

Development and Performance Evaluation of Sound proof Enclosure for Portable Generators

R.O. Kuku, N.A. Raji and T. Bello

Mechanical Engineering Department, Lagos State University, Ojo

Abstract: In an attempt to reduce sound radiated from a portable generator, a sound proof enclosure has been developed to absorb effectively the generator noise. This sound proof enclosure is designed and fabricated with locally available materials from the opinion of an idea which aims at easing the pains and stress of receiving the noise radiating from a portable electric generating set. The walls of the enclosure is fabricated by combining panels of foam, composite sawdust and grinded glass and an outer plywood with air trapped in-between the composite and plywood. A reverberation room method is used to measure the noise absorption efficiency of the enclosure using a 950 watts/220 volts rated generator to ascertain the enclosure performance average at 76.40% noise absorption.

Keywords: Enclosure, panel, sound, sound pressure, sound proof

INTRODUCTION

Sound is caused by fluctuation in air pressured. The fluctuation starts from the source of the sound. It has been shown that excessive sound (noise) can have a lasting adverse effect upon health and lowers the efficiency at work. The use of generators as alternative source of electricity power supply is almost if not a norm, in the Nigerian society today and the growing concern is to avoid the noise from these generating set.

There is a considerable body of medical evidence that directly implicate ambient sound levels exceeding 60-70 dB as 'pollution' which leads to significant health problems including, but not limited to hypertension, depression and most commonly, loss of hearing Hong (2005) and Mikolajczyk and Cieslewicz (1982). There has been considerable research and development of sound dampening technology to reduce sound pollution. Many different technologies have evolved to address the problem.

Wöhle and Elmallawany (1975) deals with the calculation of the sound transmission for the case of several acoustic power sources placed in an arbitrary structure consisting of any number of rooms, separating panels and cavities, by using the Statistical Energy Analysis (SEA). Craik and Smith (2000) used same Statistical Energy Analysis (SEA) to model sound transmission through double leaf lightweight partitions. It was found that the best SEA model depends on the frequency range considered and the method of construction. At low frequencies the wall was modeled as a single subsystem while at higher frequencies it was modeled as a number of interconnected subsystems. The structural connection between the two panels could be

modeled either as a series of independent points or as a line connection, depending on the nail spacing. The sound transmission loss of a single metal panel obtained with the sound intensity technique and the conventional method have been compared with the theoretical model of Statistical Energy Analysis (SEA) in Minten *et al.* (1987). This method of comparison with a theoretical model is useful in order to explain small systematic variations between the results of both experimental methods. Good agreement was obtained between the results of both experimental methods as well as with the SEA model.

Lai and Burgess (1991) used the sound intensity method to determine the field transmission loss and offer the advantage of providing the transmission loss data for elements of walls, such as doors and windows. The sound intensity method shows good correlation with the conventional methods for laboratory test procedures.

Craik (2003) presented a model for computing coupling loss factor for prediction of sound transmission through lightweight double walls. A simple design method for a sound proof sheet with high transmission loss and high coincidence frequency was discussed in Chonan and Kugo (1989). In their study the exact solutions for the coincidence frequency and the sound transmission loss of two-layered infinite plates excited by a plane acoustic wave was discussed. Guy and Sauer (1984) discussed the effects of sills and reveals on the transmission of sounds through windows and panels. New data was presented and a sill and reveal design guide was proposed for the purpose of increasing the sound transmission loss of light panels.

The basic principle for noise control is to prevent the transmission of noise by the introduction of a mass barrier. Common materials have such as brick, concrete,

metal etc. The noise emanating from the generating set could be termed as airborne. The airborne noise insulation is against the noise transmitted by the air from the generating set.

The priority of noise control is to reduce the noise at source by engineering means once the main noise source has been verified. Yang and Kim (2003) studied the acoustic properties of rice straw-wood particle composite boards and found that the sound absorption coefficient in the frequency range of 500 to 8000 Hz is higher than other wood based materials which are due to the low specific gravity of the composite boards. It was studied that the acoustic properties of materials could be improved by perforating the panel made of such materials. Davern (1977) studied the effect of the perforated plate, airspace layers and porosity on the acoustic properties of materials and found that the porosity of the perforated plate and the density of the porous material would significantly affect the acoustic impedance and sound absorption coefficient of the panel in which case the frequency and near resonance frequency achieved high acoustic absorption.

Previous studies show that achieving sound reduction is mainly by placing a noise absorbent close to noise source and also in the case of an enclosure to ensure tightness. Also discontinuous construction of multiple panels will reduce sound or noise. This study tends to develop noise absorbing panels built of different acoustic materials with perforated effect which are assembled as encasement for portable gasoline generators mostly used in homes towards reducing the noise emanating from such generating set.

Different types of enclosure have been design for various uses which include sound proofs application. These include:

- **Acoustic enclosures:** These are full chambers, enclosures, or rooms designed to attenuate or minimize acoustical noise.
- **Acoustic foam and acoustic ceiling tile:** These materials absorb sound to minimize echo and reverberation within a room. Electronic enclosures and instrument enclosures house electronic components and instruments. They are usually designed for handheld or desktop applications.
- **Industrial enclosures:** Are used to house electronic components, equipment and devices. They are designed to protect personnel from accidental injury and to prevent the ingress of environmental contaminants.
- **NEMA and IP enclosures:** Are used to house and protect electrical devices and electronic components. NEMA enclosures are rated by the National Electrical Manufacturers Association (NEMA) and designed for hazardous or non-hazardous locations

- **Modular enclosures:** Consist of smaller components that can be assembled to create custom enclosures, often for temporary or mobile systems.
- **Rack enclosures:** (Rack cabinets, laboratory enclosures) are used to house standard in. Rack-mounted components or other standard-sized devices
- **PC enclosures:** are designed to protect Personal Computers (PCs) in industrial or office environments. They are designed to prevent the ingress of environmental contaminants such as dust and water and can be used to integrate a monitor,

This study tends to apply local available material to fabricate an enclosure for purpose of absorbing the noise emanating from a gasoline generating set mostly used in homes as alternative source of electricity supply in Nigeria.

MATERIALS AND METHODS

Figure 1 show the picture of the enclosure. The design is the attempt of the on-going research work on reducing sound pollution from generating set which is been carried out in the Mechanical Engineering department of Lagos State University, Nigeria. The passive absorption principle is applied for the fabrication of the panels which are assembled to build the enclosure. The panels are fabricated from foam, particleboard and combination of sawdust and grinded glass mould. The panels are arranged as shown in Fig. 2 to form a single rigid wall with the plywood placed as the outer panel. Six of the walls were fabricated and assembled to form the enclosure making one of the six into a door and another into the floor in the form of a slider in order to facilitate the easier placement of the generator inside the enclosure. The mould of sawdust and grinded glass is used to imitate the concept of fiberglass which has high noise absorption capacity. The inside of the enclosure is padded with perforated foam. A flexible pipe is attached to the enclosure for the generator exhaust pipe.



Fig. 1: The sound proof enclosure

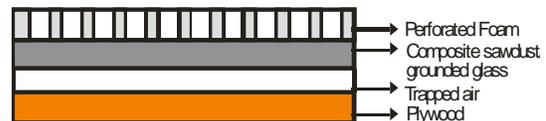


Fig. 2: The multilayer panel



Fig. 3: Sound-pressure meter

The outside dimension of the enclosure is 500×500×650 mm. The thickness of each of the panel could range between 10 to 50 mm. The thickness of both the perforated foam and the plywood used in the present design is 15 mm while the composite sawdust and grounded glass is made 50 mm thick.

RESULTS AND DISCUSSION

A reverberation room method is used to measure the noise absorption efficiency of the enclosure. A 950 watts portable generator is operated in a room. The sound pressure level of the sound emanating from the generator is measured with the sound meter shown in Fig. 3 at various radial distances from the generator. A second test is performed with the enclosure placed in the room and the 950 watts portable generator operated within it. The results are as shown in Table 1. In the tests, the generator is operated at 220 voltage output to power total wattage of 650 watts.

The sound intensity measurement technique could be employed to determine the transmission loss of the sound proof enclosure as discussed for panels in De Mey and Guy (1987). An experimental procedure could be established, the technique validated and subsequently exploited to determine transmitted intensity contours for two sizes of panel, as well as to examine the influence of a deliberately introduced construction fault.

As can be seen in Fig. 4, soundproofing increases drastically at the different distances with the highest percentage reduction of the radiating sound obtained at 4 ft after which the sound pressure stabilized at -15 dB. The enclosure shows a deep at 0.6 m which is the critical frequency level of the sound. The behavior indicates that increasing the mass of the panels could aid the soundproofing efficiency. However it is suggested that multilayer panels be used with a mixture of different materials so as to obtain soundproofing improvements greater than those achieved by improving the wall mass.

Table 1: Sound pressure level variance with distances

Distance (m)	Sound pressure without enclosure (dB)	Sound pressure with enclosure (dB)	% reduction in radiating sound
0.3	+3.0	-6.8	42.61
0.6	+2.6	-14.2	74.34
1.0	+2.2	-14.0	73.00
1.2	+1.8	-15.0	77.06
1.6	+1.4	-15.0	76.64
1.8	+1.0	-15.0	76.19
2.0	+0.6	-15.0	75.73

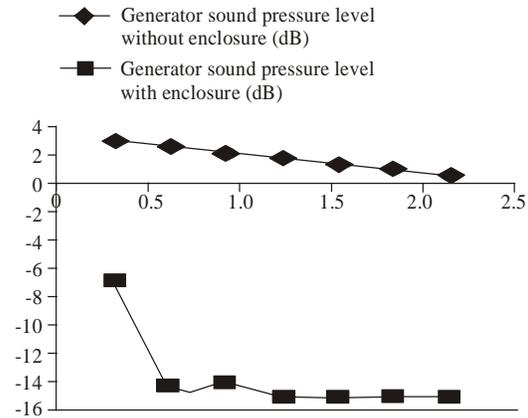


Fig. 4: Sound proof capability of the enclosure

CONCLUSION

This project reports a system for reducing sound radiated from a portable generator mostly used in homes using noise absorber panels. The panels were fabricated from plywood, combination of sawdust with grinded glass and perforated foam aligned to form the sides of an enclosure in which the generator could be placed while operating. The performance of the enclosure is evaluated by the reverberation room method. The enclosure is found to drastically reduce the radiating noise from the generator by an average of 76.40%. The combined material of absorber and thick foam thus satisfies the concept of the design.

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