MS6708 sound level meter

The effectiveness of the prototype model of silencer was tested by attaching it to the exhaust pipe of a small utility engine used for grass-trimming machine of Tanika BG328 model. It was a two-stroke engine, and it drove the cutting head of the grass trimmer at speeds 1000 rpm and 6000 rpm, respectively. The noise measurement was conducted under two conditions: 1) grass trimmer without muffled exhaust, 2) grass trimmer with attached silencer to the exhaust. Meanwhile, the measurement of noise in the experiment is referred to the exposure level standard as recommended by National Institute for Occupational Safety and Health (NIOSH) as depicted in Table 2.

Table 2: Different time - weighted averages (TWAS) decibel levels maximum exposure [5]

Sound Intensity (dB)	Maximum Time (Hour / Minute)
85	8 Hours
88	4 Hours
91	2 Hours
94	1 Hour
97	30 Minutes
100	15 Minutes
103	7.5 Minutes
106	3.75 Minutes

3. Results and Discussion

3.1 Final design

A resonance type of muffler was selected as the final design of prototype model of noise silencer for grass trimmer in this study as illustrated in Figure 6. The selection of the design was based on the advantages of the muffler, which was successfully assembled at outside of the engine to reduce heat, and to avoid interruption of each parts of the engine of grass trimmer. Meanwhile, Figure 7 shows the positioning of noise silencer, which was attached at the outer side of the grass trimmer.

Figure 6: Final design of noise silencer

Figure 7: Positioning of silencer on grass trimmer

3.2 Measurement of noise without silencer

The results of noise measurement without the use of silencer at distance of 0 – 10 m between the operator and grass trimming machine with a condition of machine operation of 1000 and 6000 rpm are presented in the following parts of this chapter.

3.2.1 Measurement of noise without silencer at 1000 rpm

Table 3 shows the data collected from the measurement of noise at certain distance. In this testing, the silencer was not attached with the grass trimmer part. In this setting, grass trimmer machine was set to operate at 1000 rpm. Three value of measurement were taken for the testing of noise. Then, the average value of the measurement was computed to get the precise data of noise level in the measurement unit of decibel (dB) by using noise level meter (NLM).

Table 3: Noise level obtained without silencer at 1000 rpm

Distance between noise level meter and machine (m)	Value of noise level (dB)			Average value
	1	2	3	
0	89.0	88.6	89.5	89.0
2	84.2	83.4	83.8	83.8
4	79.0	79.2	79.4	79.2
6	74.4	73.3	73.3	73.7
8	69.6	69.8	69.2	69.5
10	62.6	61.9	61.2	61.9

Meanwhile, Figure 8 shows the graph of noise reduction versus distance without using silencer. The result by representation of curve of noise reduction (NR) indicates that noise decreases when the distance is increased within the average range of 89.0 – 61.9 dB.

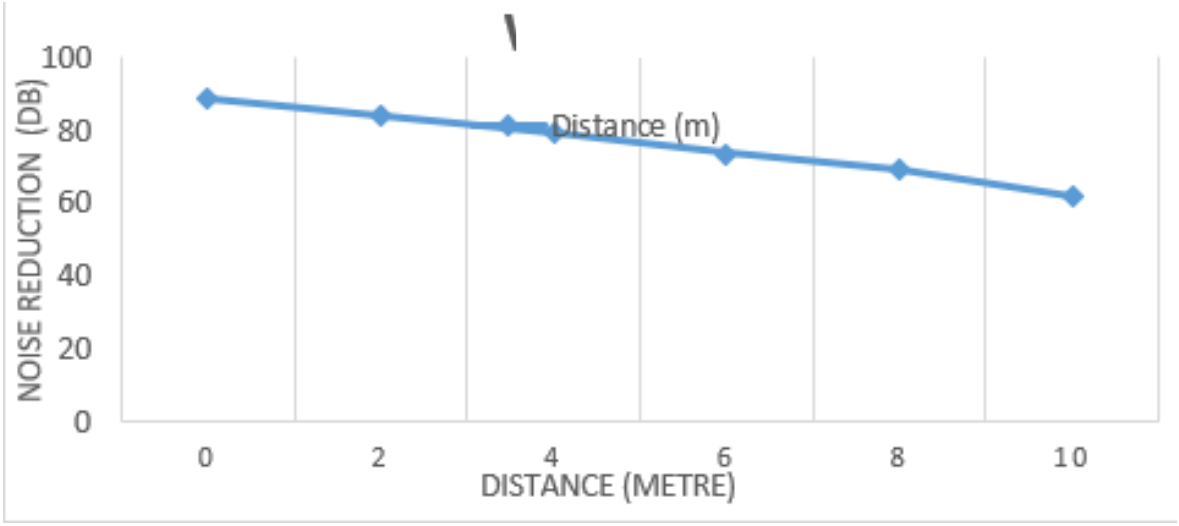

Figure 8: Noise reduction without silencer at 1000 rpm

3.2.2 Measurement of noise without silencer at 6000 rpm

Table 4 shows the data collected from the measurement of noise at certain distance. In this testing, the silencer was not attached with the grass trimmer part. In this setting, grass trimmer machine was set to operate at 6000 rpm. Three values of measurement were taken for the testing of noise. Then, the average value of the measurement was computed to get the precise data of noise level in the measurement unit of decibel (dB) by using noise level meter (NLM).

Table 4: Noise level obtained without silencer at 6000 rpm

Distance between noise level meter and machine (m)	Value of noise level (dB)			Average value
	1	2	3	
0	94.7	93.7	93.9	94.1
2	86.6	87.1	86.3	86.7
4	82.0	82.7	81.6	82.1
6	79.5	78.5	78.8	78.9
8	73.9	73.3	73.6	73.6
10	71.7	71.3	70.6	71.0

Meanwhile, Figure 9 shows the graph of noise reduction versus distance without using silencer. The result by representation of curve of noise reduction (NR) indicates that noise decreases when the distance is increased within the average range of 94.1 – 71.0 dB.

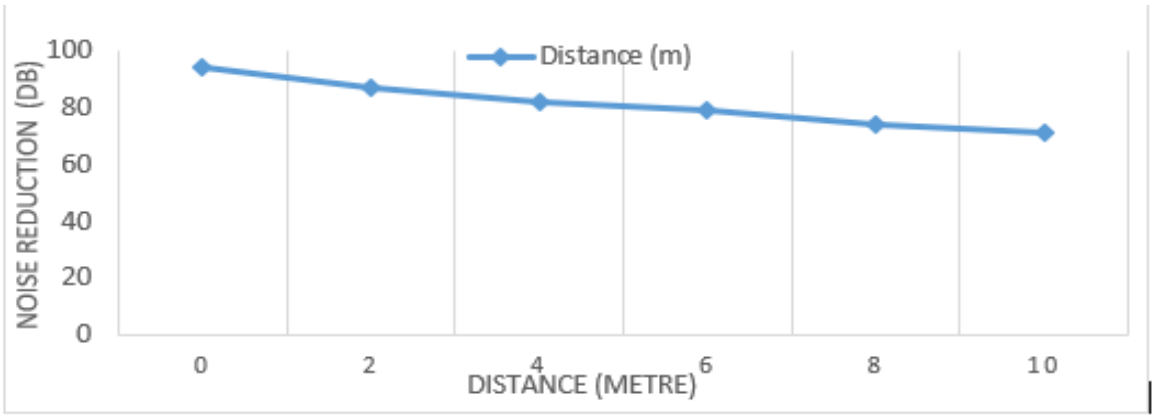

Figure 9: Noise reduction without silencer at 6000 rp

3.3 Measurement of noise with the use of silencer

The results of noise measurement with the use of silencer at distance of 0 – 10 m between the operator and grass trimming machine with a condition of machine operation of 1000 and 6000 rpm are presented in the following parts of this chapter.

3.3.1 Measurement of noise with the use of silencer at 1000 rpm

Table 5 shows the data collected from the measurement of noise at certain distance. In this testing, the silencer was attached with the grass trimmer part. In this setting, grass trimmer machine was set to operate at 1000 rpm. Three value of measurement were taken for the testing of noise. Then, the average value of the measurement was computed to get the precise data of noise level in the measurement unit of decibel (dB) by using noise level meter (NLM).

Table 5: Noise level obtained with silencer at 1000 rpm

Distance between noise level meter and machine (m)	Value of noise level (dB)			Average value
	1	2	3	
0	84.8	83.9	85.5	84.7
2	75.5	75.9	76.3	75.9
4	67.6	67.5	67.1	67.4
6	60.5	59.3	61.7	60.5
8	58.4	57.8	57.4	57.9
10	54.8	56.2	55.2	55.4

Meanwhile, Figure 10 shows the graph of noise reduction versus distance by using silencer. The result by representation of curve of noise reduction (NR) indicates that noise decreases when the distance is increased within the average range of 84.7 – 55.4 dB.

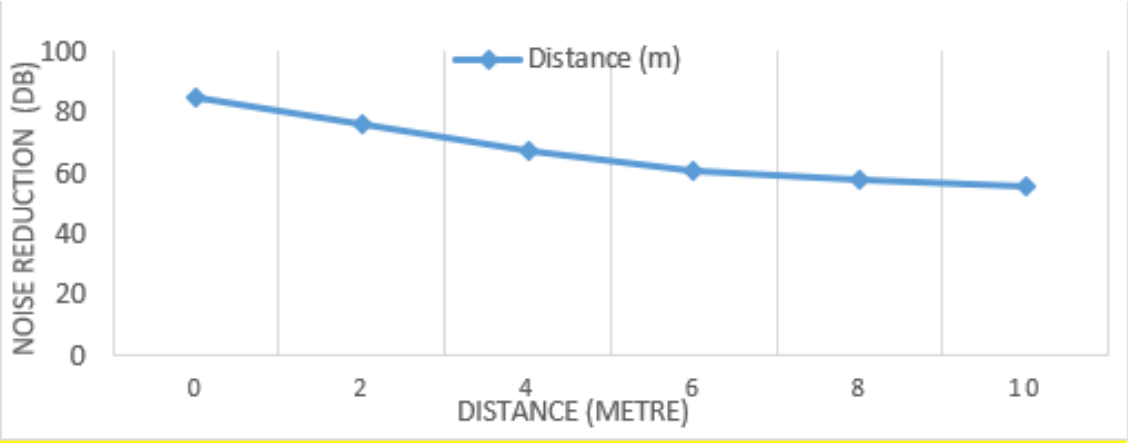

Figure 10: Noise reduction with silencer at 1000 rpm

3.3.2 Measurement of noise with the use of silencer at 6000 rpm

Table 6 shows the data collected from the measurement of noise at certain distance. In this testing, the silencer was attached with the grass trimmer part. In this setting, grass trimmer machine was set to operate at 6000 rpm. Three values of measurement were taken for the testing of noise. Then, the average value of the measurement was computed to get the precise data of noise level in the measurement unit of decibel (dB) by using noise level meter (NLM).

Table 6: Noise level obtained with silencer at 6000 rpm

Distance between noise level meter and machine (m)	Value of noise level (dB)			Average value
	1	2	3	
0	89.0	89.4	89.6	89.3
2	84.0	84.7	83.4	84.0
4	73.1	73.7	72.9	73.2
6	70.2	69.3	69.6	69.7
8	67.2	63.6	63.1	64.6
10	65.6	63.7	61.3	63.5

Meanwhile, Figure 11 shows the graph of noise reduction versus distance by using silencer. The result by representation of curve of noise reduction (NR) indicates that noise decreases when the distance is increased within the average range of 89.3 – 63.5 dB.

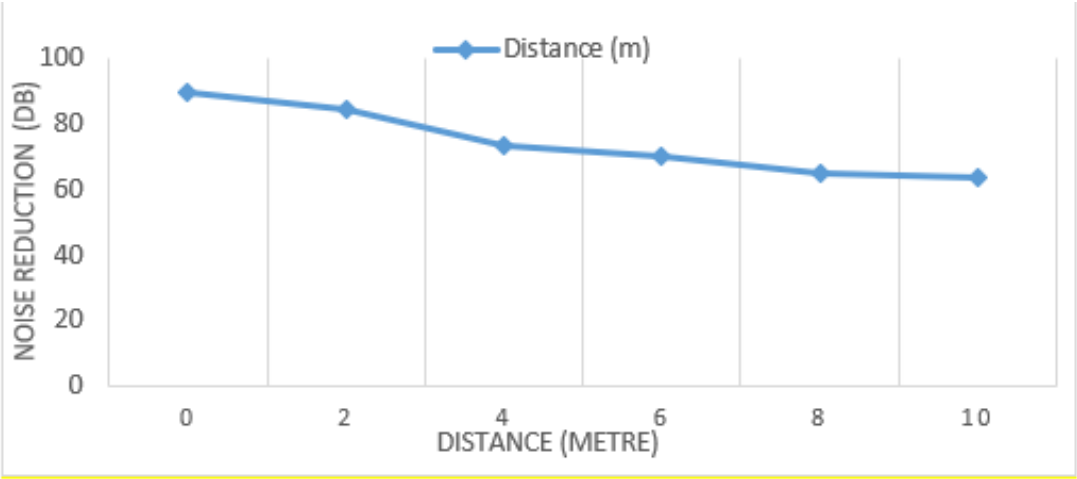

Figure 11: Noise reduction with silencer at 6000 rpm

3.4 Comparison of noise between the use and without use of silencer at 1000 rpm

Table 7 illustrates the result noise level measurement for grass trimmer with the engine running at 1000 rpm. The result revealed that the noise level decreased relatively with the increase of the distance between the engine and noise level meter for both use and without use of silencer.

Table 7: Average value of noise reduction between the use and without use of silencer at 1000 rpm

Distance between noise level meter and machine (m)	Average value of noise without silencer (dB)	Average value of noise with silencer (dB)
0	89.0	84.7
2	83.8	75.9
4	79.2	67.4
6	73.7	60.5
8	69.5	57.9
10	61.9	55.4

Meanwhile, Figure 12 shows the level of noise for the use of silencer reduces more significant from the risk noise level towards safety noise level than without the use of silencer at the operation condition of 1000 rpm.

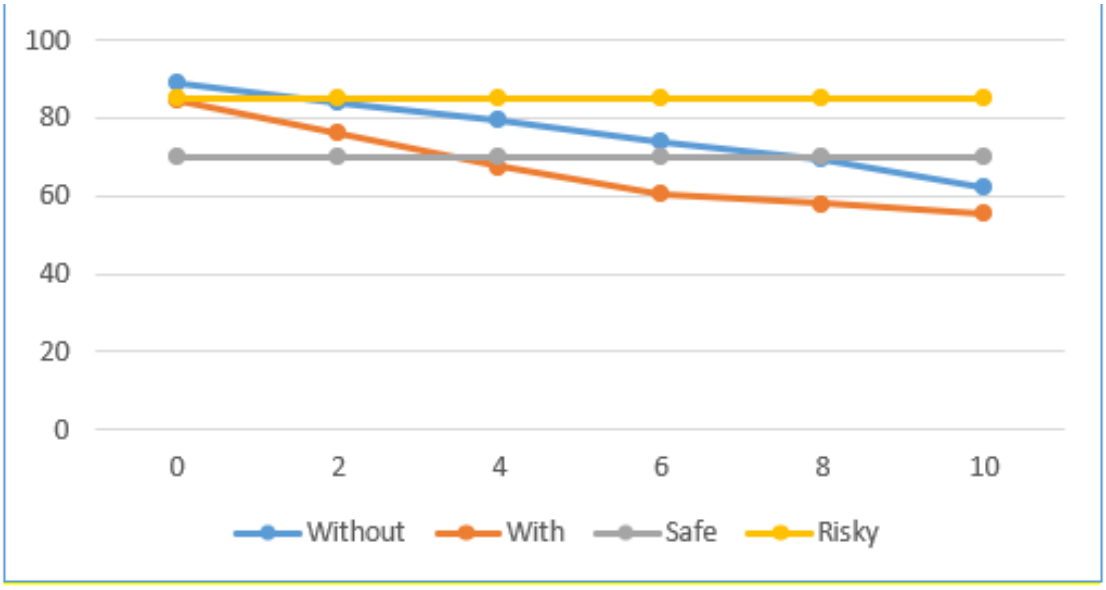

Figure 12: Noise reduction between the use and without use of silencer at 1000 rpm

3.4.1 Comparison of noise between the use and without use of silencer at 6000 rpm

Table 8 illustrates the result noise level measurement for grass trimmer with the engine running at 1000 rpm. The result revealed that the noise level decreased relatively with the increase of the distance between the engine and noise level meter for both use and without use of silencer.

Table 8: Average value of noise reduction between the use and without use of silencer at 6000 rpm

Distance between noise level meter and machine (m)	Average value of noise without silencer (dB)	Average value of noise with silencer (dB)
0	94.1	89.3
2	86.7	84.0
4	82.1	73.2
6	78.9	69.7
8	73.6	64.6
10	71.0	63.5

Meanwhile, Figure 13 shows the level of noise for the use of silencer reduces more significant from the risk noise level towards safety noise level than without the use of silencer at the operation condition of 6000 rpm.

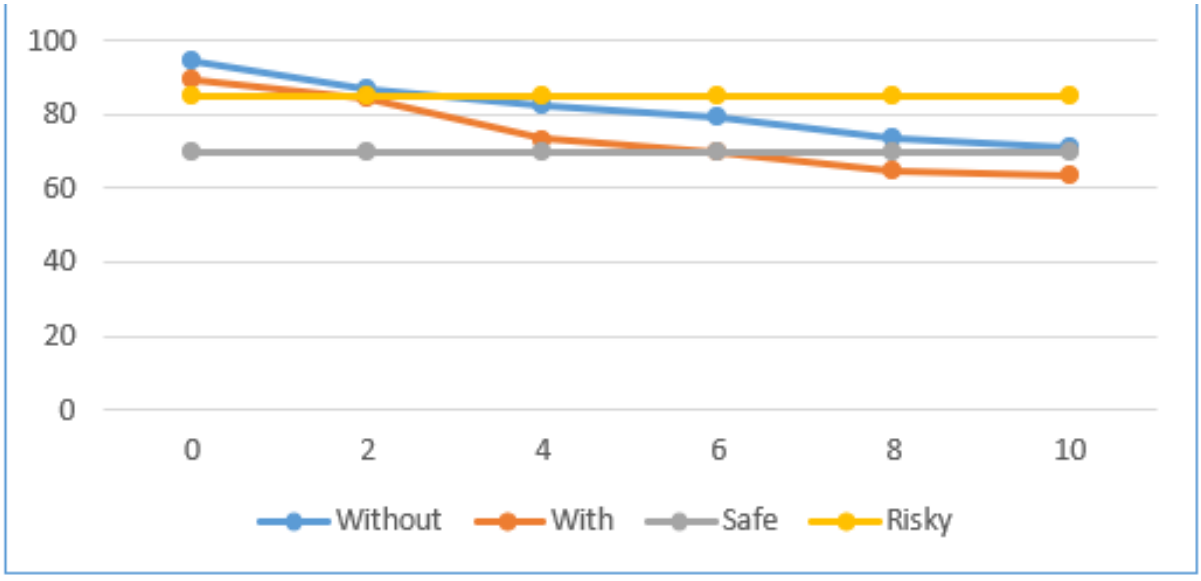

Figure 13: Noise reduction between the use and without use of silencer at 6000 rpm

4. Conclusion

In this study, the use of silencer by means of resonance type of muffler is introduced as solution to reduce the noise that exposed by grass trimmer. A computer software of SolidWorks is employed to successfully design the proposed prototype model of silencer for grass trimmer of Tanika BG328 in representing the applicable model of grass trimmer in the work environment. This research project has developed the prototype model by utilizing the tools, equipment, and machines for the purpose of fabrication and assembly operations including cutting machine and welding machine. The final fabrication and assembly part of silencer is then installed at the outer part of grass trimmer for further testing and analysis using noise level meter.

Based on the measurement of noise level and analysis results, the noise level of grass trimmer reduced significantly with a longer distance after applying the silencer. The noise reduction occurred at a distance in between 0 meter to 10 meters. In conclusion, the proposed prototype model is confirmed effective in reducing the harmful effect of noise produced by grass trimmer. The findings could be used as guide to explore the opportunity for improvement in reducing the noise related health effects such as hearing loss, and other safety risks. Nevertheless, several recommendations are highlighted for further development including redesigning the model to fit with the characteristics of the commonly used grass trimmer in work environment.

Acknowledgement

The authors gratefully acknowledge the Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia (UTHM) for its support.

References

[1] V. S. Prasad, "A Review on Muffler Design for Exhaust Noise Attenuation," *Int. J. Eng. Technol.*, vol. 9, no. 3S, pp. 428–431, 2017.

[2] B. Luka, "*How to Reduce Exhaust Noise*," 2020, [Online]. Available: https://soundproofadvice.com/how-to-reduce-exhaust-noise/.

[3] I. Zaman, M. R. Abdurasad, B. Manshoor, A. Khalid, and M. S. M. Sani, "Study on Dynamic Behaviour of Grass Trimmer Using Finite Element Analysis," *Appl. Mech. Mater.*, vol. 786, no. January 2017, pp. 383–387, 2015.

[4] U. Sekaran, "*Research Methods for Business: A Skill Building Approach*". 2nd Ed. USA: John Wiley & Sons, 2013.

[5] NIOSH (National Institute for Occupational Safety and Health), "*Criteria for a Recommended Standard*", 1998.