

SAFETY ANALYSIS AND IMPLEMENTATION FOR SAFER DESIGN OF WOOD PROCESSING MACHINES; A CASE STUDY OF SOUTHERN NIGERIA

Okuma Silas Oseme^{*1}, Ejiroghene Kelly Orhorhoro^{*2}, Olorunleke Aregbe^{*3}

^{*1}Department of Mechanical Engineering, Nigeria Maritime University, Okerenkoko, Delta State, Nigeria.

^{*2,3}Department of Mechanical Engineering, Igbinedion University Okada, Edo State, Nigeria.

ABSTRACT

Machines used in wood processing industries are dangerous, especially when handle without proper safeguards. Workers can suffer injuries from minor cuts to amputations and blindness. This research work is focused on the safety practices of wood processing machines, basically industrial circular saw and band saw. Data used in this present work were collected using structured questionnaires approach; through inspection of records and individual interview from sawmill industries in Southern Nigeria on machine operations that can possibly result in mishaps. The education acquired, age, level of skills of persons using the machines, and the degree of injuries suffered by them were considered. The analysis of data was done using descriptive statistics and this was based on American Injury Scale (AIS) rating. The results obtained show that injuries sustained are due to carelessness of the machine operator, inadequate safety skill on machine operation and machine setups without appropriate safety guarded systems. A safer design mechanism was recommended for the machines currently in use in the study area.

Keywords: Sawmill, Wood Processing Machines, Hazard, Kickback, Circular Saw, Band Saw.

I. INTRODUCTION

One of the main wood processing industries in Nigeria is located in Delta State known as Africa Timbers and Ply Wood (AT&P). The state is ranked among the highest producer of timber in Nigeria due to its predominant high rainfalls and numerous rain forest. The essential wood products produced and utilized and traded in Nigeria are sawn-wood, plywood, particle boards, new-print and papers. Fifty percent (50%) of timber process in Nigeria are mostly privately owned sawmill. This industry is a thriving business in Southern part of Nigeria because of the availability of timber as well as current high demand for the product in the local market. The processing of wood has gotten to the limits of accessible forest resources such that the future increase in wood production, revenue, and sustainability could be derived from further processing of sawn wood, rather than the usual area expansion of sawmill and exploitation of wood resources. The prerequisite for wood processing industries integration has been emphasized by [1-3], thus, efforts should be geared towards having most of the wood processing industries in the country integrated [4].

Many of the ventures belong to either small or informal sector. The informal sawmill are usually characterized by number of staff and is commonly one to five casual workers as minimal staff strength while the registered sawmill industry have an average of ten to twenty staff. Also, the nature of the work carried out by workers in these profession, the types of equipment used, and materials they handled have resulted to injuries on the job. The injuries suffer from such incidence includes being struck by the machinery, falling, heavy lifting or repetitive movement and twisting. Machine used in wood processing are dangerous particularly when handled indecorously or without proper safe guards, workers/operators can suffer various degree of injuries from minor cuts, amputations, blindness, etc. Wood processing machinery can cause injury from improper operation or from poor maintenance. Individual wood processing machines must be evaluated for specific operating hazards. Thus, personal protective equipment and proper understanding of the safety concerns is required to address them with engineering and administrative controls [5-7]. Primary hazard that causes immediate injury to workers such as cuts and lacerations can result from machines threat, kickbacks, flying chips, tool projection etc.

As a result of this analysis, it was observed from literature that the rate of awareness on safety measures, appropriateness of safety equipment, economic of safety programs, extent of implementing safety rules

and regulations, efficacy of safety related events is low in many wood processing industries. Various causes have been reported for injuries related cases among which are negligence, physiological impairment, economic obligation, dawdling responses, and other age related issues among older age group [8]. Furthermore, in developing countries with low-income, majority of agro processing workers are not insured. Also, adequate infrastructure for medical facilities and enforcement of safety standard to protect workers from injuries are lacking. According to the International Labour Organization (ILO) publication on a manual for safety in Agriculture titled "Guide to safety in agriculture", the High-Income Country (HIC) are safety cautious, thus safety rules and regulations are properly implemented but the reverse was the case among Low-Income Country (LIC). Nevertheless, several safety standard as references have been schedule for agricultural activities that covers safety standard for agricultural processing machines operators and control [9]. There are several reported cases of disabling injury yearly among operators of agro-mechanical and the causes of the injury is mostly often describe as multiple and sequential [10]. Nonetheless, a complete safeguard can be accomplished by effective maintenance culture, awareness and safety performance. Although, this embroils a serious task since there is going be consideration base on the rules and resolution to be taken on the equipment in order to avoid accidents that can amount to huge financial loss. This is evident from [11] assessment of safety practices which divulge a financial loss that is estimated at \$49.7 million. This cost could have been minimized or avoided if good and safer design of these processing machines was in place. Therefore, with the magnitude of wood processing machines injury among operators, a safety evaluation and the possible factors that can influence machine injuries were conducted in this study.

II. RESEARCH METHODOLOGY

The study was conducted in three states in Southern Nigeria. The states include Delta, Edo and Bayelsa state. The choice of these states stems from the fact that over 60% of the small scale wood processing industries in these location deals with milling, sawing and integrated mill process. In each of the aforementioned state, wood processing industries within the states were visited, workers interview, and findings documented. As depicted in Fig. 1 is the picture of some selected wood processing industries across states in Southern Nigeria.



Fig-1: Picture of some of the Selected Wood Processing Industries in the Study Area

In this study, data on sawmill related injuries were collected from workers from different sawmill industries visited. A purposeful sampling technique was adopted to select from the industries, The research method for primary data collected for the study include on the spot assessment [12] for physical appraisal of safety workplace. The respondent are made up of sawmill machine operators and maintenance personnel's. The employees of the sampled of selected wood processing industries was used as the targeted population and 96 filled questionnaires was used for data analysis.

In the survey, daily injury data resulting from the activities of the industries over a period of five (5) years were collected through the use of interview, structural questionnaire, personal observation and the vetting of records. Although as a results of bad record keeping among wood processing industries in the area, limitations on data collection were encountered. The collected data were analyzed using descriptive statistic [13] and according to work-related hazard survey conducted by the National Occupation Health and Safety Commissions [14]. Thus, band saws and circular cut saws wood processing machine commonly used in the study area was considered. Each accidents/injury was analyzed considering body area affected and machine operations resulting to injury.

III. RESULT AND DISCUSSION

The statistical data of the frequency of age group of the respondents selected in the wood processing industries and their corresponding percentage are shown in Fig. 2 and Fig. 3. Also, as shown in Fig. 2, the majority of the workers are above 45 years without proper safety training. It was also observed that teenagers and youth within the age of 15-25 years equally worked in several wooding processing industries in the selected area. The percentage of the age group of the respondents as shown in Fig. 3 revealed that able bodies within the age of 25-34 years made up 31% while ageing people above 45 years was 33% of the 96 selected respondents across the three states used in this study. Also, respondents within the age range of 35-44 years and 15-25 years are made up of 25% and 11% of the total respondents.

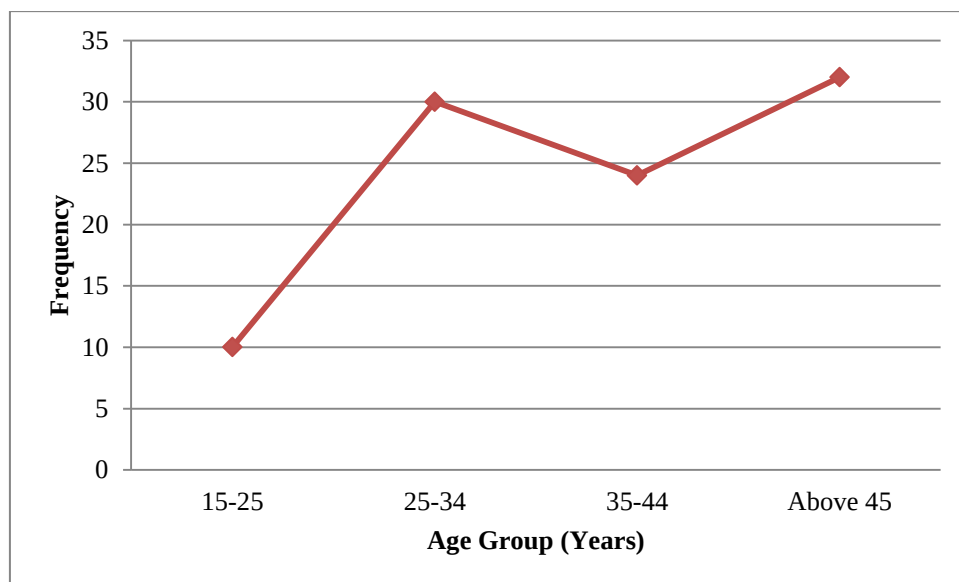


Fig-2: Frequency of the Age Group of the Respondents

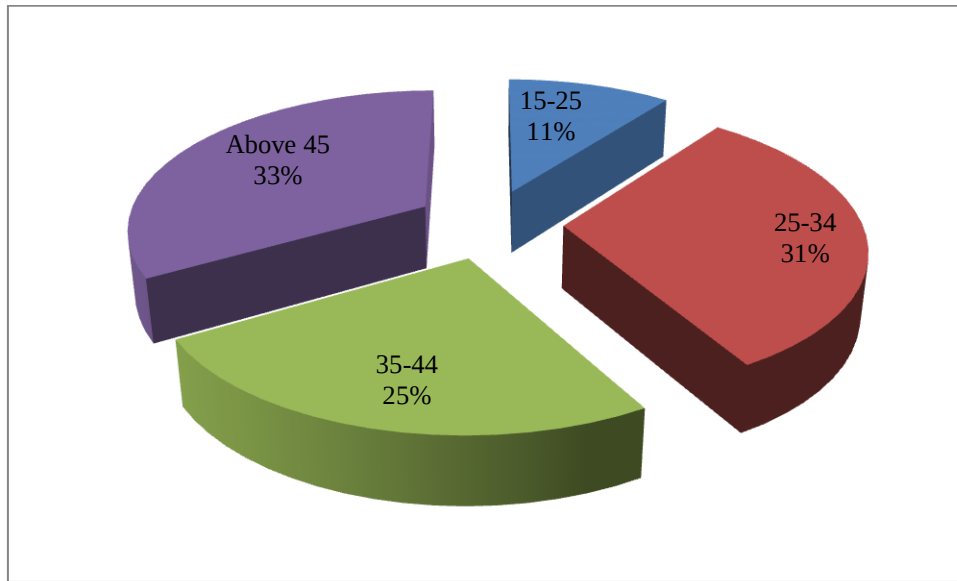


Fig-3: Percentage of the Age Group of the Respondents

The level of qualification of the respondents and their percentages are shown in Fig.4 and Fig. 5 respectively. The outcome of the results showed that majority of the workers are people with secondary school leaving certificates (60 persons) and primary school leaving certificates (30 persons) without basic safety training. Thus, they worked daily in the industries without safety kits (Fig. 1) and safety precautionary measures are not followed. With just 8% with higher certificates and half of the numbers without previous industrial experience, safety procedures are hardly followed.

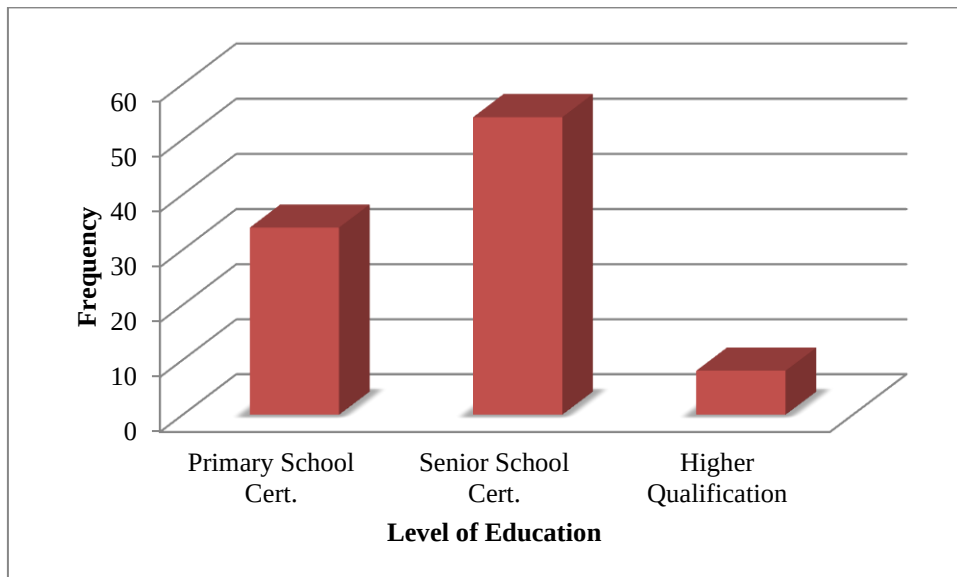


Fig-4: Frequency of Level of Education

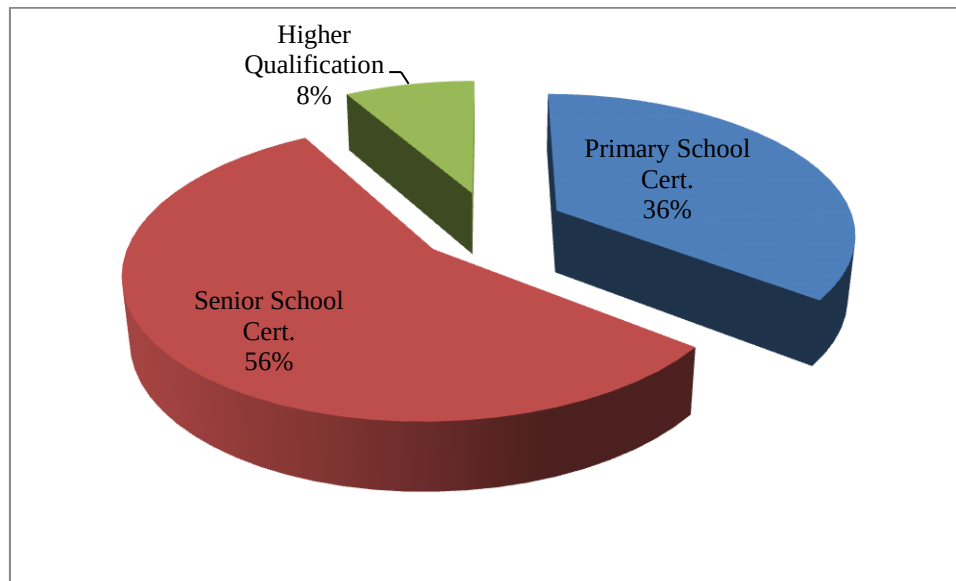


Fig-4: Percentage of Level of Education

The level of operators trained on the certified safety technique to operate the machine is 35% as showed in Table 1 and this falls below average. This can be deduced as a major factor responsible for the increase in cases of accident in wood processing industries in the study area.

Table-1: Level of Safety Training Acquired

S/N	Machine Operator	No of Workers	Percentage (%)
1	Circular Sawmill	32	15.00
2	Band sawmill	46	12.00
3	Maintenance	18	8.00
Total		96	35.00

Table 2 shows the machine where accidents cases occurred, the operation performed at the time of injury and part of the body affected. Cases of injuries in the back and low back region was recorded highest with 35.47% due to poor positioning during machine operations and these as resulted to loss of postures and back pains disorders. The injury takes time to be observed, hence interaction with workers with such feasible deformities regarded not as an injury but natural occurrence. Wrist and hand injuries were also on the increase at 29.07%. These include fingers cuts or hand due to carelessness on the part of the operator during machine handling.

For the essence of difference in term of body parts most susceptible to injury cases, body area was classified into three major segment as follows; upper limbs injuries, back injuries and lower limb injuries. Upper limb injuries (shoulder, arm wrist and hand) were more prominent (96.5%) and lower injuries were less prominent (3.5%). The distribution of injury between upper limb, back/low back and lower limb were relatively consistent with most industries in the region where manual handling of machine was present because the upper limb are the body area most commonly engaged in these functions.

Table-2: Injuries to Body Area due to Wood Processing Operations

S/N	Body area affected	Milling using Circular saws	Milling using Band saws	Maintenance	Total Injury cases	Body injury among 96 workers (%)
1	Neck and head	3	2	2	7	4.07
2	Back and low back	27	20	14	61	35.47
3	Abdomen and Chest	2	0	0	2	1.16
4	Shoulder	4	3	5	12	6.98
5	Arm	8	16	10	34	19.77
6	Wrist and hand	20	18	12	50	29.07
7	Hip/Leg	0	1	5	6	3.49
	Total	64	60	48	172	100.00

IV. RECOMMENDED MODIFICATION

Having carried out the research work on safety analysis and implementation for safer design of wood processing machines in Southern Nigeria, it was observed that modifications are urgently required. Therefore, for effective safety performance of industrial circular saw and band saw, the following are recommended;

- A guard with specific design that will aligned with the require machine must be fitted to prevented access to the saw teeth or feed drive hob during operation. These fabricated guards must be incorporated in all the area of the machines that will pose a high risk to accident. For example, considering placing a fixed guard over the area of the machine where the crushing hazard exists. The design will need to allow wood to pass underneath the guard but the ingoing and outgoing aperture should be small enough to prevent worker access to the dangerous parts.
- One of the most unsafe operation that have resulted in 45% accident cases is the process of adjusting the packing of circular saw while the blade is running. There have been many cases of incident where fingers have been severed during the adjustment of the packing of a running saw because of the closeness to the saw blade. These can be modified by increasing the adjusting screws so they extend past the sides of the bench or hand adjustment can be fitted to the front of the bench by the use of steels rod and swivel joints.
- Machine vibration during operation has exposed workers to increased risk of low back pains, loss of balance and shakiness. This can be controlled by installing a proper rubber footing or other form of damping suspension to reduce the degree of vibration.
- A protective material should be inbounded in the machinery to cover the area between the table and the lowerhood. This will reduce dust level.

V. CONCLUSION

From the outcome of the research work carried out safety analysis and implementation for safer design of wood processing machines; a case study of Southern Nigeria, it could be deduced that there is an urgent need for the development of safer design and modification of wood processing machines which is targeted to reduce the degree of occurrence of accident/injury among workers. The analysis also revealed that most accident occurs as a result;

- The categories of operators in the industries did not undergo a mandatory safety training to equip them on the necessary safety skills required in operating the machines.

- Of the carelessness among workers especially the machine operators.
- Poor installations of machines have made operators prone to accident during operations.
- Machines manual instructions guidelines must be adhere to when carry basic operations.

VI. REFERENCES

- [1] Omoluabi,A.C 1985. Development of the Nigeria Particle Board Industry. Ph.D Thesis Department of Forest Resources Management. University of Ibadan.317pp
- [2] Oyagade.A.1997. Nigerian rainforest conservation: The challenge to the wood-base sector. Proceeding of 25th Annual conference of forestry Association of Nigeria, pp.299-304
- [3] Larinde,S,L.2008.Techno-economic analysis of sawnwood processing into furniture parts in a vertically integrated sawmill in Ibadan,Nigeria Unpublished Ph.D thesis, Department of forest Resources Management, University of Ibadan, Nigeria.Pp 182
- [4] Larinde, S, L.2010.Secondary wood processing and the Nigeria sawmill Industry, pp.25
- [5] Baybutt, P. (2017). Issues for security risk assessment in the process industries. Journal of Loss Prevention in the Process Industries, Volume 49, pp.509-518
- [6] Alli, B.O. (2008). Fundamental principles of occupational health and safety. Geneva: International Labour Office
- [7] Sylvia A., George A. , Bernard E., Frimpong-Mensah K., Charles A. (2015). Safety Measures in Wood Processing: An Important Component for the Entrepreneur - The Case of a Local Furniture Industry in Ghana. International Journal of Innovative Research in Science, Engineering and Technology, 4(5), pp.2677-2686
- [8] Muckala, K. A. (1967) Farm accidents and their prevention: an Epidemiological approach. Minnesota Med. 50, pp.1477-1482
- [9] Mohan, D., Patel, R., (1992) Design of safer agricultural equipment: Application of ergonomics and epidemiology. International Journal of Industrial Ergonomics 10, 301-309.
- [10] Jorgensen K. (2016) Prevention of "simple accidents at work" with major consequences Safety Science 81, pp.46-58
- [11] Adebisi, K.A., Charles- Owaba, E.O., Jekayinfa, S.O, (2005). An Appraisal of safety practices in agro-allied industries in south western Nigeria. Journal of Disaster prevention and management vol. 14(1), pp.80-88.
- [12] Robson 1993.Real World research a resources for social scientist and practitioner's researchers Oxford Blackwell, pp.228.
- [13] Gomez. K.A and A.A Gomez 1984.Statistical procedures for agricultural research 2nd edition. John Wiley&Sons, New York.
- [14] NOHSC 1998-1999.Work related traumatic fatalities involving timber activities in Australia. Epidemiology unit. National occupational Health and Safety commission Sydney.