Minimize Noise Dose Exposure by Karnaugh Map Technique for a Small Scale Manufacturing Industry in West Bengal of India

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***Abstract*— Noise is one of the most found physical contaminants in the manufacturing Industry. Professional deafness or even permanent hearing loss may produce due to most negative effect caused by noise exposure. It also produce ill effects on people's health, since basic activities such as sleeping, resting, studying and communicating etc. are highly affected. It endures high environmental pollution. We have collected different noise related parameters like L_{eq} (Equivalent sound level), L_{av} (Average sound level), L_{AE} (Sound exposure level) and TWA (Time Weighted Average level) from different machines used in an industry, especially power press machine, grinding machine etc. We propose a noise exposure minimizing technique with the help of Karnaugh map which is generally used in Boolean algebra simplification. By implementing Karnaugh map technique, different noise exposure parameters are minimized, and maximum sound exposure sources are identified.**

***Index Terms*— Precision dosimeter, Small scale Industry, Noise exposure, Effect of noise, Karnaugh map.**

1. INTRODUCTION

Unlike other contaminant agents, the effect of noise may be instantaneously unnoticed and its accumulation can lead a social, psychic and physical deterioration. The loss of hearing is the effect of over-exposure in noisy environment. It is one of the causes in environmental pollution.

Every day in West Bengal, thousands of workers, especially in manufacturing units, are exposed to noise and consequently they are affected risks and deterioration of health in their workplace. One, out of ten workers in West Bengal must raise his voice to be heard for more than one third period of the working day and 5-7% of them suffer from noise related hearing problem [3]-[13].

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For the study and health of workers, noise exposure can cause several risks. The risk of accidents in the workplace is increased due to noise flowing beyond the limit. The speech and alarm sound can mask both due to noise exposure. Different physical problems like voice problems, nodules, abnormalities in the vocal cord, loss of voice, hearing problem, migraine etc. are suffered by our workers. It is more dominant when the workers are subjected to communicate with in noisy environment with more than 90 dBA levels.

As it is involved with the market interest of a company as well as employee's health issue, excess noise removal in the work place is not just a legal responsibility of the organization, but it is also a burning crisis to all.

This work has studied in the manufacturing unit of a sheet metal industry which creates a very noisy zone in the factory premises. The same results with little variations are obtained in all other sectors of the small scale industries in West Bengal state of India. It causes serious environmental pollution. Hence it effects country's development. Previously noise levels were studied by many researchers like Nelson *et al.* (1999), M.A Martin *et al.* (2006), Marcos D. Fernandez *et al.* (2009) and Ktarina Paunovic *et al.* (2009). After calculating different noise exposure parameters by Noise Dose meter, we minimize these noise parameters or variables by adopting Karnaugh map technique which is generally used for Boolean algebra simplification purpose.

This innovation of applying Karnaugh map technique in minimizing noise exposure is the first time use in environmental pollution area. The minimized form of noise parameters assigns a new simplified noise solution for noise exposure measurement.

II. METHODOLOGY OF THE STUDY

We are studying the characteristics of noise dose from different machines, like power press and grinding machine in a small scale industry in Kolkata city, West Bengal, India.

The factory unit is a manufacturer of emergency car brake in which different sheet metal components are assembled.
The noise standards are generally set on the basis of World Health Organization (WHO) stipulations [11], [12]. WHO has stipulated 65 dB permissible noises from an industrial area during both day and night. In commercial area it is 60 dB whereas 55 dB and 45 dB is prescribed for commercial, residential and silence zones respectively.

The following measures have to be applied in the work place that overpasses a daily equivalent level of 70 dB and a peak level of 140 dB.

1) The workers are to give personal hearing devices that demand them.
2) Once in every three years, the workers are subjected to initial medical checkup or hearing.
3) Each worker is provided with a proper information for

- Use of personal hearing system.
- Regular medical hearing checkup.
- Potential risks for hearing and assessment for Noise exposure.

A. Instrument Used

Type 4444, Noise Dose Meter has been used for recording assessment and noise level associated with the workers in that small scale industry. It is a light weight instrument. There are seven build in setups, which include, ISO 90A, ISO 85A, DOD, MSHA, ACGIH, (USA standards) and obviously a very important unit is OSHA, which corresponds to most widely used standards today. The meter has a capability to store the data to memory, the sound level setups are specified in which SLM gives on screen result and METER can store data to memory.

Fig.1.Noise Dose Meter 4444 used for this study

B. Method of measurement

Measurements are done in presence and also absence of noise exposure from machines to the effected workers by placing the microphone in his collar (the microphone will be placed preferably in front of his ear, approximately at a distance of 10 cm). For this study, measurements are taken according to ISO 1999: 1990 "Guidelines for the measurement and assessment of exposure to noise in a working environment" [11], [12].

For this study, an integrative and averaging Bru¨ el & Kjær, made Noise Dose Meter type 4444 has been used. The measurements are made using the dosimeter computing some common indexes like, L_{eq}, L_{av}, L_{AE} and TWA.

Where, L_{eq} = Equivalent sound level,
L_{av} = Average sound level,
L_{AE} = Sound exposure level,
TWA = Time Weighted Average level.

All measurements are taken in OSHA which is an international standard.

The industry plant is a manufacturer of hydraulic gear for car and has a press shop where seven 100 Ton, one 150 Ton, one 25 Ton Power press machines and one medium size Grinding machine are working. The plant is running in two shifts, morning and evening each for 8 hours. Leisure period is 30 minutes for both shifts. The registered parameters with the dosimeter are:

- Duration of measurement (Time in sec),
- Maximum and minimum threshold level L_{OSHA1} and L_{OSHA2} for individual machine,
- Equivalent continuous A-weighted sound pressure level, registered along the whole measurement (L_{eq}, T in dBA),
- Threshold level is 80 dB and criteria level is 90 dB,
- Upper and lower threshold value for individual machine,
- 8 hour percentage projected dose,
- Exchange rate Q = 5,
- Exceedance times from sound pressure level (SPL).

III. RESULTS AND DISCUSSION

From noise related parameters or variables like L_{eq}, L_{av}, L_{AE} and TWA, we take average threshold level for each parameter and make a truth table for the same. If any one of the variables is greater than the threshold value, i.e., noise is exposed more than normal limit, then the value is taken as one (1), and if less than the threshold value, i.e., noise is tolerable, then it is taken as zero (0).

Here we are selecting only four (4) variables (parameters) out of ten noise sources (Machines). For 100 Ton Power press machines, average value is taken. Apart from that, one 150 Ton Power press machine, one 25 Ton Power press machine and one Grinding machine are selected.Table-1 shows details of all machine parameters.

TABLE-I: NOISE PARAMETERS (VARIABLES) MEASURE FROM DIFFERENT NOISE SOURCES (MACHINES).

Machine Type/ Sound level	L_{eq} (dBA)	L_{av} (dBA)	L_{AE} (dBA)	TWA (dBA)
Power press -1 (100T)	98.2	128.0	98.0	73.4
Power press -2 (100T)	99.9	120.6	97.6	57.9
Power press -3 (100T)	111.5	126.5	108.5	59.4
Power press -4 (100T)	100.6	128.7	100.3	72.9
Power press -5 (100T)	98.0	117.5	97.2	55.5
Power press -6 (100T)	96.2	125.2	95.9	70.0
Power press -7 (100T)	98.0	127.0	97.7	71.9
Power press-1 (150T)	97.6	127.3	97.2	72.4
Power press-1 (25T)	98.5	128.1	98.5	73.5
Grinding Machine-1	91.6	117.1	91.5	59.8

The above Table-1 is transferred to Table-2 by reducing seven 100T Power press machines to a single 100T Power press machine, average value of all 100T machines are taken.

Now, upper threshold level for all noise parameters which are available from Dosimeter for individual machine are taken in Table-3, we are ignoring lower threshold value, although it is available in Dosimeter. Since, upper threshold value assures that beyond this value, noise is more dominant factor and creating environmental pollution.

TABLE-II: SIMPLIFIED STRUCTURE OF NOISE SOURCES WITH NOISE PARAMETERS.

Machine Type/ Sound level	L_{eq} (dBA)	L_{av} (dBA)	L_{AE} (dBA)	TWA (dBA)
Average value for seven 100 Ton Power Press	100.34	124.78	99.31	65.85
Power press -1 (150T)	97.6	127.3	97.2	72.4
Power press -1 (25T)	98.5	128.1	98.5	73.5
Grinding Machine-1	91.6	117.1	91.5	59.8

TABLE-III: UPPER THRESHOLD VALUE FOR ALL NOISE PARAMETERS

Average threshold value is 97.12 dBA.

Power press-1 (100T)	97.7 dBA
Power press-2 (100T)	95.9 dBA
Power press-3 (100T)	96.6 dBA
Power press-4 (100T)	100.3 dBA
Power press-5 (100T)	100.5 dBA
Power press-6 (100T)	97.3 dBA
Power press-7 (100T)	90.3 dBA
Power press-1 (150T)	97.1 dBA
Power press-1 (25T)	98.5 dBA
Grinding Machine-1	97.1 dBA

On the basis of the above threshold value, the truth table is constructed as shown in Table-IV.

TABLE-IV: TRUTH TABLE FOR NOISE PARAMETERS VERSES NOISE SOURCE.

Machine Type/ Sound level	L_{eq} (dBA)	L_{av} (dBA)	L_{AE} (dBA)	TWA (dBA)
Average value for seven 100 Ton Power Press	1	1	1	0
Power press-1 (150T)	1	1	1	0
Power press-1 (25T)	1	1	1	0
Grinding Machine-1	0	1	0	0

From the Table-IV, we plot data in Karnaugh map. Generally Karanugh map technique is used for simplifying Boolean algebra functions which are practically used in digital electronics and other electronics circuit synthesis. In Fig. 2, we simplify Karnaugh Map plot and find minimized function for noise parameters with respect to noise source.

For noise sources from different machines are represented by two attributes or variables R and S, where noise from each machine is designated with the followings:

$\overline{R}\overline{S}$ represents average noise source from 100T Power Press machines (7 numbers).

$\overline{R}S$ represents noise source from one 150T Power Press machine.

RS represents noise source from one 25T Power Press machine.

$R\overline{S}$ represents noise source from one Grinding Machine.

Noise parameters or variables are represented by two attributes P and Q, when

$\overline{P}\overline{Q}$ represents L_{eq}, Noise equivalent sound level in dBA.

$\overline{P}Q$ represents L_{av}, Noise average sound level in dBA,

PQ represents L_{AE}, Noise sound exposure level in dBA,

$P\overline{Q}$ represents TWA, Noise Time Weighted Average level in dBA.

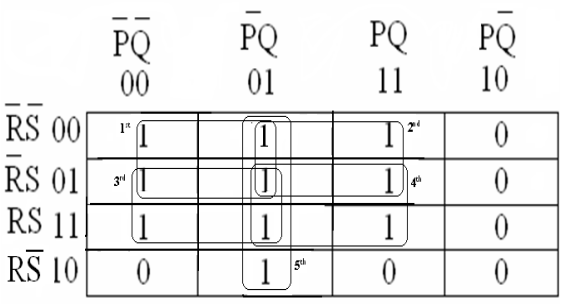

Fig. 2. Karnaugh Map plot for Noise Sources verses Noise Parameters.

We are implementing sum-of-product method used in Karnaugh map technique. Here five grouping rectangles with four number 1's in each group are possible for minimizing the sources and the parameters.

Let minimized output for the above plot is represented by T,

Then, $T = \overline{P}\overline{R} + Q\overline{R} + \overline{P}S + QS + \overline{P}Q$,

Where, $\overline{P}\overline{R}$ indicates L_{eq} and L_{av} (i.e. $\overline{P}$ remains in L_{eq} and L_{av}) having higher than threshold value for Power press 100T and 150T (i.e. $\overline{R}$ remains in 100T and 150T Power press) machines.

Similarly, $Q\overline{R}$ indicates L_{av} and L_{AE} having higher than threshold value for Power press machines 100T and 150T.

$\overline{P}S$ indicates L_{eq} and L_{av} having higher than threshold value for Power press machines 150T and 25T.

QS indicates L_{av} and L_{AE} having higher than threshold value for Power press machines 150T and 25T.

$\overline{P}Q$ indicates L_{av} having higher than threshold value for all machines including Grinding machine.

IV. CONCLUSIONS

Noise is one of the main resources causing environmental pollution in full order. Noise exposures from different sources (machines) of an industry or manufacturing unit are computed in this paper. By adopting Karnaugh map technique, we have minimized all the components of noise parameters or variables. Hence it ensures a holistic study of noise exposure in a real time basis. After optimizing minimized noise exposure situation, we can easily take care for safety or precautionary measure to guard against noise out-bursting as well as environmental pollution.

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