RESEARCH ARTICLE

Assessment of fugitive personal noise intensity exposure among open-type hot forging industrial workers

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ABSTRACT

Background: Fusitive noise exposure is a major occupational hazard for workers in open-type hot forging industries I and II, which manufacture products like plain shafts, hubs, big nuts, spindles, piston rods, seat/bearing/gaskets, gear rings, etc., using two-ton and one-ton hammers. *Objective*: To assess the fugitive personal noise dose intensity exposure among exposed workers. *Methodology*: The personal noise intensity exposure was measured by using a noise dosimeter, among exposed workers for 8 hours full shift. *Results*: The personal noise intensity exposure, and time-weighted average (TWA), in both industries individually and combined were 91.87 ± 1.47, 93.17 ± 1.65, and 92.56 ± 1.68 dB(A), respectively. The L_{EQ} noise intensity for both industries individually and combined data were 94.22 ± 2.03, 96.77 ± 2.64, and 95.59 ± 2.67 dB(A). Both TWA and L_{EQ} values between Industry I and II were different and this was statistically significant (p <0.05). The L_{peak} noise intensity in linear scale for Industry I, II and combined data were 139.78 ± 8.03, 141.35 ±6.76, and 140.62 ± 7.33 dB(Z), respectively. *Conclusion*: The noise intensity was above 90 dB(A) as per statutory guidelines of the Factories Act 1948, and Mines Act 1952. Preliminary findings of this study indicate that the workers may develop stress and health effects like noise induced hearing loss (NIHL) if proper actions are not followed. Accordingly, suitable intervention suggestions were given to them. The results were further compared with World Health Organization (WHO) and Occupational Safety and Health Administration (OSHA) standards.

Keywords: Open-type hot forging, Fugitive noise intensity, Noise pollution, Time-weighted average.

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INTRODUCTION

Mechanization in forging manufacturing processes has increased production, improved in quality, and precision of products, and has boosted the economy of underdeveloped and developed countries throughout the world. However, noise is a major pollutant and a by-product of rapid industrialization in the last century due to the accelerated development of powerful high-speed machinery.[1,2] The deafening sound of open-type hot forging hammering strokes of one-ton or two-ton hammers of heavy machines threatens both the physical and mental health and well-being of many forging industrial workers.[3,4] In 1960, Burrows reported that noise is an auditory stimulus or stimuli bearing no informational relationship to the presence or completion of the immediate task.[5] Noise is any sound that is undesired by the recipient and may adversely affect the health and well-being of the individuals or populations. It is the perception of the wrong sound, in the wrong place, at the wrong time.[6] Stansfeld and Matheson defined occupational noise as an unwanted sound, which is perceived as an environmental stressor and nuisance.[7] Noise can auditory stressor to some people when it is unwanted; however, the same may be interpreted as a welcome sound or a social outburst of joy for others.[8] Occupational hazards like noise exposure are given the lowest priority among the workers of forging industries who are exposed to high-intensity hazardous noise to sustain their source of revenue for themselves and also for their dependent families. Most of these open-type hot forging industry workers are migrant laborers from North India. These migratory workers maintain a very unhygienic life and do not go for any personal medical check-ups related to their health and well-being. Also, manufacturing companies employ these migratory laborers without maintaining their respective occupational work life records, induction medical records in service, periodic medical check-ups, health-related problems, induction training, etc.

Occupational high-intensity noise exposure is a major threat to workers affecting their hearing mechanism, health, well-being, and quality of life.[9-12] The administrations of these industries are obligated to control the noise at source, at medium, and at the personal protective level as per statutory guidelines, safety rules, and regulations of Factories Act 1948, statutory guidelines of Central Labour Institute, Mumbai, Directorate of Factories and Boilers, Karnataka,

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Central Pollution Control Board, and State Pollution Control Board, yet the situation remains unchanged. In addition to high-intensity noise exposure, the working hours of each operator, his overtime working hours, wages, inductive and periodic medical examination, and issuing of safety personal protective devices should be controlled by the competent authorities of Central and State statutory bodies. According to the National Institute for Occupational Safety and Health (NIOSH), the workplace daily noise exposure of any worker should not exceed 85 dB(A)for protection against high-intensity noise hazard exposure in work environments.[4,10,13] The effects of noise exposure on humans range from disturbance or annoyance to temporary or even irreversible deafness.[11] These workers will likely develop noise-induced hearing loss (NIHL) in the course of their occupational work life. The objective of this study was to monitor the high-intensity time-weighted average (TWA) noise exposure of exposed workers.

METHODS

This study of personal noise dosimetry monitoring was conducted among forging industry workers working in the Bangalore industrial area of Industry I and II. The sample size of exposed workers in forging industry I and II were 20 and 23, respectively. The current study protocol (IEC Protocol 0020/ROHCS/IHEC/2022 version 1.0) was approved by the Institutional Human Ethics Committee, ICRM-ROHC(s), NIOH, Bangalore on its meeting held 07/07/2022. The workers recruited as volunteers in this study were identified by the management of participating industries who were working in hot forging units and there were no control subjects for this study. This study was a cross-sectional study which was carried out in 2024-25. Basic demographic details and occupational details were taken using a questionnaire. Informed consent was taken from all studied subjects of both industries. The personal noise intensity exposure monitoring was conducted by using an intrinsically safe, Type-II, noise dosimeter, model Noise Pro DLX (Quest Technologies, USA).[14] The Personal Noise Dose monitoring was done by attaching the microphone of the noise dosimeter to the forging industry worker's shoulder collar and the dosimeter instrument on his waist belt for the entire working shift of 8 hours.[14] This set-up of a personal dosimeter enables the undisturbed continuous logging of noise intensity level during the entire working shift.[14] The Noise dose monitoring was undertaken for full shift (portal to portal sampling) for all workers of the forging process.[14] The logging interval of the Noise Dosimeter was set at one minute with an exchange rate of 3 dB in slow response "A" weighting scale in dB(A).[14] This slow settings (500 $msec^{-1}$) measurement of noise intensity in Type II precision grade noise dosimeter instruments confirms ISO standards (1979).[14] The criterion level and danger limit value was fixed at 90 dB(A) in an eight hours shift for an unprotected ear having 100% noise dose and the warning limit value was fixed at 85 dB(A) as per the Directorate General of MineSafety, Circular No.18, 1975.[14-16] The different process of making heavy-duty rings and big nuts by the forging process is depicted in Figures 1 and 2.

Collected data were entered in a spreadsheet and processed for t-test considering the level of significance at $p < 0.05$.

RESULTS

The personal noise was monitored among the exposed workers of Industry I and II. The personal noise intensity monitoring data in Industry I, and Industry II, the percentage of samples exceeding the criterion level of 90 dB(A) is depicted in Table 1

It is observed all measured noise intensity samples of Industry I, II and combined data exceeded the 90 dB(A) criterion level. The preliminary findings of this study indicate that the workers may develop stress and NIHL health effects if proper actions are not followed or taken care. Figures 3 and 4 indicated the TWA, L_{EQ}, and L_{PEAK} noise intensity data of both industries.

The age-wise classification of subjects is depicted in Table 2. It is observed that the maximum number of subjects falls under the age group of 20 to 39 years followed by 40 to 59 years in Industry I, II, and clubbed data. Only 4 workers were above the age of 60 years in Industry 1 and none in Industry II was above 60 years.

Figure 1: Different forging processes in making heavy-duty rings

Figure 2: Different forging process in making heavy duty big nuts

Table 1: The personal noise intensity monitoring of Industry I, Industry II, and clubbed data

Industry data	*N*	*L_{EQ} dB(A)*	*L_{EQ}>90 dB(A)*	*L_{peak} dB(Z)*	*TWA dB(A)*	*TWA >90 dB(A)*
Industry I Personal Noise	20	94.22 ± 2.03 (91.0 - 118.8)	20 100%	139.78 ± 8.03 (124.3 - 150.5)	91.87 ± 1.47 (90 - 95.3)	20 100%
Industry II Personal Noise	23	96.77 ± 2.64 (90.9 - 121.8)	23 100%	141.35 ± 6.76 (124.8 - 150.7)	93.17 ± 1.65 (91.2 - 97)	23 100%
Clubbed data Personal Noise	43	95.59 ± 2.68 (90.9 - 121.8)	43 100%	140.62 ± 7.33 (124.3 - 150.7)	92.57 ± 1.68 (90.0 - 97.0)	43 100%

The majority of workers had less than 10 years of experience in Industry I, II, and clubbed data. Among workers in Industry I, 9 workers had work experience of 20 or more years in the forging Industry. However, none of the workers had more than 20 years of experience in Industry II (Table 3).

The results of the one-sample t-tests of clubbed data indicate that the average noise exposure levels for both Industry I, II, and clubbed data were significantly greater than the permissible limit and criterion level value of 90 dB(A). The t-tests for TWA, and L_{EQ} of all samples for Industry I, II, and clubbed data show statistically significant differences from 90 dB(A), with p <0.05. This indicates that the mean noise levels for variables TWA and L_{EQ} in dB(A) exceed the permissible limit and criterion level of 90 dB(A).

The L_{EQ} noise intensity between Industry I and II showed a significant statistical difference (t-test-3.521, p = 0.001). Industry II had higher L_{EQ} noise intensity compared to Industry I. The true difference in L_{EQ} noise intensity falls between 1.09 and 4.02 dB(A).

The comparative analysis of TWA in dB(A) by the Mann-Whitney test revealed that the TWA *p-value* was 0.022, which is less than 0.05, so there is a significant statistical difference in the TWA dB(A) noise intensity between Industry I and II. The mean ranks depict that Industry II has higher TWA noise intensity compared to Industry I, so there is a significant statistical difference between both industries.

Similarly, the comparative analysis of L_{PEAK} by the Mann-Whitney test revealed that the L_{PEAK} *p-value* was 0.770, which is greater than 0.05, so there is no statistically significant difference in the L_{PEAK} dB(Z) noise intensity between Industry I and II. The mean ranks are fairly close, which suggests that both companies are exposed to similar L_{PEAK} intensity of noise exposure.

Table 2: Age-wise classification of subjects in Industry I, II, and clubbed data

Age group in years	*The industry INo. of subjects*	*The industry IINo. of subjects*	*Clubbed data No. of subjects*
20-39	9	19	28
40-59	7	4	11
> 60	4	0	4
Total	20	23	43

Table 3: Classification of subjects based on experience in Industry I, II, and clubbed data

Experience in years of classed data	*The industry I No. of subjects*	*The industry II No. of subjects*	*Clubbed data*
<10 years	7	12	19
10–19 years	4	11	15
≥20 years	9	0	9
Total	20	23	43

DISCUSSION

This article deals with noise exposure to workers in the forging industry. The open-type hot forging industry workers are exposed to high-intensity continuous, broadband, intermittent, impulsive noise. The scope of this study is to monitor the workers' personal noise intensity exposure TWA_{8hours} high intensity of noise, generated by impulsive drop hammers of one-ton and two-ton capacities. High-intensity

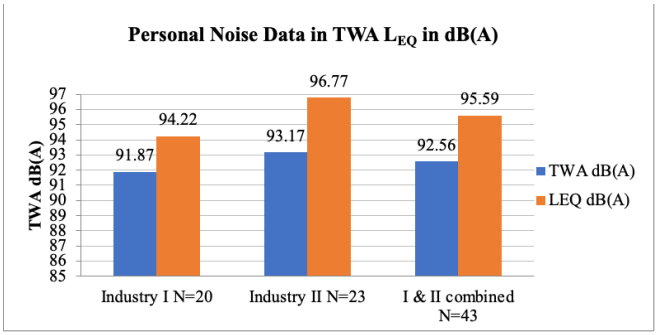

Figure 3: Personal noise data in TWA and L_{EQ} in dB(A)

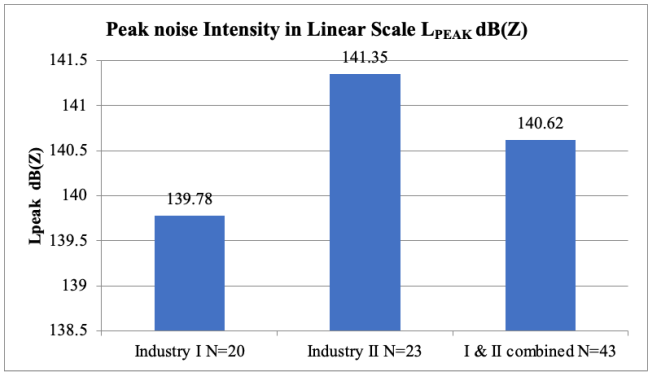

Figure 4: Graphical representation of L_{PEAK} noise intensity in dB(Z)

noise exposure to continuous, broadband, intermittent, impulsive noise may lead to temporary threshold shift (TTS) followed by permanent threshold shift (PTS) leading to NIHL in the long run.[1]

In India, the permissible exposure limit of noise intensity exposure for 8 hours of TWA criterion level is 90 dB(A), which is also the danger limit value and 85 dB(A) warning limit value.[2,15,16] The noise intensity was above the acceptable limit for all samples collected from both industries. The intensity onset of NIHL differs from person to person, depending on his/her physiological conditions, moderation of noise exposure level, frequency, and duration of exposed time.[12] The impact of noise intensity on human beings is physiological and psychological. NIHL is the most common effect among exposed workers.[1,2]

The WHO has documented seven categories of adverse effects of noise pollution on human beings which are annoyance, irreversible hearing loss, cardiovascular effects, sleep disturbance, and mental illness.[1,2,7,9-12,17,18] Besides these, high-intensity noise exposure affects concentration during work, requires more time for the worker to complete the assigned job, and the onset of fatigue and feeling of tiredness is quicker among the exposed workers. The efficiency, quality, and precision of work output deteriorates and productivity output decreases among the exposed workers.[1,2,7,10-12]

Occupational high noise intensity exposure TWA and L_{EQ} was above 90 dB(A), in both industries I and II. It is a major hazard among the workers working in both these industries.

The interaction with workers of both industries reveals that most workers were illiterate, having an addiction to drinking alcohol, chewing tobacco (*Khaini*), and smoking *biddies* and cigarettes. They stay alone without their families in shared unhygienic clustered accommodation. The workers complained of speech interference, headache, ringing sensation in their ears, irritation in their ears, and annoyance. Some workers were slurring in their speech. None of them were wearing earplugs or earmuffs. The main reason for not using the personal protective device (PPD) in the hot forging process is the glass wool earplugs, which have a wax coating that melts in a hot fugitive environment. In the case of an ear muff, the synthetic lining cover of the outer ear which touches the skin around the ear pinna (tragus, helix, and lobule) melts in the hot working environment. All workers work without using PPD. The workers are illiterate and there is a lack of awareness regarding the impact of noise on the human hearing threshold.

Informal interaction with workers revealed that besides noise hazards, they also faced occupational heat stress, infrared light, peripheral burn or deep burn, hand-arm vibration exposure hazard, and poly aromatic hydrocarbon exposure hazard. Most of these workers, approximately 60%, have served in the forging industry for more than fifteen years. Further, 74% of workers revealed that they were disturbed by their occupational noise exposure. They were having physiological problems like headache, backache, wrist, elbow, and shoulder joint aches. Some workers, especially old workers above 55 years, were having numbness in their hands and fingers.

Limitation of the Study

There were no control subjects in both forging industries, so a comparative study between exposed and unexposed workers could not be carried out. The exposed forging workers were supplied as per employment rules by both forging industries. Follow-up studies were not possible as most workers were migratory and came from different parts of the country.

Besides noise, workers were exposed to other hazards also. However, these parameters, like heat stress, infrared light, hand-arm vibration, and toxic fumes were not covered, as they were beyond the scope of the study.

CONCLUSION AND RECOMMENDATIONS

The noise intensity was above the danger limit value of 90 dB(A) for all Industry I and II samples as per the Factories Act 1948, Mines Act 1952, OSHA, and WHO standards.[1,18-20] Noise pollution is a chronic occupational hazard of the open hot forging industry. Further studies will evaluate the impact of high-intensity noise on workers' hearing thresholds. However, from the present study, the management of these industries may formulate mechanisms to control high-intensity occupational noise by changing the engineering

design of hammers and forging machines cover to control the noise at source and medium. Suitable heatproof ear muffs and ear plugs are necessary to control noise at the personal protective level and to protect the forging industry workers from noise-induced hearing loss. Rotation of work to lesser noise-prone areas is necessary for forging industry workers.

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PEER-REVIEWED CERTIFICATION

During the review of this manuscript, a double-blind peer-review policy has been followed. The author(s) of this manuscript received review comments from a minimum of two peer-reviewers. Author(s) submitted revised manuscript as per the comments of the assigned reviewers. On the basis of revision(s) done by the author(s) and compliance to the Reviewers' comments on the manuscript, Editor(s) has approved the revised manuscript for final publication.