EVALUATION OF INDUSTRIAL NOISE: A CASE STUDY OF TWO NIGERIAN INDUSTRIES

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ABSTRACT

This study is aimed at quantifying noise pollution from industrial noise (machine and human generated) at two selected processing and manufacturing industries namely: Denki Wire and Cable Nigeria Limited and Wanwood Nigeria Limited, both in Akure, Ondo State, Nigeria. The machines used for processing and production in these two industries were considered for the research study as well as their operators and workers. Emphasis was given to noise emitted by the individual industrial machines. The average noise equivalent level (LA_{eq}) was studied to identify the noisy machines and to generate baseline data. A precision grade sound level meter was used to determine the various pressure levels of sound at thirty minutes interval for five days. It was observed that noise limit values were exceeded at almost all machines based on the regulation criteria and international standard. Also, the results of this study shows that noise control measures were not put in place or where provided they were not adequate in the industries surveyed.

Keywords: Industrial noise pollution, industrial machines, workers, noise control measures.

INTRODUCTION

Most machinery and manufacturing processes generate noise as an unwanted by-product of their output. Typical examples of noise and vibration sources in the industrial environs include; combustion processes associated with furnaces, impact noise associated with punch processes, motors, generators and other electro-mechanical devices, unbalanced rotating shafts, gears, steam or gas flows in piping systems, pumps, compressors, washing machines, vibrating panel etc.

The mechanism of noise generation depends on the particular noise operations and equipment including crushing, riveting, punch presses, drilling, pneumatic equipment, tumbling barrels, dividing and metal cutting such as punching, pressing, lathes, milling machines and grinders as well as pumps, in-plant conveying systems etc. Equipment induced vibration is widely recognized as a health hazard. It is a physical stressor to which many people are exposed to at work place.

High levels of industrial noise remain a problem all over the world. In the USA, more than 30 million workers are exposed to noise hazards (NIOSH, 1998). In Germany, 4-5 million people (12%-15 % of the workforce) are exposed to noise levels defined as hazardous by World Health Organization (WHO, 1991). The effects of sound pressure level generated depend on the type of the noise source, distance from the source to the receiver and the nature of working environment. For a given machine, the sound pressure level depends on the part of total mechanical or electrical energy that is transformed into acoustical energy. Although noise is associated with almost every work activity, some activities are associated with particularly high levels of noise, the most important of which are working with impact process, handling certain types of materials and flying commercial jets. Occupations at

ISSN 2056-5860

highest risk for noise induced hearing loss (NIHL) include those in manufacturing, construction, transportation, mining, agriculture, and military. (Von Gierke, et al, 1982).
High level noise not only hinders communication between workers, but depending on the level, quality and exposure duration of noise, it may also result in different type of physical, physiological and psychological effects on the workers. The acceptable noise exposure standard in the workplace is 85 dB(A) averaged over an eight-hour period. This is not to imply that below 85 dB(A) a safe condition exist. It simply means that an eight-hour exposure of 85 dB(A) is considered to represent an acceptable level of risk to hearing health in the workplace.

Data for developing countries are scarce, but available evidence suggests that average noise levels are well above the industrial level recommend in many developed nations (Suter, 2000). Many researchers have delved into industrial noise and assessed the adverse health effects it has on industrial workers (Goerlzer et al, 2001; Van Kenpen et al, 2002; Hernandez-Gaytan et al, 2000; Palmer et al, 2001; Osibogun et al, 2000; Hessel, 2000; Georgiescu, 2000; Davis, 1989; Shaikh, 1996). A number of studies have been carried out to evaluate industrial noise in processing, mining, oil and gas, construction and manufacturing industries and the results show that high percentage of industrial workers were exposed to more than 85dB(A) noise levels (Ydego, 1991; Boateng and Amedofu, 2004). In spite of these studies, high noise levels have been taken for granted in industries in developing countries especially Nigeria Ydego (1974) investigated the industrial noise exposure of workers in a Textile industry in Tanzania. The results of the investigation indicate gross industrial exposure to noise where more than 30 % of the workers are exposed to noise levels exceeding 90 dB(A).

Kisku and Bhargava (2006) looked into the major sources of noise producing machines of a thermal plant and showed that lowest average noise (70.37 dB(A)) was found at control room while the highest average noise (95.91 dB(A) was at F.D fan. Compressors generate the second highest noise of (89.98 dB(A)). Saadu (1985) assessed the industrial noise of newspaper printing press, steel rolling mill, soft drink bottling, match making, mattress making, beer brewing and bottling industries in Ilorin metropolis. The lowest and highest average noise recorded were 82 dB(A) at mattress making industry and 98 dB(A) at beer brewing and bottling industry respectively.

For Industrial noise, the best characterized health outcome is hearing impairment. The first effects of exposure to excess noise are typically an increase in the threshold of hearing (threshold shift) as assessed by audiometry. Audiometry defined as a change in hearing threshold of average 10dB or more at 2000,3000 and 4000Hz in either ear (poorer hearing) (NIOSH,1998).

Industrial employees are exposed to noises from a variety of sources, such as: traffic noise from busy roadways, stationary vehicles and street noise, Compressors and pneumatic tools in garages, workshops and maintenance areas, handheld power tools, heavy machinery and other equipment, ventilation systems operating at substandard levels, human sources such as children and co-workers. (Ahmed et al, 2000).

In view of the negative effect of noise on industrial workers, there is need to evaluate industrial noise by using Denki Wire & Cable Limited and Wanwood Nigeria Limited both in Akure, Ondo State, Nigeria as a case study.

RESEARCH METHODOLOGY

Field work

Study area: - The study reported here was carried out at two manufacturing and processing industries (Denki wire & cable and Wanwood industries, both in Akure, Ondo State of Nigeria). Estimates of noise levels were determined in all machines of the industries using a simple digital sound level meter.

Noise measurement: - The digital sound level meter was the principal instrument used to measure the noise of the machines. The instrument was held in hand and pointed towards the direction of the source of noise from a distance not less than 1m. The measured values were then used to compute various noise descriptions such as equivalent sound level, the daytime average noise level, the noise pollution level using the following noise equations.

(i) Equivalent continuous sound pressure level, ($LA_{eq)}$. This sums up the total energy over some time period (T) and gives a level equivalent to the average sound energy over that period. Such average levels are usually based on integration of A-weighted levels. Thus $LA_{eq,}$T, is the average energy equivalent of the A-weighted sound over a period T.

$$LAeq,T = 10\log_{10}\left\{\frac{1}{T}\sum_0^T\left[\frac{P_\alpha(t)}{P_O}\right]^2 dt\right\}$$

(1)

(ii) Daily personal noise exposure of a worker ($L_{EP,d}$) is expressed in dB(A) using this formula:

$$L_{EP},d = LA_{eq},T + 10\log_{10}\frac{T}{T_O} \qquad (2)$$

where

T = daily duration of a worker's exposure to noise (hours)

T_o = 8 hours (8 hr/day allowable exposure duration, adopted by ISO 1999 Standard)

$P_o = 20P_a$µ (minimum sound frequency of a normal ear of a healthy young person)

$P_{\alpha =}\ A$ −weighted instantaneous sound pressure in pascals

(iii) The noise pollution level

$$L_{NP} = LAeq + (L_{10} - L_{90})$$

(3)

where;

L_{NP} = noise pollution level

L_{10} = sound level exceeded in 10% of the time

L_{90} = sound level exceeded in 90% of the time

(iv) The maximum time of exposure is given as;

$$t = \frac{480}{2^{(L-\gamma)}/\mu} \qquad (4)$$

where;

t = maximum exposure duration (seconds)

L = exposure level dB(A)

µ = exchange rate

γ = Recommended exposure limit (REL)

Data collection

Data collections through the use of one hundred and twenty (120) structured questionnaires were administered out of which one hundred and two (102) were received. Interview/discussion was done with the employees in the industries. The questionnaire comprises of personal information of employee, noise exposure records and site information (history of machines).

Instrumentation and noise survey

The experimental apparatus employed in the recording of noise levels consist of a precision grade sound level meter $^1/_2$ inch condenser microphone and with frequency range and measuring level range of 31.5Hz to 8KHz and 35 to 130 dB(A) respectively. The desired response of the Sound Level Meter (SLM) was set to A-weighting. When measurements were made, the microphone was located in such a way as not to be in acoustic shadow of any obstacle in appreciable field of reflected waves. (Harris, C.M 1991); (U.S.A Dept. of labour 1974).

The Federal Medical Centre, Owo, was approached for the health record of hearing impaired patients. It was discovered that between 4.8 to 12.2 % of the patients who reported hearing difficulties were diagnosed to have noise induced hearing loss. Ondo State Environmental Protection Agency was visited to know the stand of state government and responses to noise related problems. It was discovered that there is strong regulation for the control of noise but the enforcement is at low ebb.

Procedure for noise measurement

Proper care was taken against reflected sound waves from the operators' body when using the sound level meter. The noise level was recorded at a regular interval of thirty (30) minutes for fifteen times for five days which gives a total of seven hundred and sixty five (765) readings in all the machines. The noise level meter was pointed to the direction of the major source of noise in each location and being very sensitive it gives the accurate readings which were recorded from the meter screen (Liquid Crystal Display, LCD).

A total number of Twelve (12) industrial machines were assessed for noise emissions, Six (6) at Denki Wire & Cable and Six (6) at Wanwood industries. The noise exposure patterns of these machines are as tabulated in Table 1.

Subjects

The participants in this study were workers in the two industries. Workers aged between 20-50 years who had spent between six months to ten years were interviewed. A structured bio-data, daily noise exposure level and machine information questionnaire to elicit information from the selected workers was used. Administering of the questionnaire was done by passive interview of the employers in the two industries.

RESULTS AND DISCUSSION

Twelve industrial machines were assessed for noise emission. The hourly sound pressure levels recorded during survey work for the different machines in the two industries are presented in Figures 1 – 12. The range of the noise level (LA_{eq}) for the two industries is 82.84 to 117.50 dB (A). The daily noise exposure of workers in the industries surveyed exceed the maximum exposure limits of 85 dB(A) recommended by FEPA and OSHA. As at the time of this measurement, the highest and lowest average equivalent continuous noise levels were 117.50 dB(A) and 82.84 dB(A) of Circular saw machine and Coiling machine respectively.

All these machines emitted time varying/impassive noise exposure pattern. At Denki Wire & Cable industries, the highest noise producing machine was Generator 95.39 dB(A), followed by Wire Drawing machine 92.85 dB(A), Rewinding machine 90.25 dB(A), Cabling machine 85.81 dB(A), Extruder machine 85.72 dB(A) and Coiling machine 82.84 dB(A) in that order. At Wanwood Nig. Ltd, the highest noise producing machine was Circular saw machine 117.50 dB(A), Power chain saw 114.06 dB(A), Band saw 100.72 dB(A), Generator 99.81 dB (A), Planning machine 93.40 dB(A) and Tractor 89.39 dB(A) also in that order.

The possibility of developing a chronic health hazard problem is very high for workers working in these environments and other areas where noise levels are greater than 85 dB(A), This is because after the workers are exposed to high noise levels, they come out from the noise source after their duty hours to an environment of lower noise level; hence, physiological change and psychological stress occurred in their system. The result of this survey shows that (83.33%) of the machines in the two industries produced noise above 85 dB(A) based on Occupational Safety and Health Administration, OSHA / WHO / ISO / FEPA criteria.

Noise level is never constant; it changes with the number, type, speed and conditions of use of the equipment which produce the noise as well as the operating skill of the machine operator.

Noise levels for the woodworking machineries

Some of the factors affecting noise when using woodworking machineries include:

- Species: (Wood Machinability/Hardness/Thickness) Hard, stiff timbers mean more noise and more noise transmission. The tougher the wood, the higher the noise produced. Thinner work pieces generally vibrate more if the work piece is not securely clamped
- Machine setting (Timber control): The freer the timber, the greater the vibration and the noise level.
- Moisture content: Dry timber is brittle and good transmitter of noise.
- Tooling sharpness: Cutter sharpness is important as dull knives and worn blades and bands exert more force on the timber and so make more noise.
- Tooling speed: Noise increases with tool speed. High speed can cause too much heat lessening the life of the tool, while low speed will cause overfeeding thereby increasing the machine noise. Cutting speed needs to be reduced when cutting dry woods.
- Tooling balance: Out of balance tools create vibration, changes in cutting conditions, reduce cutting efficiency and increase noise levels.
- Machine condition: Old or new, woodworking machinery needs to be properly maintained. A well maintained bandsaw may have a 10 dB(A) difference between idling and cutting noises, but a poorly maintained machine may show hardly any difference. Well maintained condition contributes to how well it runs and noise level. (Johnson L.L, 1982)

Noise levels for the electrical machines

Electrical machines in Denki Wire and Cable did not produce much noise compared with woodworking machinery as presented in the Tables 2 and 3.

ISSN 2056-5860

Noise in electrical machines can be mechanical or electrical caused by internal or external factors. Mechanical noise occur either due to wear over time of various elements or as a result of shock transmitted from the driven elements. Electromagnetic excited vibrations are also substantial cause of the audible noise radiated by most electrical machines. Vibrations due to internal causes include unbalanced rotating parts, weakening of the magnetic core wedges, weakness in the functioning of the stator and advanced wear of the bearings. Bearing components (rings, cage, rolling bodies) in the actual operation generates vibration and noise. Other causes of noise are overload (drawing excessive current over a sustained period of time), many machines running at the same time means more noise, fluctuations in the supplied voltage and sudden increase in voltage (surge) and varying rotation speed of generators.

The workers in these industries generally work for more than 8 hours per day and 6 days per week (>48 hrs/wk) and are exposed to high noise level. The noise exposure levels in these industries are excessively high as compared to the maximum permissible noise exposure limit of

(i) 85 – 90 dB (A) for 40 hours per week, as suggested by ISO. (ISO, R-1999 (1971)

(ii) 90 dB (A) for 40 hours per week allowed in United Kingdom, Denmark, Canada

(iii) 85 dB (A) for 40 hours per week allowed by Occupational Safety & Health Act (USA)

(USA, Dept. of labour, 1974)

Such high level of noise not only hinders the communication between the workers, but its long term exposure may also result in ill effects especially in permanent hearing threshold shift. The hazardous nature of industrial noise in Nigeria laid credence to the formulation of permissible levels/standard by the federal environmental protection agency to which an employee may be subjected to. The FEPA Noise exposure limits guideline for Nigeria is shown in Table 4.

But this guideline has been violated in many processing and manufacturing industries in Nigeria due to inefficiency of the statutory body in enforcing and implementing the regulatory laws to limit high level of industrial noise and the unawareness of the workers about the ill- effects of high level of noise. (FEPA, 1991)

Analysis of the results of the Questionnaires

A total of 120 questionnaires were administered to study:

- employee's bio-data including the age and sex distribution
- employee's daily noise exposure level
- employee's working environment (level of noise produced) and machines maintenance
- effects of noise on employee's vis-a-vis job performance, interference with communication, hearing impairment, response to doctors consultation etc

The working environment was very noisy, 77.45% of the respondent agreed to that fact. Also it was deduced that there was a correlation between a very noisy working environment and the frequency of hearing impairment caused on the respondent. Although the machines were adequately maintained, the working environment was very noisy. Factors like machines condition, operation processes or the workpiece might be responsible. It is thus evident that the noise produced was as a result of the production processes. 80.39% and 51.96% of the

ISSN 2056-5860

respondent confirmed negative interference with their communication and job performance respectively.

CONCLUSION

The following conclusions can be drawn about the level of noise pollution in the selected processing and manufacturing industries (Denki Wire & Cable) and (Wanwood Nig. Ltd.):

- The average noise exposure level (LA_{eq}) in both industries is found to be above 85 dB(A) and that is well above the healthy noise level of 85 dB(A) recommended by World Health Organization (WHO).
- The workers in the industries are at high risk of developing noise induced hearing loss (NIHL) and other associated ailments due to excessive exposure to industrial noise.
- The damaging consequences of exposure to excessive noise are cumulative and usually do not shows up for several years since workers who work in such noisy environment soon become desensitized. They get used to the noise quickly, they do not notice anymore, they do not worry about it and they do not take precaution to protect themselves from its debilitating effects.
- There is need to develop and apply a well-defined, comprehensive and enforceable noise regulation. The limit of 85 dB(A) for 8 hours/day stipulated by OSHA (also stated by Nigerian factories Act 1960) has to be followed with caution as working hours in most of the processing and manufacturing industries in Nigeria are above 8 hours/day and 48 hours/week.
- Noise exposure level should be reduced by providing a wide green belt of thick vegetation around the factories' premises, covering the outer surfaces of the rooms within the factories with sound absorbing materials, setting a noise limit of at least 5 – 10 dB (A) below the prescribed standard, designing/fabricating new machines for the factories, organizing periodic health education programs for the workers and enforcing /implementing the noise regulatory laws by appropriate government agencies.

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Table 1: Noise Exposure Pattern of the machines in the Industries visited

Location	**Noise source**	**Noise exposure pattern**
Denki Wire & cable Industry	Drawing Machine	Steady continuous state
	Coiling machine	Steady cyclic state
	Rewinding machine	Steady continuous state
	Extruder Machine	Steady continuous state
	Cabling Machine	Steady continuous state
	Generator 1	Steady continuous state
Wanwood Industry	Circular Machine	Time varying/Impulsive
	Power chain Machine	Time varying/Impulsive
	Tractor	Time varying/Impulsive
	Band saw	Time varying/Impulsive
	Planning Machine	Time varying/Impulsive
	Generator II	Steady continuous state

Table 2: Mean observed noise levels in Wanwood Nig. Limited

Location	Machines	Noise level dB(A)
Wanwood Industries	Tractor	89.39
	Circular saw	117.50
	Band saw	100.72
	Planning Machine	93.40
	Generator 2	97.43
	Power Chain saw	114.90

ISSN 2056-5860

Table 3: Mean observed noise levels in Denki Wire and Cable Limited

Location	Machines	Noise level dB(A)
Denki wire & cable industries	Cabling Machine	*85.81*
	Coiling Machine	82.84
	Extruder Machine	85.72
	Drawing Machines	92.85
	Generator 1	95.39
	Rewinding Machine	*90.25*

Table 4: FEPA Noise exposure limit guidelines for Nigeria

Duration per day (Hours)	Possible Exposure limits(dB(A))
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25 or less	115

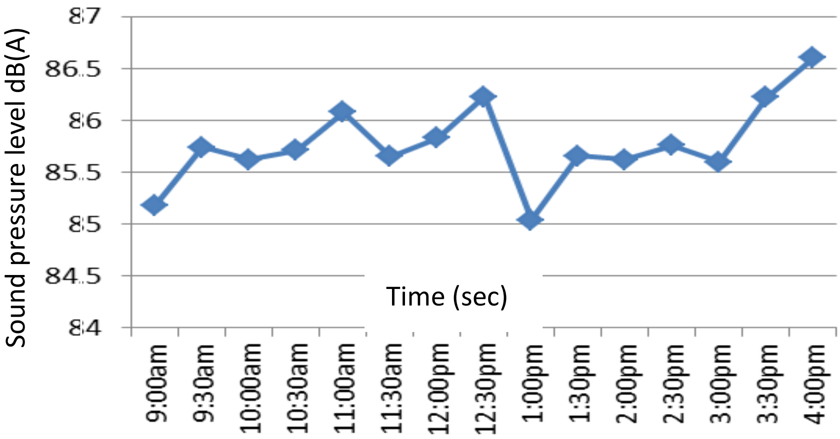

Figure 1: Hourly sound pressure level for extruder machine against time

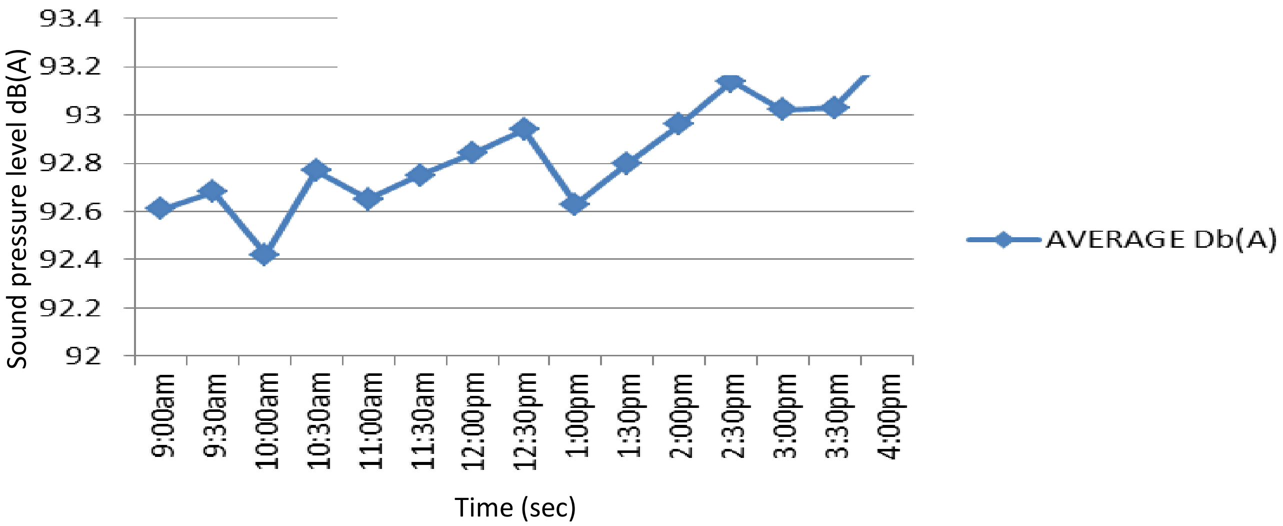

Figure 2: Hourly sound pressure level for drawing against time

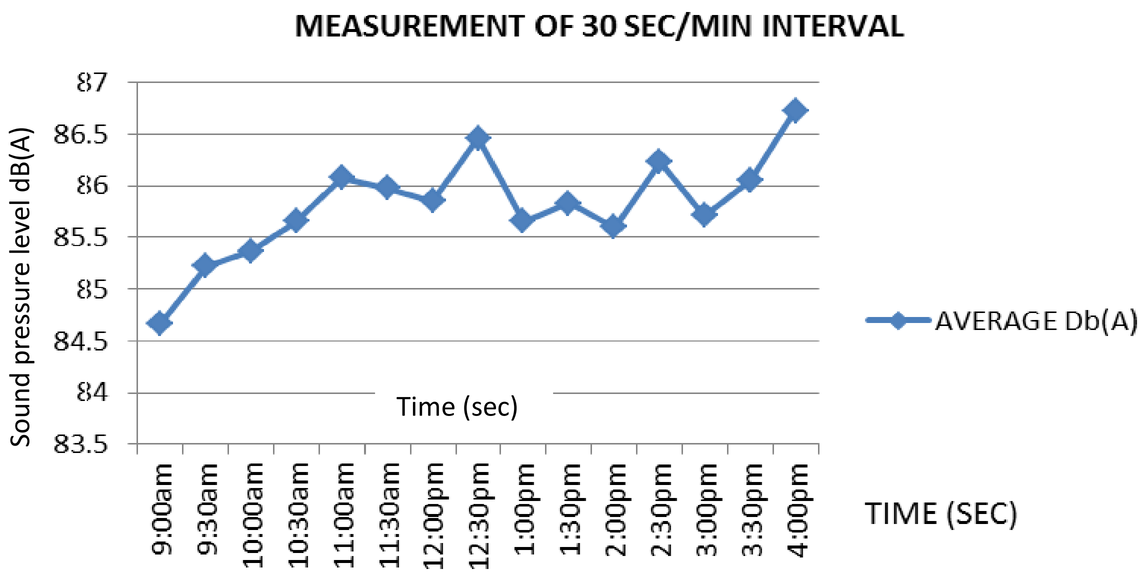

Figure 3: Hourly sound pressure level for cabling machine against time

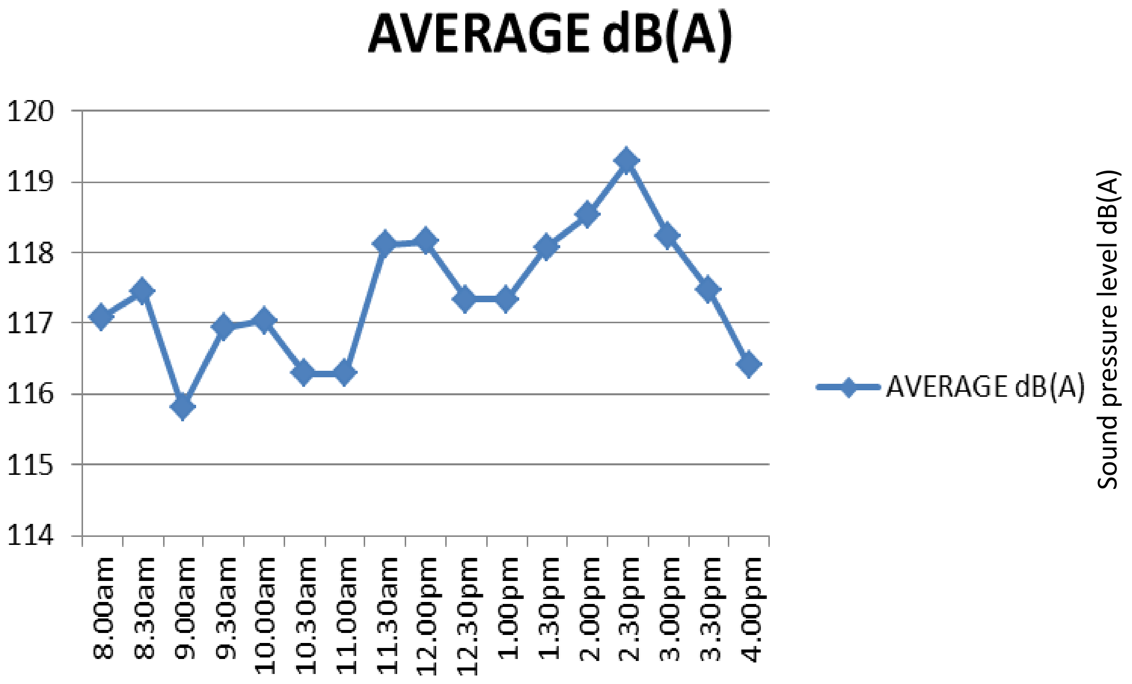

Figure 4: Hourly sound pressure level for circular saw machine against time

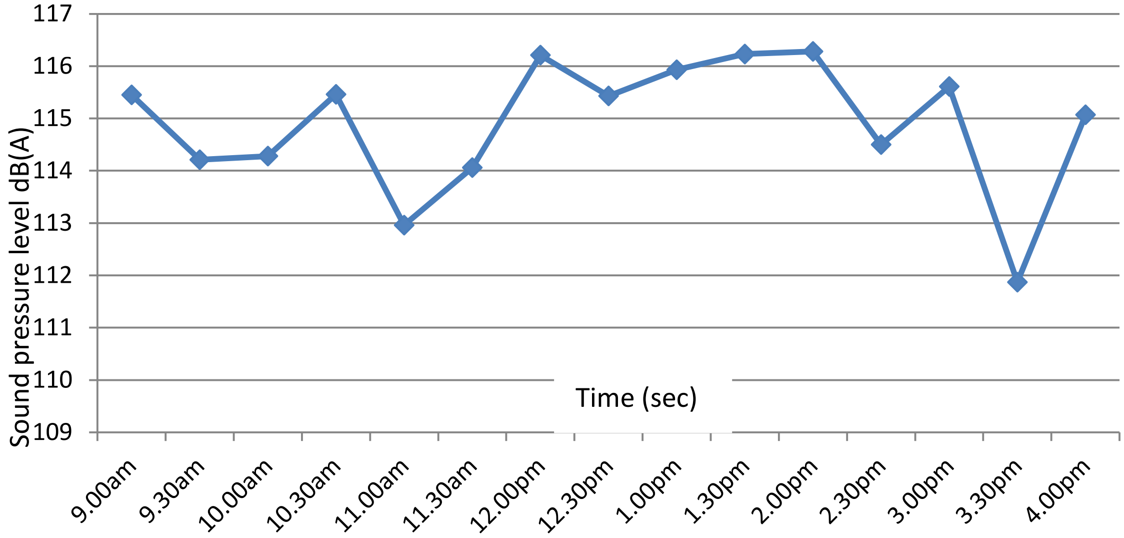

Figure 5: Hourly sound pressure level for power chain machine against time

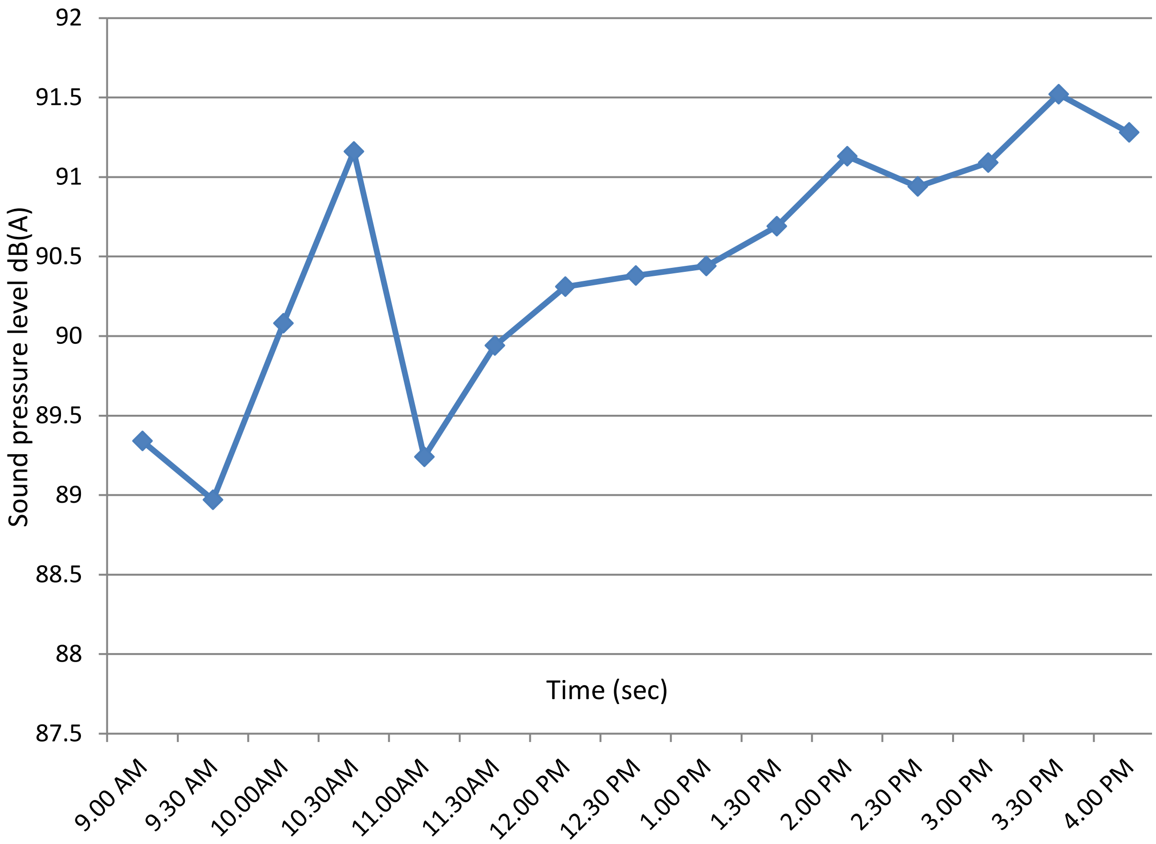

Figure 6: Hourly sound pressure level for tractor against time

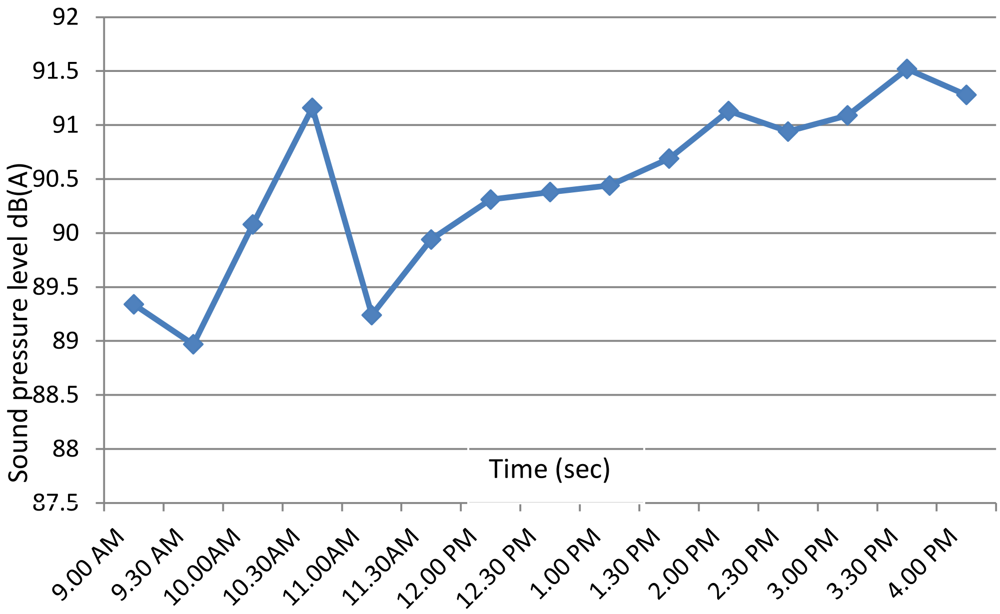

Figure 7 : Hourly sound pressure level for band saw machine against time

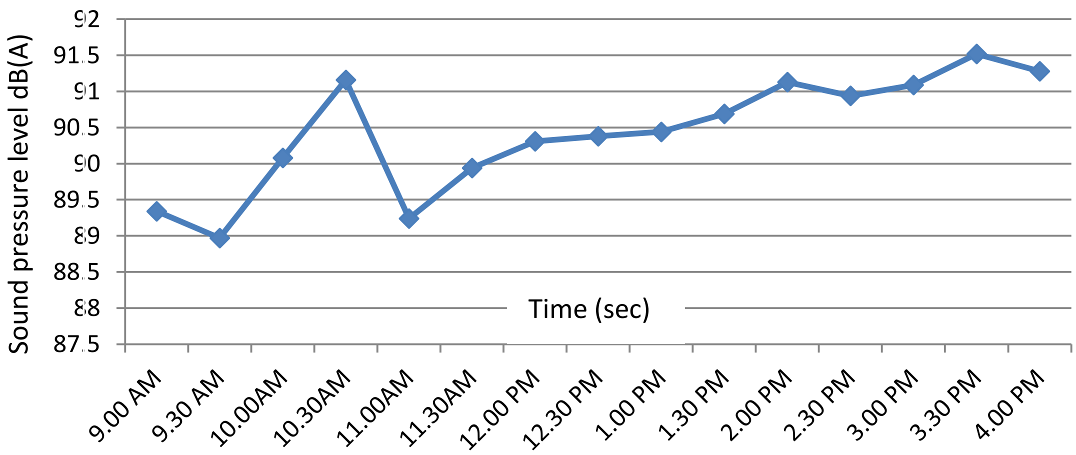

Figure 8: Hourly sound pressure level for Generator II machine against time

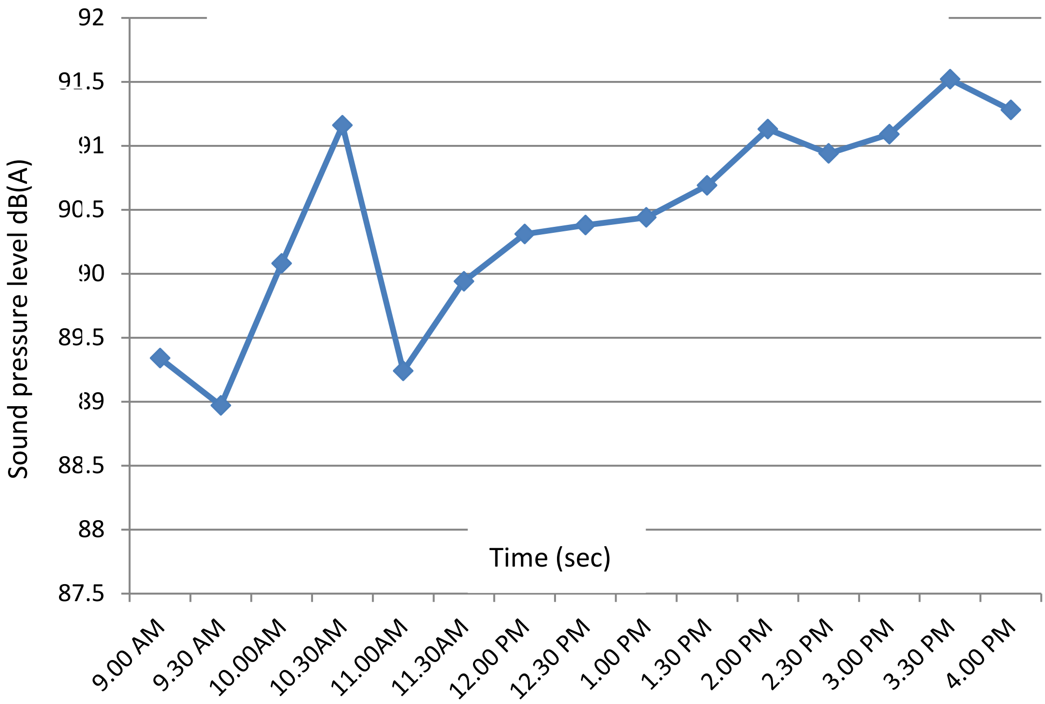

Figure 9: Hourly sound pressure level for generator I machine against time

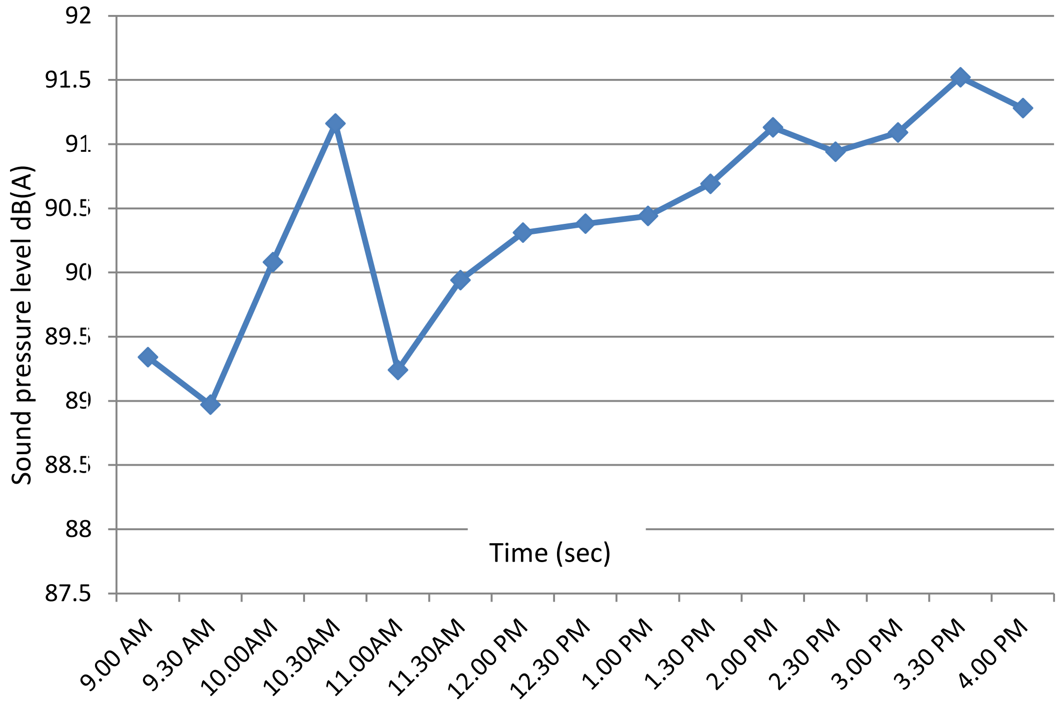

Figure 10: Hourly sound pressure level for planning machine against time

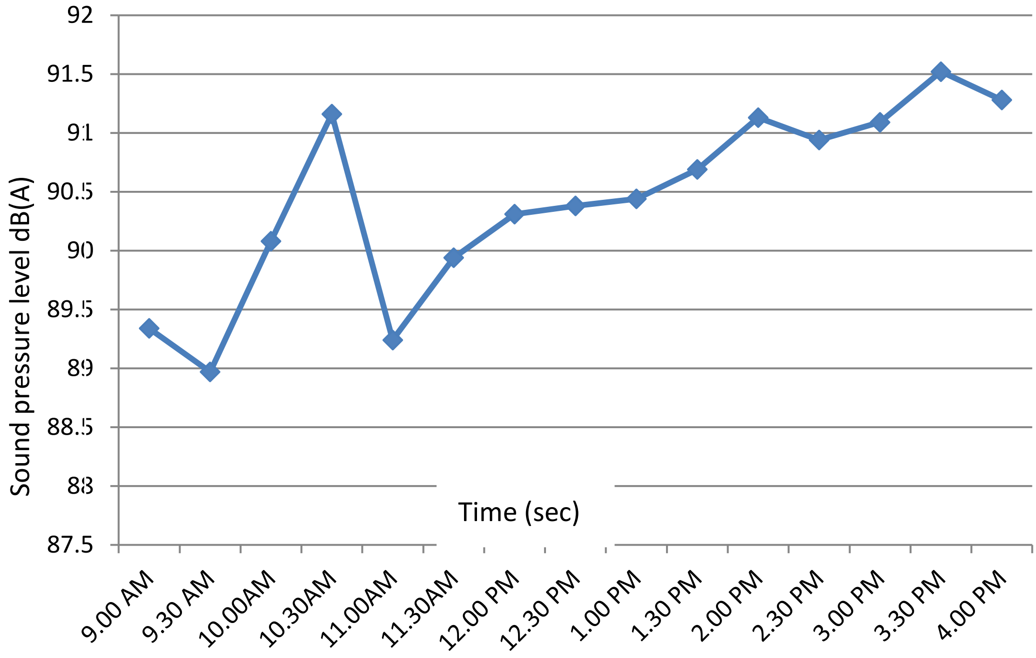

Figure 11: Hourly sound pressure level for coiling machine against time

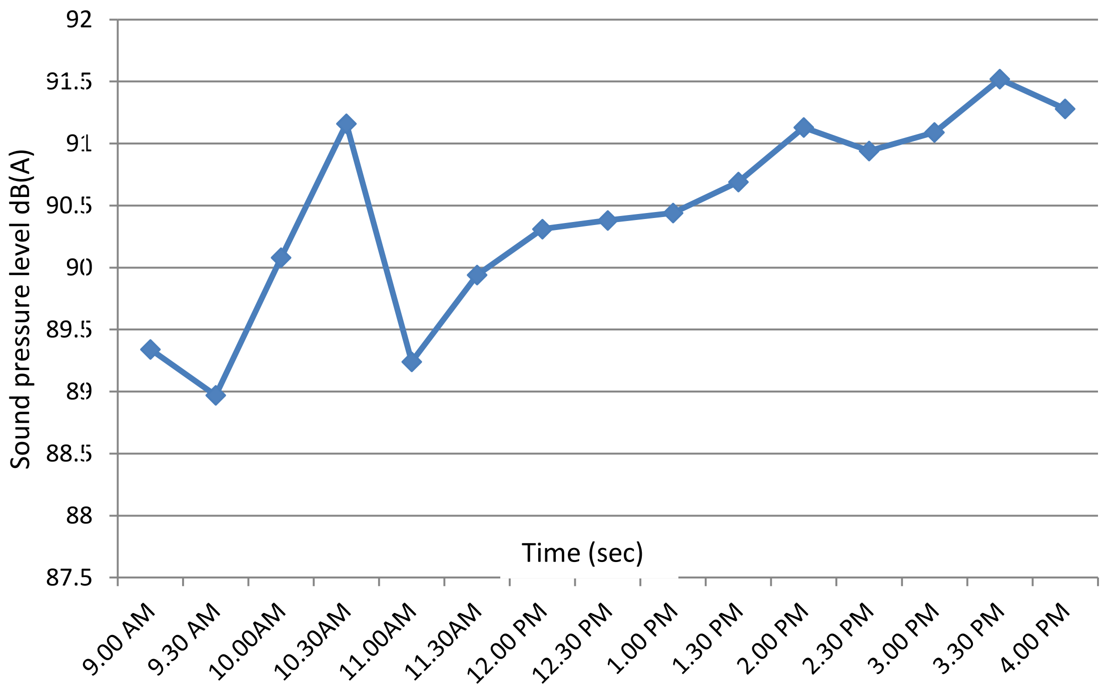

Figure 12: Hourly sound pressure level for rewinding machine against time