RESEARCH ARTICLE OPEN ACCESS

Design And Analysis of A Petrol Generator Enclosure

[1]Musa, N*, [2]Abdulkarim, M.S., [3]Aliu, S.O.
Applied Science Department, College of Science and Technology, Kaduna Polytechnic, Kaduna, Nigeria.
Corresponding Author: Musa N

ABSTRACT
Because of the attendant noise associated with petrol generators coupled with their inevitable importance in our daily lives, a sound suppression enclosure was designed and analysed. Heat, which is a constituent part of generator operation was taken care of in the design by placing appropriate ventilation systems. A sound level meter was used to take measurements of the sound pressure level of the generator inside the enclosure and in open space. The generator was placed in an open space with no reflectors or barriers to achieve a perfect result. A difference of about 10 dB was achieved in the suppression of sound between the two places.

Keywords: decibel, enclosure, noise pollution, petrol generator, Sound suppression

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Date of Submission: 16-12-2017 Date of acceptance: 28-12-2017

I. INTRODUCTION

Portable engine driven generators are used as main electric power supplying in shops, greenhouses, offices and homes in cities, especially when there is a break in power supply. They are also used for electricity supply of buildings in some rural areas with electric outage problems. However, their noise is loud and can cause inconvenience to nearby people. Exposure to high noise levels can also cause temporary or permanent hearing loss, mental and nervous discomforts, loss of working efficiency and increased the risk of hazards [1].

The Power Holding Company of Nigeria (PHCN) which is solely responsible for generation and supply of electricity have not fared too well in the discharge of its mandate. With an installed generating capacity of only 6,000MW (against the 30,000MW estimated national peak demand), the PHCN could only provide a maximum of 3,000MW with 30 – 35% losses during transmission [2]. It follows therefore that less than 10% of the national electricity demand only, could be met through the national grid. This mounts pressure on individuals, institutions, corporate bodies and businesses in the country; for private provision of electricity, with fossil fuel generators being the option most frequently adopted [3],[4]. The reason for this option has been attributed to the relatively low initial capital cost, convenience and availability of the fuel to power the generators [5].

According to [6], increasing noise pollution in the world as affected human being, animals, plants and even inert objects like buildings and bridges. Noise has become a very significant stress factor in the environment, to the level that the term noise pollution has been used to signify the hazard of sound which consequences in the modern day development is immeasurable.

According to [7], Noise pollution is one of the major problem people facing in urban areas all over the world. As a result of increase in the number of cars and industrialization, noise pollution has also increased. Most of noises in urban areas are increasing every day as a result of more people moving to urban from rural settlements. Noise in cities, especially along main arteries, has reached up to disturbing levels. Residences far from noise sources and near silent secondary roads are currently very popular. People prefer to live in places far from noisy urban areas. According to [8] Noise disrupts the tranquility of the environment and can affect climate and human health negatively.

The design of an enclosure could be evaluated from acoustic and thermal point of views [9]. The transmission paths from the source to the receiver should be determined and ordered in relative importance in order to design an acoustic enclosure for a noise source. The enclosure wall is one of the most important transmission paths. It may also have permanent openings for ventilation, inspection, passing materials and could include a door in order to access to noise source. The enclosure door must close against rubber seals (being airtight).

Statistical Energy Analysis (SEA) was used by [10] in modeling the sound transmitted through lightweight double leaf partition. It was observed that the frequency range was the best at SEA modeling. For low frequencies, the wall was modeled as a single subsystem while at higher frequencies, it took the form of several interconnected systems. These systems could be formed either as a series of independent points or as a line connection depending on the nail spacers.

1.1 Mathematical equations

Sound intensity, denoted **I**, is defined by

I = p**v** (1)

where

- p is the sound pressure;
- **v** is the particle velocity.

Both **I** and **v** are vectors, which. The direction of sound intensity is the average direction in which energy is flowing.

The average sound intensity during time T is given by

$$\langle \mathbf{I} \rangle = \frac{1}{T}\int_0^T \mathbf{p}(\mathbf{t})\mathbf{v}(\mathbf{t})\mathbf{dt} \quad (2)$$

Intensity of Sound = $2\pi^2 n^2 A^2 \rho v$

Where, n is frequency of sound, A is the Amplitude of sound wave, v is velocity of sound, and ρ is density of medium in which sound is traveling

- Inverse square law

For a spherical sound wave, the intensity in the radial direction as a function of distance r from the centre of the sphere is given by

$$I(r) = \frac{P}{A(r)} = \frac{P}{4\pi r^2} \quad (3)$$

Where

- P is the sound power;
- A(r) is the area of a sphere of radius r.

Thus sound intensity decreases as $1/r^2$ from the centre of the sphere:

$$I(r) \propto \frac{1}{r^2} \quad (4)$$

This relationship is an inverse-square law.

- Sound intensity level

The most common approach to sound intensity measurement is to use the decibel scale:

$$I(dB) = 10\log_{10}\left[\frac{I}{I_0}\right] \text{ Intensity in decibels} \quad (5)$$

Decibels measure the ratio of a given intensity I to the threshold of hearing intensity, so that this threshold takes the value 0 decibels (0 dB). To assess sound loudness, as distinct from an objective intensity measurement, the sensitivity of the ear must be factored in [11].

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

1.2 Enclosures

- **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 (2)
- **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 [12].

II. MATERIALS AND METHODS

2.1 The sound measuring device

The device is a sound level (decibel) meter used for measuring sound level. It is designed according to the IEC651, ANS S1.4 Standard for sound level meters. It has the following specifications:

Model: TES-13050A.

It has 1/2 inch electric condenser microphone.

Measuring range: Lo- 35 to100dB. Hi- 65 to 135dB.

Accuracy: 1.5dB, Resolution; 0.1dB

Power supply: one DC 9V battery

2.2 The Test Generator

The model of the test generator set is TG 2700. it has the following average dimension:

20.5inch x 21inch x 17inch with a power rating of 2.5 kVA

2.3The Enclosure

The enclosure (box) was constructed as a wooden structure with partition or space on all four sides to accommodate the sound absorber. The partition is 1.5 inch (3.7cm) wide which is approximately the thickness of the test material.

The dimensions of the enclosure are;

Outer: Length; 0.72m, breadth; 0.56m and height; 0.56m.

Inner; Length; 0.585m, breadth; 0.72m and height; 0.58m.

Air vent was created and fans installed for proper ventilation the enclosure. A model of the generator enclosure is shown in Fig. 1.

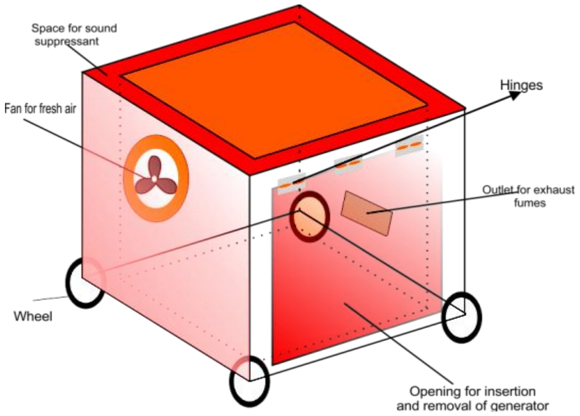

Figure 1: Model of enclosure for petrol generator

Measurements were carried out in a10 m × 10 m open field. The generator set was placed in the center of the field and the four sides were labeled A, B, C and D respectively as shown in Fig 2.Ten measurement points were marked at 1.0m intervals away from each side of the generator set. The generator was started in the open space and sound levels were measured at each marked measurement point.

The generator set was placed inside the enclosure with and measurements were also taken at each measurement point while the generator was in operation.

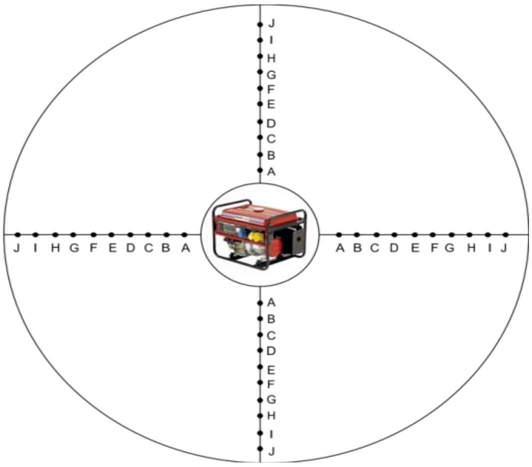

Figure 2: Field measurements with generator in the open

2.4Test Area

The test area used for this work was the parking lot of Applied Science Department, Kaduna Polytechnic, Kaduna, Nigeria. The test was carried out on a quiet Sunday free from the hustle and bustle of everyday life and far from buildings and obstacles.

The sound measuring device was placed on a stand 1.5 meters from the ground to avoid secondary noise interference from the ground and other reflecting surfaces. It was placed along the line and on the points shown in Fig. 2.

III. RESULT AND DISCUSSION

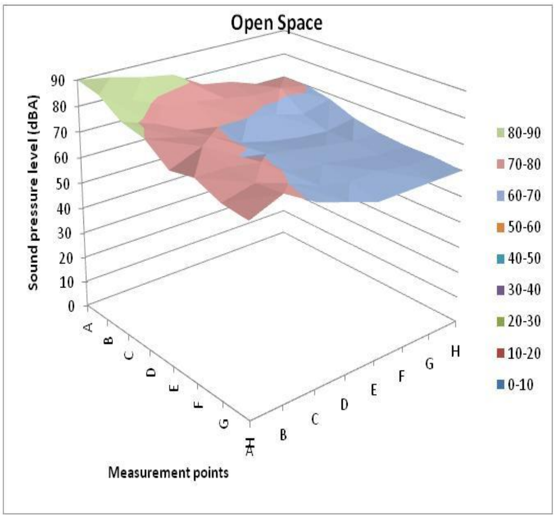

Figure 3: Sound measurement of generator in open space

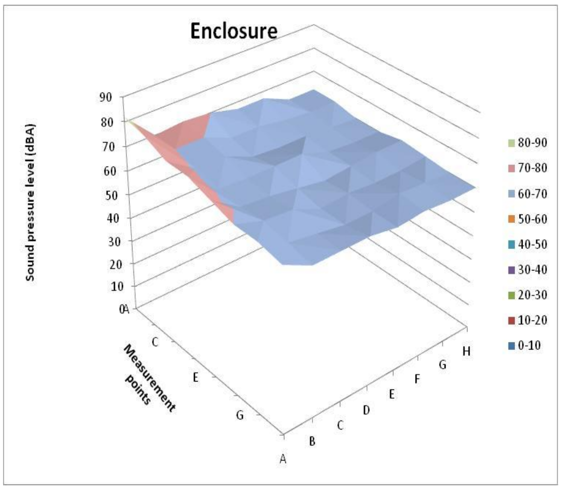

Figure 4: Measurement of sound of generator in an enclosure

Figs. 2 and 3 show the surface plot of the noise generated from the generator when placed without and with the enclosure respectively. It can be clearly seen that the there is a significant reduction in the sound produced from the generator. A reduction of about 10 dBA at the maximum was achieved.

IV. CONCLUSION

In this work, an effective means of mitigating noise from a generator explored. A noise dampening enclosure was fabricated with appropriate ventilation to reduce the noise that emanates from a petrol generator. The difference in noise level between the open space and the enclosure was found to be 10dB at the point very near the generator. This reduction is very significant in the long run.

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Musa, N "Design And Analysis of A Petrol Generator Enclosure." International Journal of Engineering Research and Applications (IJERA) , vol. 7, no. 12, 2017, pp. 87-90.