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Critical Evaluation of Locally Fabricated Maize Shelling Machine

[1]Adewole, C. A., [2]Babajide T. M, [3]Oke, A. M., [4]Babajide, N. A. [5]Aremu, D. O. and [6]Ogunlade, C. A.,
[1]Zartech Farms ltd, Ibadan, Oyo State, Nigeria
[2]Dept. of Agricultural Economics, University of Ibadan, Nigeria
[3]Dept. of Agricultural Engineering, Adeleke University, Ede, Osun State.
[4]National Rice/Maize Center, c/o Federal Dept. of Agric., Moor Plantation, Ibadan
[5]Dept. of Agricultural Engineering, Federal College of Agriculture, Ibadan, Nigeria
[6] Department of agric and Environmental Engineering, University of Ibadan, Nigeria.

Abstract-Maize shelling has been a tedious operation over the years; it takes weeks and causes pain and hand injuries, efforts have been made by artisans, welders and local fabricators at constructing some shelling machines for maize in Nigeria. This research work evaluates some locally fabricated maize shelling machines at Odo-Oba market along Oyo-Ogbomoso road, Oyo State, Nigeria. Structured questionnaires were used to assess the design features and challenges faced with the use of the machine while mathematical relations were used in evaluating the locally fabricated maize shellers in accordance with Nigerian Industrial Standard. It was obtained that petrol engines were used mainly as the power source of the machine at an average fuel consumption rate of 0.015 lit/min. The shelling efficiency ranged between 85.9 and 89.7 % with an average value of 88 %. The throughput capacity ranged from 318.4 kg/h to 400 kg/h with an average value of 360.8 kg/h. Main problems faced by machine operators include corrosion of machine parts, separation of kernels from cobs after shelling, packaging of kernels and cobs into bags after shelling and flying over of maize cobs during shelling. The maize shellers were of economic use and highly efficient though no prior design parameters and engineering properties of maize were considered before the fabrication of the machines, engineers are however tasked on the modification of the machine.

***Index Terms*- critical evaluation, maize shellers, shelling efficiency, throughput capacity**

I. INTRODUCTION

A major post harvest operation of maize is the removal of kernels from cobs termed shelling which is mainly time consuming, laborious and tedious if carried out manually, for farmers with twenty sacks of maize cobs or more, it can take a week or longer with children kept out of school to help with the work. [1] reported that maize shelling is achieved in rural areas by beating maize cobs with stick in a sack or a confined floor space, this has resulted in physical damage which makes the grains more vulnerable to pests and moulds. There are of course machines which can shell maize starting from hand-held apparatus to industrial shellers[2], [3]. The production of industrial shellers are highly productive but their energy infrastructure requirements and cost can render them unusable in rural villages, [2], [3] reported that an estimated 550 million small-holder farmers in the world lack access to mechanized agricultural technology like Industrial maize shellers due to the cost (ranging from US$1,200-1,800) thus leaving rural dwellers with the option of shelling of high quantity of maize manually by hand or use of sticks. Shelling of high quantity of maize by hand typically takes weeks and the hardened dried maize can also be painful to shell thus leading to hand injuries. Existing alternatives to shelling maize by hand are often unaffordable or difficult to obtain for subsistence farmers. However, efforts have been made by local fabricators, artisans and welders in Nigeria at locally designing and fabricating some maize shelling machines. In most locally fabricated processing machines, farmers and processors encounter difficulties. These may be in feeding of the machine, fuel consumption, low efficiency, improper operating position and so on. It is of paramount importance to assess the main and precise challenges faced with the use of locally produced maize shelling machines and proffer possible solutions so that food processing and handling will be facilitated and economical in use hence, the aim of this study is to assess the design features of the locally produced maize shelling machine (including the materials used for construction, the feeding system, belt type and operating position), evaluate the performance of the maize shelling machine, (including the fuel consumption rate, labour requirement, hopper size, throughput capacity and shelling efficiency), assess challenges faced with the use of the locally produced maize shelling and suggest possible solutions.

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II. MATERIALS AND METHODS

A. Site Selection: in order to access the locally fabricated maize shelling machines, Odo-Oba market, in Ogo-Oluwa Local Government Area of Ogbomoso was identified and selected for case study. The market has a high population density of traders, local processors, artisans and local fabricators. Most agricultural products such as cassava, yam, beans, rice, palm oil, groundnut oil, pepper, tomatoes etc are sold in the market. The market was chosen as a case study because of the high use of the locally fabricated maize shelling machines in the market.

B. Data Classification and Analysis: fifty (50) structured questionnaires were administered to the local fabricators, machine operators and local processors within Odo-Oba market however; personal observations and interviews were also used to access and evaluate the machine and obtain first hand information from their real life experience. The data collected were analysed using statistical package, information of interest on the questionnaire includes: Years of experience, Material of construction, Place of purchase of the machine, Price of procurement, Power source of the maize shelling machine, Challenges faced with the use of the machine, Possible solutions to the Challenges, machine feeding System, hopper Shape, Operating Position and Belt Type. However, mathematical expressions were used in evaluating the performance of the machine in accordance with Nigerian Industrial Standard [4], parameters evaluated from mathematical relationship include:

i. Fuel Consumption Rate: calculated as the ratio of the volume of fuel consumed to the time taken (lit/hr)

ii. Labour Cost: obtained from the amount paid an operator per time spent in operating the machine per day (#/hr)

iii. Shelling Efficiency: obtained from the equation given by [4] and [5] as presented in Equation (1):

$$Sf = \left[\frac{100X_A}{X_A+X_C}\right]\ldots \qquad (1)$$

iv. Throughput Capacity: the input materials were weighed and determined as the ratio of mass of input materials to the time of operation (kg/hr) using the Equation (2):

$$T_c = \frac{Mi}{T}\ldots \qquad (2)$$

III. RESULTS AND DISCUSSION

A. Results

Critical evaluation of some locally fabricated maize shellers were carried out, it was found that a higher percentage of respondents are male and aged, the percentage age and sex distribution of the respondents is presented in Figure 1

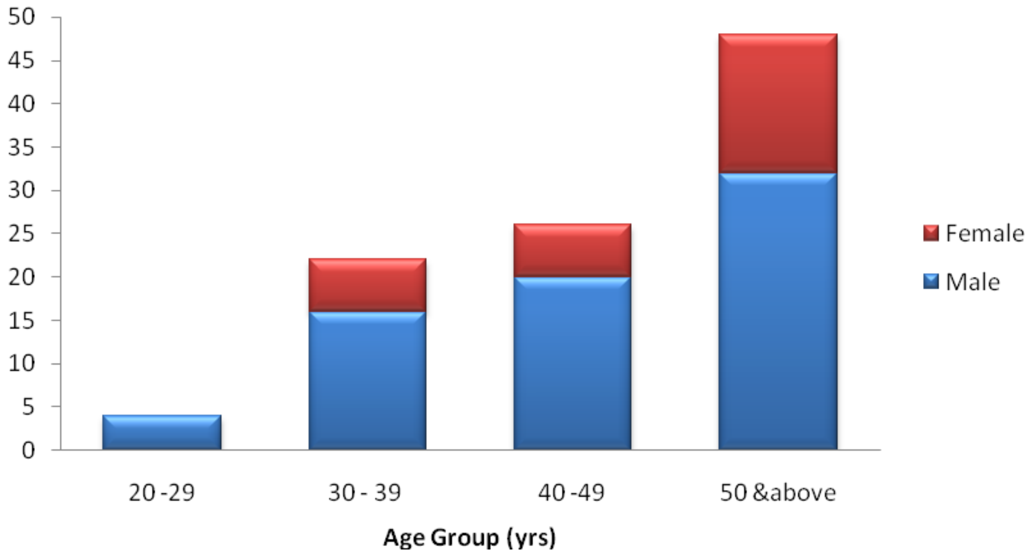

Fig 1: Age and Sex Distribution of Respondents

B. Feeding System, Hopper Shape and Belt Type

From the survey carried out, the locally fabricated maize shellers were fed manually, the hopper shape is rectangular and slightly tilted and the machines were operated at a standing position, vee-belt were used for power transmission of the machines. The hopper shape makes it difficult for input materials to slide and roll

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directly into the shelling drum/ chamber of the machine and this makes the operator to push and force the materials into the shelling chamber manually, this can be evidently seen in Plate 1.

Plate 1: Locally Fabricated Maize Sheller showing the Hopper

C. *Fuel Consumption Rate and Labour Cost*

Petrol engine is mostly used as the power source for most of the maize shellers used at Odo-Oba market, five (5) of the locally fabricated maize shellers were assessed and the quantity of fuel used with time was determined, variations in the fuel consumption rate of the maize shelling machines is presented in Figure 2.

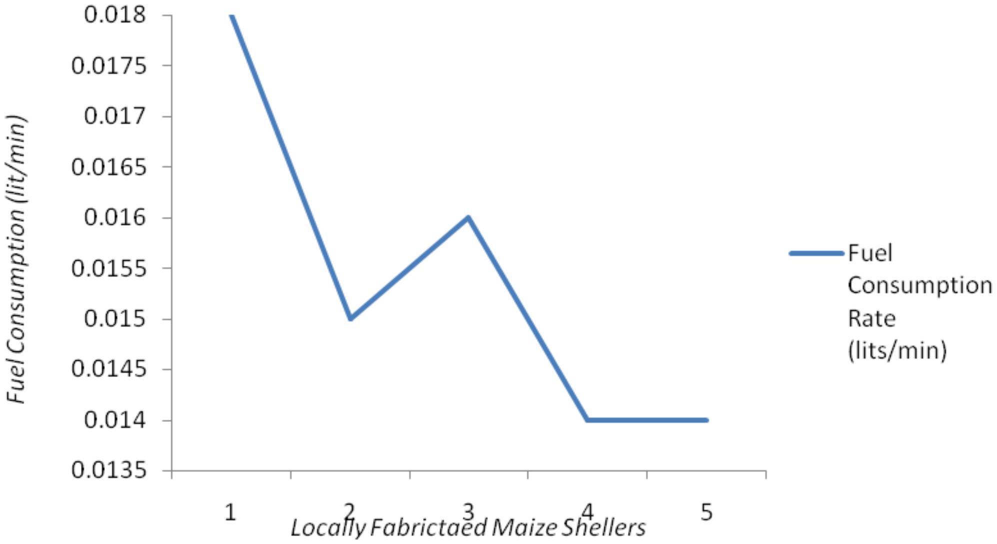

Fig 2: Fuel Consumption Rate of Maize shellers

The machine is operated mostly by the owner but women who possess the maize sheller do employ labourers as operators and the labour cost varies depending on the quantity (bags) of maize shelled, the average percentage paid operators is 17.5% of the daily income realised from the shelling of maize. A bag of maize (approximately 50kg) is shelled at an average of #200 (1.33 US Dollars) and the machine can shell 12 bags of maize in just one hour depending on customer turn-out.

Shelling Efficiency

The mass of kernels received at the seed and cob outlet was taken, the experiment was repeated five (5) times and the shelling efficiency was calculated using Equation 1, values obtained ranged between 85.9 and 89.7 % with an average value of 88 %. The shelling efficiency obtained at five different intervals of operation is presented in Figure 3.

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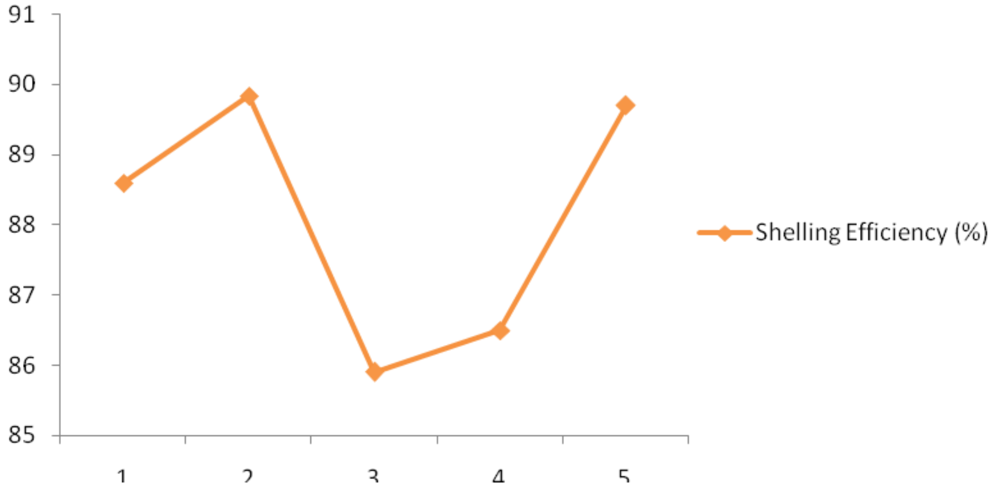

Fig 3: Shelling Efficiencies of the Maize Sheller

D. *Throughput Capacity*

The machine throughput capacity was obtained at five different intervals using Equation (2), the average throughput capacity obtained is 360.8 kg/hr (±1.09), the mass of maize shelled and time taken for shelling are presented in Table 1:

Table 1: Throughput Capacity of the Maize Shelling Machine

Trials	1	2	3	4	5	Average	S. D.
Mass *(kg)*	97	88	105	79	121	98	0.801
Time taken *(min)*	17	13	21	11	23	17	0.74
Time taken *(hr)*	0.28	0.22	0.35	0.18	0.38	0.282	0.74
Throughput *(kg/hr)*	346.4	400	300	438.8	318.4	360.8	1.09

S. D.: Standard Deviation

E. *Problems/Challenges faced with the use of Locally Fabricated Maize Shellers*

From the survey carried out on the locally fabricated maize shellers, machine operators are faced with numerous challenges, some of which are evident in Plates 2-5, some of the problems faced include:

i. Belt slippage during operation
ii. Corrosion of machine parts
iii. Leakage of shelling drum
iv. Separation of maize kernels and cobs after shelling
v. Packing of shelled kernels and cobs into bags
vi. Flying over of cobs which many times leads to injury to operators and passers-by
vii. High cost of purchase
viii. Failure of machine frame and stand
ix. Manual feeding of machine hopper
x. Disposal of maize cobs

Plate 2a: Separation of Maize Kernels and Cobs

Plate 3b: Cobs Outlet Covered with Sack to Prevent Flying Over

Plate 2b: Separation of Maize Kernels and Cobs

Plate 4: Heaps of Maize Cobs for Disposal

Plate 3a: Cobs Outlet Covered with Tyre to Prevent Flying Over

Plate 5: Bags of Shelled Maize Kernels

F. Discussions

The shelling efficiency of the locally fabricated maize sheller was obtained to be 88% while the average throughput capacity was obtained to be 360.8kg/hr, similar trends were reported for the shelling efficiency of maize thresher with a shelling efficiency of 86% [6], bambara groundnut sheller with a shelling efficiency of 80% [7], melon shelling and cleaning machine with a shelling efficiency of 90% [5], groundnut sheller and

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decorticator with a shelling efficiency of 87% [8] and an electrically groundnut sheller with a shelling efficiency of 78% [9].

The average throughput capacity (360.8kg/hr) obtained is in tandem with an electrically groundnut sheller reported by [9] as 345.5kg/hr. However, lower throughput capacities were reported for a maize thresher (119.7kg/hr) and melon shelling cum cleaning machine (145kg/hr) by [5], [6], [10] and [11].
Moreover, it was observed that there was no design prior to the construction of the machine and the engineering properties like physical and mechanical properties of maize cobs and kernels were not considered before the construction of the machine and this is the main reason behind problems. There are relevant engineering properties that must be considered before the design and construction of any agricultural processing machine as each engineering property is peculiar to a specific unit operation. The aspect which is of interest to the engineers and machine fabricators is the physical, mechanical, electrical and thermal properties. This gives the engineer guidelines for the designing of agricultural machine that will be suitable for the processing of the bio material. Most important among them is the physical property which is the first consideration in the design of the post handling and sorting equipment [12] as it gives information on size dimensions; shapes, porosity, volume, density, and coefficient of friction. Generally, engineering properties when properly considered before constructing a machines aids efficient post harvest operations like harvesting, transporting, cleaning, separating, packing, and storage. Bulk density and porosity affects the structural loads. The coefficient of friction of seeds against various surfaces is necessary in the design of conveying, transporting, and storing structures.

G. Suggested Solutions to the Problems faced with the Use of the Maize Sheller
The following are suggested solutions to the problems highlighted in Section 3.1.5:

a) Painting of machine parts to prevent corrosion or use of stainless steel for construction
b) Reinforcement of machine frame to prevent breakage and failure due to vibration
c) Diversion of kernel and cobs outlet away from each other for easy collection and separation
d) Subsidization of initial cost of machine by government and non-governmental organizations for rural dwellers and local farmers
e) Consideration of engineering properties of maize like angle of repose, coefficient of friction, size dimensions etc before construction of the machine
f) Efficient utilization of maize cobs as cooking energy to prevent environmental pollution.

IV. CONCLUSIONS
Locally fabricated maize shellers were assessed and evaluated at Odo-Oba market along Oyo- Ogbomoso road using structured questionnaires and mathematical standards, the following conclusions were drawn from the survey:

1. The machines used for shelling maize were constructed without any prior design or consideration of engineering properties of the input materials.
2. The average shelling efficiency is 88 %
3. The average throughput capacity of the machine is 360.8 kg/h
4. Petrol engines are used tom power the machine and the average fuel consumption rate 0.0154 lit/min (0.924 lit/h)

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NOTATIONS

Sf is the Shelling efficiency of the machine (%),
X_A is the Mass of seed received at the seed outlet (kg)
X_c is the Mass of seed received at the chaff outlet (kg)
T_C is the Throughput Capacity of the machine (kg/h)
M_i is the Mass of maize cobs to be shelled
T is the Time taken for shelling maize