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Safety Evaluation and Suggestion for Safer Design of Some Selected of Agro – Processing Equipment Used in Oyo State, Nigeria

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ABSTRACT

This study investigates safety practices of agro-processing equipment basically Maize – Sheller and Cassava – Grater. Data were collected using structured questionnaire, vetting of records and personal interview from small scale agro-processing industries in south western Nigeria on machine parts which usually result in accidents. Sex and ages of people using the machine tools, and nature of injuries incurred by them were put into consideration. The analysis was done using classical statistics and American Injury Scale (AIS) rating. The result shows that injuries occur due to: carelessness of operator, belt slippage due to vibratory effect of the machine as a result of poor installation of engine, slip off of winding lever and sharp edges of the hopper. A safer design was proposed for the machine considered.

Keywords: Agro-processing equipment, Cassava – grater, Injuries, Maize – Sheller, Safety.

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1. INTRODUCTION

Nowadays, the increasing complex technologies used in major industries such as chemical processing, nuclear power generation, waste removal, mining, petroleum and agro- allied industries means that, while day-to-day operation are without incident, there are also potentials for disaster when usual safeguards are defeated by combination of events. More so, with rapid industrialization and technological development, most manufacturing system rapidly grow in scale and functionality and it become more and more difficult to guarantee safety practices thereby resulting to infrequent accidents.
In the early fifties, the indigenous manufacturing of equipment for processing agro-based raw material into industrial input materials started. The demand for cheap agro-processing equipment (e.g. threshers) led to design of equipment with inadequate safety measures resulting in to a large number of fatal accidents (Singh, 2005, 172). Agro processing industries also plays a crucial role in the industrialization process of the developing countries. Although its importance declines as industrialization advances, yet with rise in income and with increased urbanization, the demand for more complex and diverse types of processed food increases (Quartey and Darkwah 2015, 100).

Machine efficiency, safety factors and portability are some necessary considerations needed in fabrications of agro allied machineries (Adetunji and Quadri 2011, 120). Research carried out on the safety practices of agro-processing equipment in manufacturing industries reveal that, world over, fatality rate for agro-processing industrial workers are higher than all other industrial work as seen in the works of Mohan et al (2004, 44), Mohan and Peter (1992, 301), Horsburgh et al (2001, 489) and Rautiainen and Reynolds, (2002, 259). In today's developing world, human being's innovative ideas had taken the world in all direction concerning the production and safety in industrial establishments (Mali et.al, 2015, 10). Agro-processing equipment related injuries involve all age group. Farmers, unlike industrial workers, work as long as they can along with their family members irrespective of age (Steuland et al, 1990, 530). In view of this analysis, the degree of safety awareness, adequacy of safety equipments, extent of enforcing safety rules, effectiveness of safety related activities and economics of safety programme is low in many farms and small-scale agro processing industries. Various reason have been reported for injuries, among which are economic necessity, slow reflexes, carelessness, physiological impairment and other age related reasons in older age group, (Muckala 1967, 1478).Also, the quality of inputs in mechanization and land and labour productivity may differ considerably (Ghadiryanfar 2009,121).

In Low-Income Countries (LICs), agro-processing workers are covered by neither insurance nor do they have adequate infrastructure for medical facilities and their safety standard and enforcement are also not enough to protect workers from injuries. The International Labour Organization (ILO) published a manual for safety in agriculture titled "Guide to safety in agriculture" which was useful in High-Income Country (HIC) but had little impact or contribution in low-income country (LIC). Nevertheless, a large number of safety standard have been scheduled for agricultural activities that covers safety standard for agro-processing equipment, workers/operators and control (Mohan and Peter 1992, 301and 302) Farmers suffer a disabling injury each year (about 170,000 injuries as given by Steuland et al 1990, 529) and at a cost of $2.5 billion for hospitalization and rehabilitation (Reed and Claunch, 2000, 70). The causes of accidents are most often described as multiple and sequential; the events as sudden, unexpected and unplanned and the consequences as harm to people, materials, production or other values (Jørgensen, 2016, 47).

However, absolute safeguard can be achieved by effective maintenance culture, consciousness and safety performance. This involves a serious task by considering the rules and revolution to be taken on the equipment in order to avoid accident leading to huge financial loss. This is evident from Adebiyi et al (2005, 87) appraisal of safety practices, which reveal a financial loss of about $49.7 million. This cost could have been minimized or avoided with good and safer design of this agro-processing equipment. Therefore, the magnitude of processing injuries among workers and safety evaluation of the factors influencing equipment injuries were conducted in this study.

2. METHODOLOGY

In this study, data on agricultural related injuries were collected from farms in Oyo-state, south west Nigeria. Different small scale agro- processing industries were visited. A purposeful sampling technique was adopted to select some agro-processing industries with heavy agricultural activities and use of modern technology. In the survey, injury data from agricultural activities over a period of 5 years were collected through the use of a structural questionnaire, interview, personal observation and the vetting of records. However, restrictions on data collection were encountered due to bad record keeping of these small scale agro – processing product manufacturing industry. Thus, two agro – processing equipment being commonly used were considered (Cassava grater and Maize sheller). Each accident was analysed considering the age of the victim, sex, part of the body injured, nature of injury and part of equipment damaged. Data were analysed using basic statistics (using measure of central tendency (mean) and percentages); and American Injury Scale (AIS). Based on the information on factors associated with injuries, engineering design intervention was developed which are suitable for retrofitting in the existing machine and for incorporating in new machine.

2.1 Cassava Grater

The grating process has been an age long process and different type of method of grating has been developed with time. Cassava grater can be broadly classified into the manual and motorized type.

Types of Cassava Grater

- **Manual grater**

The manual grater is further sub divided into two, namely the flat perforated metal sheet type and pedal operated type.

For the flat perforated metal sheet grater, it is the type commonly used by the local producer of garri. The grater consists of wooden brand of about 15cm wide and 40-60cm long. The wooden surface is covered with perforated metal sheet of the same dimension. The fine grated cassava paste is formed by rubbing the cassava tubers to and fro on the perforated metal sheet by the processor.

- **Pedal operated cassava grater**

Another form of the manual operated grater is an improvement over the flat perforated metal sheet, which is the pedal operated cassava grater. The machine consists of the grating surface being perforated found on a circular piece of wood. There is a shaft that runs through the wood. A small diameter pulley is connected to one end of the shaft with key while the other end carries the flywheel. The small diameter pulley found at the bottom of the machine frame with a v- belt. The pedal works in conjunction with the large diameter pulley. It transfers the reciprocating motion of the pedal to a rotary motion on small diameter pulley which rotates the grating drum.

- **Motorized cassava grater**

The second type of cassava grater is the motorized type. This is an improvement over the manual type. It can move faster than the manual type. It is made up of a metal frame that carries the entire body of the machine. A grating drum made up of perforated sheet of metal is wrapped round the cylindrical shaped wood. This grating drum is enclosed in the pieces of wood, which carries smaller pulley being connected to another pulley, then later connected electric motor or the internal combustion engine with a belt.

However, he machine consist of the following components

i. Hopper.
ii. Grating drum
iii. Frame.
iv. Internal combustion engine
v. Pulley
vi. Flywheel

2.2 Maize Sheller

The different methods of maize shelling can be categorized according to Nwakairea et. al. (2011, 50) as:

(i) Hand technology which involves the use of hand tools in shelling, while as observed animals were used in threshing on the field by marching on the maize. The method is unsatisfactory, because of their low output, tediousness and their requirement of extra strength (Hassan et. al. 2009, 199).

(ii) Engine powered technology which involves the use of mechanical assistance in threshing or shelling the maize. The performance of a sheller depends upon its size, cylinder speed, cylinder concave clearance, fan speed and the sieve shaker speed (Oni and Ali 1986, 40). Also, the properties of the crop that affect the shelling performance are crop variety, shape and size, hardness of the seed, the moisture content of the seed and density (Hassan et. al. 2009, 199).

Maize Sheller is used to separated maize grains from its cob. Maize grains are used as feed mill in poultry. It consists of the following components:

- The frame
- The hopper
- The threshing compartment
- The aspirator
- Cob, straw and trash outlet
- Oscillatory compartment
- Prime mover / primary engine seat
- Clean grain outlet
- Sheave and motor

3. RESULTS AND DISCUSSION

This section presents the results and discussion based on the magnitude of the injury.

3.1 Injury magnitude for cassava grater

A total of 34 injuries were reported. Cassava grater accounted for 19 (55.89% as shown in Table 1) of total agricultural injuries with minor injury having the highest percentage as shown in Table 2. The machine is used to grind cassava which is used to make *garri*, *fufu*, Starch, e.t.c., after processing. The usage depends on the number of peeled cassava available. On an average, cassava grater is operated for about 4-6 hours daily. Over twenty five machines are found in villages visited and comprising both pedal operated and motorized types.

3.2 Injury Magnitude for Maize Sheller.

Maize sheller accounted for 15(44.11%, as shown in Table 1) of the total agricultural injuries recorded with minor and moderate injuries having the highest percentage as shown in Table 2. On an average, maize Sheller is operated for about 5-6 hours daily depending on the season. During the dry season work are quiet many since the maize would have dried up. Over thirty maize sheller machines were found in places visited. Based on the data collected, from observation and oral interviews of the visited locations the causes of accident under maize sheller and cassava grater may be summarized as follows:

a. Carelessness of operators
b. Belt slippage due to vibratory effect of the machine as a result of poor installation of engine
c. Slip off of winding lever, sharp edges of the hopper
d. Loose garment being wore by the operator.

Table 1: Distribution of Injury by Type of Agricultural Implement Used and Severity of Injury

Implement	Minor	Moderate	Fatal	Total %
Cassava Grater	14	4	1	19(55.89%)
Maize Sheller	7	7	1	15(44.11%)
Total %	21(61.77)	11(32.35)	2(5.88%)	34(100%)

Table 2: Distribution of Injury by Type of Agricultural Implement Used and Age of Victim.

Implement	0-4	5-14	15-24	25-54	55-64	65	Total%
Cassava Grater	-	2	6	5	1	1	20 (10.37)
Maize Sheller	-	3	9	5	2	1	15 (7.77)

Thus, Tables 3 and 4 show machine parts that contribute to injuries in using cassava graters and maize shellers, respectively. Base on the information on factor associated with injuries, engineering design intervention was develop which are suitable for retrofitting in the existing machine and for incorporation in new machines.

Table 3: Machine Parts Involved in Cassava Grater Injury.

Case No	Ages	Sex	Body Part	Injury	Machine Part
1	22	Male	Left hand	Deep cut	Belt
2	18	Female	Right hand two finger	Deep cut	Shaft
3	22	Female	Left hand finger	Deep cut	Belt
4	25	Male	Whole body	Discomfort	Foundation
5	23	Male	Right hand	Slight cut	Grater
6	24	Male	Jaw	Swollen	Winding
7	18	Male	Teeth	Deep cut	Winding
8	14	Male	Right hand	Slight cut	Grater
9	23	Male	Right hand	Slight cut	Grater
10	13	Male	Neck	Strain	Hopper
11	14	Male	Left leg	Fracture	Shaft
12	65	Male	Right leg	Fracture	Shaft
13	22	Female	Neck	Stain	Hopper
14	62	Male	Left hand	Fracture	Winding
15	56	Female	Right hand	Slight cut	Grater
16	40	Male	Whole body	Deep cut	Shaft
17	53	Male	Chest	Pain	Winding
18	42	Male	Left hand	Deep cut	Shaft
19	30	Female	Left hand two finger	Amputation	Grater

Table 4: Machine Parts Involved in Maize Sheller Injury.

Case No.	Age	Sex	Body Part	Injury	Machine part
1	56	Male	Right hand	Slight cut	Belt
2	54	Male	Right hand	Deep cut	Shaft
3	24	Female	Right hand two finger	Slight cut	Belt
4	32	Female	Left hand two finger	Deep cut	Shaft
5	65	Male	Left hand	Slight cut	Belt
6	23	Male	Shoulder	Pains	Belt
7	22	Male	Left hand two finger	Amputation	Belt
8	14	Female	Right hand	Slight cut	Hopper
9	30	Male	Hand	Dislocation	Winding
10	24	Female	Hand	Fracture	Gear
11	50	Male	Head	Fracture	Winding
12	13	Male	Whole body	Body pain	Machine
13	24	Female	Head	Swollen	Gear
14	26	Male	Left leg	Swollen	Roller
15	52	Female	Left leg	Slight cut	Roller

4. MODIFICATIONS

The necessary modifications are suggested for effective safety performance:

4.1 Necessary Modifications in Cassava Grater

The following parts of cassava grater are modified accordingly for effective safety performance:

Foundation

Poor installation of the internal combustion engine as resulted into 1 (5%) of the injury recorded. The injuries recorded occur as a result of vibrations which affect both the operator and the machine. For the installation of internal combustion engine, the following should be considered:

(a) Engine should sit on a footing; the area of the footing should be calculated
(b) It must be ensured that the bearing capacity of the soil must be greater than the load, thus, a foundation should be made for the machine.

There is another type of load known as vibration. This can be control using a special type of bolt called foundation bolt via the excavation of the ground. Additionally, concrete is added (the concrete must be allowed to dry up for 28 days) .The concrete is to bear compression and not tension. Vibration causes fatigue and bolt can break as a result of fatigue, for the bolt on the machine, one should use a fatigue resistance bolt and a washer to reduce noise.

Winding (Manual start off of the Machine)

Before the internal engine could start, winding is done and this resulted into 4(20%) of the total injuries recorded. The accident caused by this process is quite bad that engineering intervention is necessary. There is the need to introduce auto start control switch which will on and off the engine. This will make it possible for older people (60years and above) to operate the machine.

Hopper

Hopper recorded 2(10%) of the total injuries. The hopper should be blunted at the edges to prevent accident. Also, the ergonomics assessment of the equipment should be studied to determine the height of the hopper in respect to the total height of the equipment for ease of use by the operator.

Belt

Use of belt by operator has resulted into 3 (15%) of the total injuries recorded. Most operator uses wear belt in order to reduce cost, to prevent this, a standard period for the use of a belt should be stipulated and communicated to all operator.

Shaft

At certain speed, a rotating shaft will become dynamically unstable and the resulting vibration and deflection that occur result in damage of not only the operator, shaft but to the machine of which it is a part. The speeds at which such dynamic instability occurs are called critical speed of the shaft. A shaft may be safely operated either above or below its critical speed, good practice indicate that the operating speed be at 20% above or below the critical speed. Also, the applied torque should be increased. If these is practiced it may reduced about 25% of the injuries recorded.

4.2 Modification of Maize Sheller

The following parts of maize sheller are modified accordingly for effective safety performance:

Gear Cover

The safety gear cover is made out of mild steel shaft, which cover the open gear system available on the maize sheller. It can be fitted with the help of two bolts/nuts to the body of the maize sheller. On the sides, the plates have been bent to cover gear from the sides. At the top, the centre hole has been provided for facilitating the lubrication of gear.

Belt

It is noted that for most maize sheller, the internal combustion engine and the flywheel are placed in front of the hopper. It is advisable that the engine is placed by the side or back of the hopper.

Winding

An internal combustion that will have a switch should be incorporated.

Finger Guard

A finger guard should be installed on the hopper. This would prevent cut when dropping the maize into the machine.

5. CONCLUSIONS

In the course of the analysis carried out with respect to this project, it could be deduced that there is the need for the development of safer design and construction of agro-processing equipment which is targeted to reduced to minima level, the occurrence of accident among users.

The following conclusions were also drawn from the outcome of the survey and analysis.

- The analysis shows that most accident occur as a result of the carelessness among operator
- Poor installation of engine affects operator and efficiency of machine.

6. RECOMMENDATIONS

The following recommendation are made for greater efficiency and effectiveness in the use of agro-processing equipment so as to have the desired output in the utilization of the equipment and also to reduce in injury occurrence level

- Placement of the internal combustion engine at the back of the hopper.
- Proper installation of the internal combustion engine by following earlier stated rules.
- Regular maintenance of the machine by strictly adhering to the standard method of operation and maintenance guidelines.
- The transmission line (belt) should be guarded to enhance the safety of the operator.

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