Journal of Mines, Metals and Fuels, *71(12D) : 165-168; 2023. DOI: 10.18311/jmmf/2023/47997*

Print ISSN : 0022-2755

Journal of Mines, Metals and Fuels

Contents available at: *www.informaticsjournals.com/index.php/jmmf*

Noise Level Measurement and Analysis in Safety Management in A Metal Work Fabrication Industry Using Six Sigma Methodology

M. R. Shivakumar[1], M. Shilpa[2], S. Hamritha[3] and S. Madhosh Gowda[4]

Department of Industrial Engineering and Management, Ramaiah Institute of Technology, Bengaluru – 560054, Karnataka, India; mrshivakumar@msrit.edu, mallikashilpa@gmail.com, hamritha.ap@gmail.com, madhoshgowda@gmail.com

Abstract

This study was conducted in metal work fabrication industry. During the metal work fabrication, machineries and equipment are produces the noise. The excessive noise in the workplace causes the hearing disorder in workers, also annoys and disrupts the activities. Present study was to assess the magnitude of noise and remedial actions in controlling the industrial noise expose at an electrical equipment manufacturing plant. The noise level of 105dB was observed in coil winding machine. This noise level is highly unsafe as per the safety standards for noise level. This paper discusses about the Six Sigma methodology in reducing the noise level of the plant. The noise levels are smoothened by calculating Risk Priority Numbers (RPN) and implementing engineering control techniques in the machinery area. With the implementation of the Six Sigma Methodology, the noise level in the plant was reduced to less than 75db, which is an acceptable safe noise level as per the standard noise level of a manufacturing plant.

Keywords: *DMAIC, Engineering Controls, Noise Level, Safety Management, Six Sigma*

1.0 Introduction

Metal work industries are involved in metal fabrication process. Metal work includes cutting, machining, forming, grinding to create finished products. The metal work application sectors are mining, construction, automotive, *etc*. During the metal work operation, the machines and equipment produces noise.

Safety-related efforts are necessary in an organisation to create an injury-free environment. Injuries in the manufacturing plant are not only reducing productivity directly but also they affect the workers, time, and may lead to damage to machinery. As a result, the metal fabrication industries are experiencing a need for organisational safety measures and policies to reduce these injuries[1].

Noise results during fabrication process. If the noise level in a plant is exceeding the normal noise level, hearing damage may be caused. Also, loud noises cause high blood pressure, fatigue, heart problems, and stress in the workers[2,3]. As per noise pollution rules, the permissible noise level in the day-time is 75dB and during the night-time, 70dB.

The Six Sigma concept has become the standard methodology for quality improvement in many industries. Six Sigma is a systematic methodology that helps in the development and delivery of near-perfect products and services. The objective of Six Sigma is to improve

**Author for correspondence*

the quality of processes by identifying and removing the causes of defects[4,5]. Six Sigma is a five-step process. These steps are: Define, Measure, Analyse, Improve, and Control (DMAIC). The define-stage clearly identifies the work and target. This stage also identifies what processes are failing and their injuries. In the measure-stage, data is collected and validated. During this stage, statistical tools are used to validate the collected data. These tools include histograms, parotoes, and process capability. The data is analysed to find the root causes of the injuries in the analyse-stage. The most commonly used tools to analyse the data include cause and effect fishbone diagram, five whys, and correlation testing. After the completion of the analysis stage, potential corrective measures have to be taken to reduce the injuries in the improve-stage. The main objective of the control stage is to monitor the results of the implementation of safety measures and ensure the expected improvement and sustainability. This process is repeated till the desired output is achieved[6-9].

The present work was carried out at electrical equipment fabrication process plant. When the plant was established the noise level was in safe level. With the addition of equipment in the plant, the noise level was increased and crossed the standard noise level limit, the present average noise level at core winding equipment was 105dB. This noise level is more than the permissible noise level. The objective of the present work is to reduce the noise level through the implementation of safety measures and design of control sheet for maintaining safety noise level in the plant. A systematic Six-Sigma methodology was used in elucidating the situation to reduce the noise level[10].

2.0 DMAIC Methodology and Result

2.1 Define Phase

In the definition phase, the causes of the excessive noise in the plant was identified. The major causes for noise are shown in cause and effect diagram (Figure 1).

2.2 Measure Phase

In the measurement phase, noise levels were measured separately at working machineries and at workplace by avoiding the noise effect from other machineries. A noise level meter was used to measure noise intensity in decibels (dB). Data was collected in two different shifts. The noise levels are shown in Table 1.

2.3 Analysis Phase

From Table 1, it is observed that, high level of noise is mainly due to the machineries. There is a need to take suitable actions to reduce the noise level in machineries. Failure Modes and Effects Analysis (FMEA) was used to analyse the noise levels[11]. Risk Priority Number (RPN) was calculated to identify effect of noise by the machineries, workplace and oral communication of workers. Probability of occurrences (O), level of severity (S) and likelihood of detection (D) of noises were considered for the analysis[12]. These factors were rated from 1 to 10 scale. Rating values are shown in Table 2. RPN values were calculated based on the ratings and necessary actions are recommended to reduce the noise level. Table 3 shows the RPN values and recommended actions.

2.4 Improvement Phase

The RPN value of "Maintenance of the machineries" is high. The recommended actions were implemented

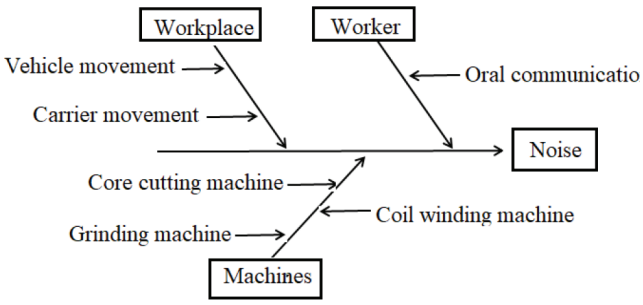


Figure 1. Cause and effect diagram

Table 1. Measured noise level

Sl. No.	Particulars	Noise level (dB) Shift 1	Noise level (dB) Shift 2	Average Noise level (dB)
1	Coil winding machine	110	100	105
2	Core cutting machine	90	90	90
3	Grinding machine	80	80	80
4	Workplace	30	30	30
5	Oral communication of workers	15	15	15

Table 2. Tables for severity, occurrence and detection rating scale

Probability Occurrence		Level of Severity		Likelihood of Detection	
Description	**Rating**	**Description**	**Rating**	**Description**	**Rating**
1 in 2	10	Very high	9, 10	Non-detection	10
1 in 8	9	High	7, 8	Very low	9
1 in 20	8	Moderate	4, 5, 6	Low	7, 8
1 in 40	7	Low	2, 3	Low	5, 6
1 in 80	6	Minor	1	Moderate	3, 4
1 in 400	5	--	--	Moderate	1, 2
1 in 1,000	4	--	--	--	--
1 in 4,000	3	--	--	--	--
1 in 20,000	2	--	--	--	--
1 in 10^6	1	--	--	--	--

Table 3. RPN values and recommended actions

Sl. No.	Function Process	S	O	D	RPN	Recommended Actions
1	Maintenance of machineries	9	9	9	729	Use of enclosures and sound absorption walls. Use of acoustic silencer in air exhaust
2	Workplace	1	8	9	72	Use of proper PPE equipment
3	Worker	1	7	6	42	Awareness programs, adequate supervision of workers

Table 4. Noise levels after the implementation of recommended actions

Sl. No	Particulars	Noise level (dB) Shift 1	Noise level (dB) Shift 2
1	Coil Winding machine	75	75
2	Core cutting machine	70	70
3	Grinding machine	70	70
4	Workplace	30	30
5	Oral communication of workers	15	15

in the plant to reduce the RPN value of "Maintenance of the machineries". The absorption walls and silencer were installed to coil winding, core cutting and grinding machines. Then noise level was measured in shift 1 and shift 2. The average noise level was reduced. Table 4 shows the noise levels after the implementing the recommended actions. Noise levels in coil winding machine, core cutting machine and grinding machine is below 75dB.

2.5 Control Phase

In this phase of DMAIC, the noise levels at various machineries and work places are to be measured and recorded on daily basis. Based on these recorded values of suitable action may be taken for noise level reduction.

3.0 Conclusion

This work deals with Six Sigma methodology to reduce the noise level in an electrical equipment metal work fabrication plant. Noise level in coil winding machine, core cutting machine and grinding machine was more than the standard noise level. Six-sigma methodology was adopted to reduce the noise level. The fishbone diagram was used to identify cause of noise and effect was analyzed using Risk Priority Number. The RPN is 729. Based on this RPN, appropriate action was taken to reduce noise level. The major cause of increased noise level was due to improper maintenance of machinery. Suitable recommendations such as installation of absorption walls and silencers to machineries were made. After the implementation of recommended actions, the noise level in machineries was reduced from 105 dB to 75dB, thus bringing the noise within permissible limits. To sustain this noise level, monitoring of noise level and suitable actions on daily basis is recommended. The six–sigma

methodology may be used in any other noise making manufacturing industries to reduce the noise level.

4.0 References

1. Bundele M, Upadhayay V, Ladhe YP. Sustainable quality of safety in safety management system with Kaizen and Six sigma. Int J Sci Eng Res. 2014; 5(5):88-93.
2. Kehinde TO, Oluleye AE, Olaleye KJ, Jegede SL. Six sigma approach in safety management of a production firm. Int J Eng Res Technol. 2019; 12(10):1654-1663.
3. Gajbhiye PR, Waghmare AC, Parikh RH. Safety management in manufacturing industry: A lean six sigma approach. 5th International. 2014; 26:646-1.
4. Ateekh-ur-Rehman LU. Safety management in a manufacturing company: Six Sigma approach. Engineering. 2012; 4(7):400-407. https://doi.org/10.4236/eng.2012.47053
5. Doble M. Six sigma and chemical process safety. Int J Six Sigma Compet Advant. 2005; 1(2):229-244. https://doi.org/10.1504/IJSSCA.2005.006425
6. Sánchez-Rebull MV, Niñerola A, Ferrer-Rullan R, Hernández-Lara AB. Six Sigma for workplace safety improvement: improving hazards and unsafe conditions in a metallic packaging manufacturing company. Int J Occup Saf Ergon. 2022; 28(2):766-778. https://doi.org/10.1080/10803548.2020.1829318 PMid:32993475
7. Sangode PB, Hedaoo HR. Six sigma in manufacturing industries: Barriers to implementation. Amity J Oper Manag. 2018; 3(1):12-24.
8. Praharsi Y, Jami'in MA, Suhardjito G, Wee HM. The application of Lean Six sigma and supply chain resilience in maritime industry during the era of COVID-19. Int J Lean Six Sigma. 2021; 12(4):800-834. https://doi.org/10.1108/IJLSS-11-2020-0196
9. Valles A, Sanchez J, Noriega S, Nuñez BG. Implementation of Six sigma in a manufacturing process: A case study. Int J Ind Eng. 2009; 16(3):171-181.
10. Knop K. Using Six sigma DMAIC cycle to improve workplace safety in the company from automotive branch: A case study. Manuf Technol. 2022; 22(3):297-306. https://doi.org/10.21062/mft.2022.040
11. Mascia A, Cirafici AM, Bongiovanni A, Colotti G, Lacerra G, Di Carlo M, *et al.* A Failure Mode and Effect Analysis (FMEA)-based approach for risk assessment of scientific processes in non-regulated research laboratories. Accredit Qual Assur. 2020; 25:311-321. https://doi.org/10.1007/s00769-020-01441-9
12. Sellappan N, Nagarajan D, Palanikumar K. Evaluation of Risk Priority Number (RPN) in Design Failure Modes and Effects Analysis (DFMEA) using factor analysis. Int J Appl Eng Res. 2015; 10(14):34194-34198.