Nigerian Journal of Technology (NIJOTECH)
Vol. 40, No. 5 September, 2021, pp.947 –953
www.nijotech.com

Print ISSN: 0331-8443
Electronic ISSN: 2467-8821
http://dx.doi.org/10.4314/njt.v40i5.20

Determination of the Effect of Quantity of Maize Cobs and Shelling Speed on the Performance of a Maize Sheller

O.K. Ajayi[1,*], A. J. Adeyi[2], A. A. Fadairo[3], B. O, Ologunye[4]

[1,3]Department of Mechanical Engineering, Obafemi Awolowo University, Ile-Ife, Osun State, NIGERIA
[2]Department of Mechanical Engineering, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, NIGERIA
[4]Department of Mechanical Engineering, Federal Polytechnic, Ede, Osun State, NIGERIA.

Abstract

Arable farming of maize is the most common of all crops in Sub-Saharan Africa. Most often, the processing is done domestically using manual effort, but on few occasions some part are done visiting commercial mechanized processors. This work presents the evaluation of the performance of a maize sheller scaled for domestic use. Three set of maize input (2kg, 3kg and 5kg) were each tested at different shelling speed of 2500 rpm, 2600 rpm and 2800 rpm respectively. The output parameters measured were; shelled maize, unshelled maize, cylinder loss and spilled loss. Subsequently, shelling capacity, cylinder loss (%) and spilled loss (5) were determined. It was however discovered that the 5kg shelling at 2600 rpm gave the highest shelling capacity at 24. This is in agreement with the assessment of the machine when 10kg maize was shelled at 2600 rpm.

Keywords: Maize; shelling speed; weight of maize; shelling capacity; shelling efficiency

1.0 INTRODUCTION

Maize is the most common of cereals to arable farming [1, 2] as well as large scale farming. It is a major raw material for livestock farmers used as feedstock and also for many processed foods such as custard, pasta, pap among others. Maize shelling is the most tedious stage of maize processing and it consumes energy and time [3, 4]. The manual process of shelling by hand or hitting a bag of maize with stick is the oldest and most common method in the major producing countries. This method has adverse effect on the fingers and palms of the shellers [4].

The use of wet shelled maize is restricted mainly to domestic use in very small quantity [5], though mechanization of this process is still in the developmental stage, there is less effort in this direction. The dry maize however accounts for over 95% of the shelling need, because it's in this form that the maize is converted or mixed with other ingredients for other food and industrial products [5, 6].

However, with recent clamor for increased food production [4] and awareness on arable farming [1, 2], arable farmers are beginning to acquire agricultural products processing machines individually and in clusters. Maize shellers have been developed over the years to meet immediate needs [7] and there is continuity in the modification to meet various geographical locations need as well as available technology [8-10]. Performance evaluation has been reported for various work to determine the influence of input parameters into machines and processes and their effect on the output [11-12]. This work considers the effect of quantity of maize shelled at once using different shelling speed on the shelling capacity and shelling efficiency of a maize sheller reported by [13].

2.0 METHODOLOGY

This section talks about the evaluation of the performance of a maize sheller (Fig. 1a) designed and fabricated by [14] and the design and assessment reported by [13]. This work presents the testing of the machine using two input variables of weight of maize and speed of the prime mover. Fig. 1 b & 1c shows the unshelled maize samples and total shelled maize respectively. The measured outputs were; weight of shelled maize, weight of unshelled maize, cylinder loss, and spilled loss as presented in Table 1.

*Corresponding author **(Tel:** +234 (0) 8035266603**)**

Email addresses: *okajayi@oauife.edu.ng* (Ajayi O.K.), adeyi.abiola@yahoo.com (Adeyi A. J.) afadairo@oauife.edu.ng (Fadairo A. A) ologunye.opeyemi@federalpolyede.edu.ng (Ologunye B. O.)

Table 1: Description of measured output parameters to be measured.

Output	**Description**
Shelled maize	This was the quantity of maize that was shelled and passed through the machine outlet
Unshelled maize	This refers to the unshelled maize left in the cylinder and those that passed out through the chaff outlet
Cylinder loss	These are the grains left in the barrel
Spilled loss	These are grains that spilled out of the machine during shelling operation.


(a) Maize sheller

(b) Maize test samples in 2 kg, 3 kg and 5 kg for 2500 rpm, 2600 rpm and 2800 rpm.

(c) Total shelled maize.

Figure 1: Picture of maize sheller during testing

2.1 Kernel and moisture content

As reported by Ajayi et al., 2016 [13], the maize samples were weighed, and then oven dried in an electric oven at 105^{0}C for 24 hours before being weighed again. This procedure is necessary because the drier the seed, the more effective the shelling [6, 12]. The moisture content was determined thus;

$$Percentage\ moisture\ content\ (MC) = \frac{W_w - W_d}{w_w} \times 100\ \% \quad (1)$$

Where;
$W_w - weight\ of\ wet\ maize\ (10\ kg)$
$W_d - weigth\ of\ dry\ maize\ (8.4\ kg)$

Therefore, the moisture content was determined to be 15 %.

The performance criteria as reported by Ajayi *et al.* (2016) [13] are expressed in equations 2 - 5, while the values are presented in figure 2.

$$Shelling\ Capacity = \frac{W_k}{T} \times 60 \quad (2)$$

$W_k = weight\ of\ total\ output\ kernel\ (kg), T = Recorded\ time\ (min)$

$$Throughput\ capacit = \frac{Weight\ of\ whole\ cob}{Time\ taken} \times 60 \quad (3)$$

$$Cylinder\ loss = \frac{Weight\ of\ cylinder\ loss\ kernel}{Total\ kernel} \times 100 \quad (4)$$

While,
$$Spilled\ kernel\ loss: PL = \frac{Weight\ of\ spilled\ kernel}{Total\ kernel} \times 100 \quad (5)$$

3.0 RESULTS AND DISCUSSIONS

3.1 Results

The testing of the performance of the machine was done with 2 kg, 3 kg and 5 kg unshelled maize. At the end of the complete shelling, the outputs are presented in Table 3, but the result of the 10kg testing was presented for comparison in Table 2 [13].

The total weight of the cob tested was 40 kg; 10 kg as a whole and 30 kg divided into 2 kg, 3 kg and 5 kg under 2500 rpm, 2600 rpm and 2800 rpm shelling speeds respectively.

$The\ weight\ of\ the\ cob\ determined\ to\ be$;
$$= (weight\ of\ dry\ maize - weight\ of\ (output + broken\ grain + cylinder\ loss + separation\ loss + spilled\ loss); \quad (6)$$
$$= 8.4 - (7 + 0.2 + 0.3 + 0.1 + 0.6)$$
$$= 0.2\ kg$$
This represents 18% of the total maize.

Table 2: Output parameters for the testing of the shelling machine for the 10kg input [13]

Factors considered	Weight (kg)	Value (%)	Rate (kg/hr)
Unshelled maize	8		
Broken grains	0.2		
Cylinder loss	0.3		
Output grain	7		
Spilled loss	0.6		
Shelling capacity			270
Throughput capacity			300
Cylinder loss		3.75	
Spilled grain loss		7.5	

The shelling efficiency was determined using equation 7;

$$Shelling\ efficiency: = \frac{(Shelled - unshelled)}{Total\ kernel} \times 100 \quad (7)$$

Table 3: Results of output parameters for 2 kg, 3 kg and 5 kg shelling

Mass (kg)	Speed (rpm)	Shelled (kg)	Unshelled (kg)	Cylinder loss (kg)	Spilled (kg)	Shelling capacity	Cylinder loss	Spilled kernel loss	Shelling efficiency
2	2500	0.7	1.28	0.020	0.000	11	1.00	0.00	-29
2	2600	0.8	1.18	0.017	0.017	12	0.85	0.85	-19
2	2800	1.3	0.49	0.210	0.017	20	10.5	0.85	41
3	2500	1.6	1.23	0.170	0.210	24	5.67	7.00	12
3	2600	1.8	1.16	0.040	0.210	27	5.67	7.00	21
3	2800	2.1	0.86	0.040	0.030	32	1.33	1.00	41
5	2500	2.5	2.29	0.210	0.100	38	4.20	2.00	4
5	2600	2.7	2.09	0.210	0.210	41	4.20	4.20	12
5	2800	4.0	0.80	0.210	0.000	60	4.20	0.00	64

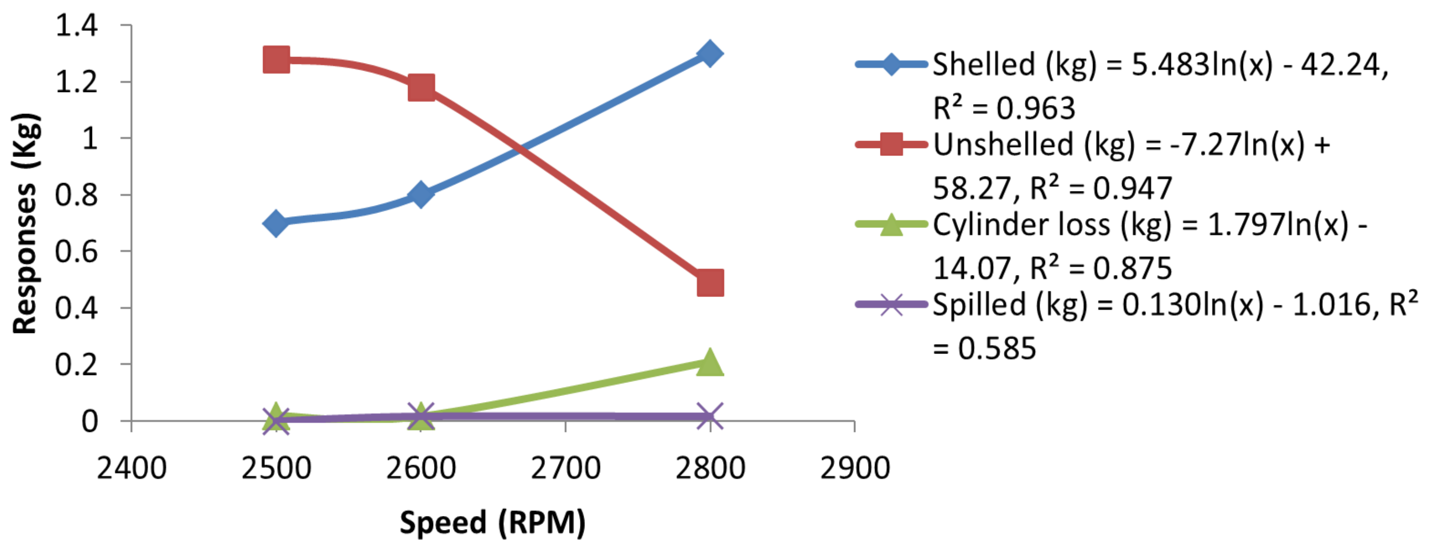

Figure 2: Evaluation at 2 kg Maize quantity

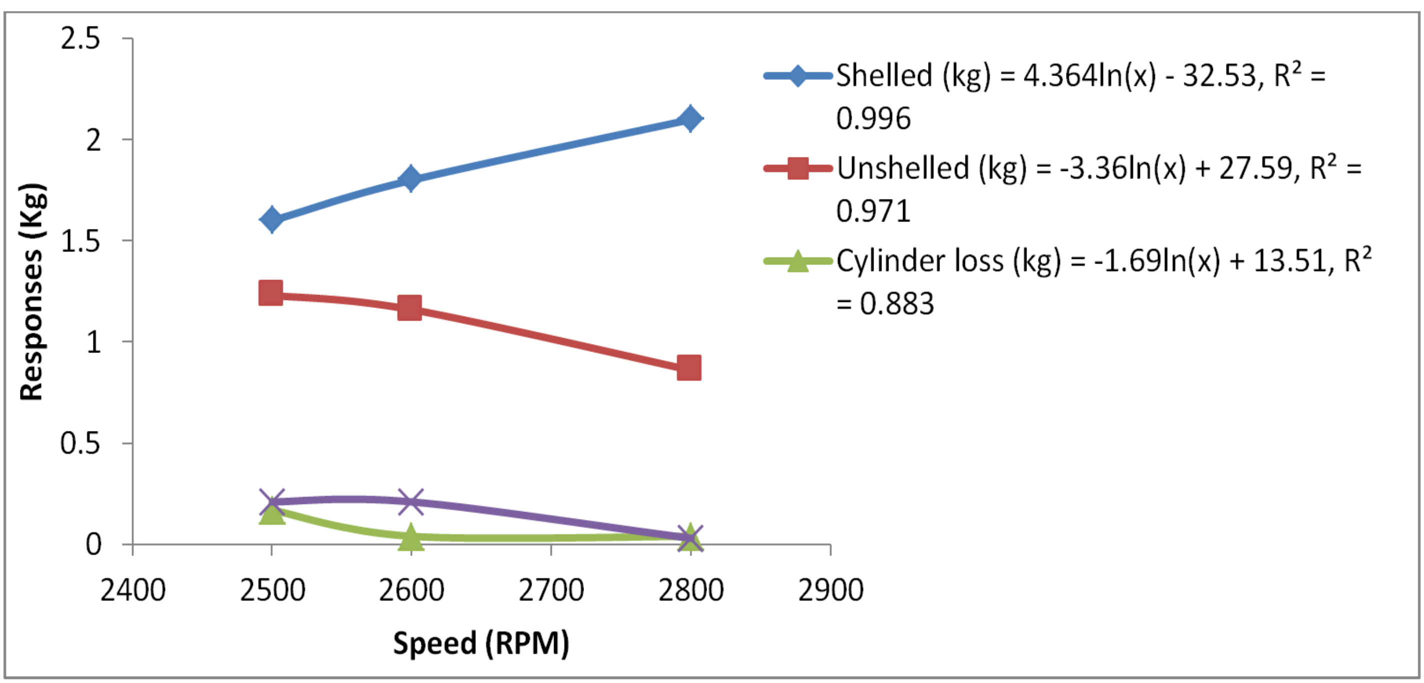

Figure 3: Evaluation at 3 kg Maize quantity

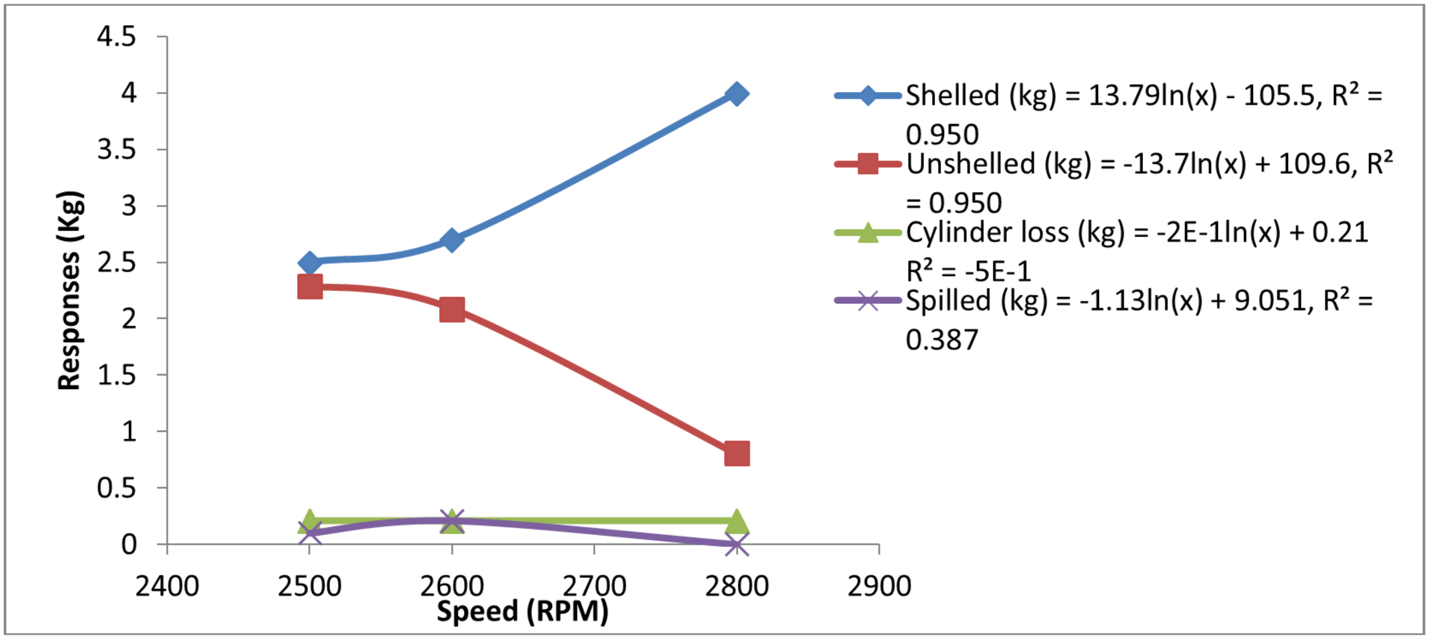

Figure 4: Evaluation at 5 kg Maize quantity

3.2 Discussions

Figs. 2 – 3 shows the effect of maize sheller variable speed on the performance indictors including shelled, unshelled, cylinder loss and spilled quantity of maize when 2 kg, 3 kg and 5 kg maize were processed for 4 secs each. The maize sheller speed increased the amount of shelled maize and decreased the amount of unshelled maize for all the weights, but differently. In Fig. 2), increase in maize sheller speed increased the maize cylinder loss and does not seem to have any effect on the maize spilled. The crossing of trends or curves of shelled and unshelled responses and curve of cylinder loss and spilled responses may signify an optimum point (best process setting or specification) for the interacting pair. Although the cylinder loss response increased undesirably, this increment is minimal and can be considered as not too significant to impair the overall performance of the developed maize sheller.

From Fig. 3, the increase in shelled maize does not have much significant increase with increase maize quantity with increase sheller speed. However, the cylinder and spilled losses declined throughout the speeds unlike in the other two weights. In Fig. 4, the shelling efficiency was highest, because the unshelled maize, cylinder loss and spill losses were lowest for the three speeds compared to other weights. Significantly, 80% of the maize was shelled while 16% was unshelled, 4% was lost in the cylinder and there was not spilled loss.

The logarithmic model fitted to each of the responses in Figs. 2 & 3 showed that significant model occurred for shelled, unshelled and cylinder loss responses because their coefficient of determination (R^2) value is greater than 0.7 while insignificant model occurred for spilled response because of its R^2 value that is less than 0.7. Significant models can be used for prediction while the insignificant models cannot be used for the same purpose. However, in Fig. 3, the coefficient of determination (R^2) value was greater than 0.7 for both shelled and unshelled only, whereas it is less than 0.7 for both cylinder and spilled losses. Therefore, wider range of data collection is needed to accurately derive a model for spilled response in this study.

From Table 2, shelling capacity and shelling efficiency of was highest for the 5kg at 2800 rpm, but lowest for 2kg at 2500 rpm. More importantly, considering the high value recorded for the whole 10kg test, where 87.5% of the maize was shelled, it can be deduced that more maize in the barrel results in better shelling by the maize sheller.

4.0 CONCLUSIONS

Analytically, the performance evaluation observed in Fig 3 seem to be the most desirable performance of the evaluated developed Maize sheller because the effect of speed increment when 3 kg of Maize was shelled on all the performance evaluation indicator was desirable where quantity of shelled maize constantly increased, unshelled maize constantly decrease, cylinder loss constantly decreased and spilled constantly decreased. However, the values of the 5 kg for shelling capacity (60%) and shelling efficiency (64%), depicts that the more the maize in the shelling barrel, the greater the shelling efficiency as compared to 10kg testing by [13].

REFERENCES

[1] Awotide D.A., Ikudaisi O.J., Ajala S.O. and Kaltungo J.H. “Input use and profitability of arable crops production in Nigeria”. *Journal of sustainable development*, 8(3), (2015), 139-146.

[2] Jeffrey A. G. and Maria N. G. “Processing maize flour and corn meal food products”. *Annals of the New York Academy of Sciences*. (2014).

[3] Adewole C. A., Babajide T. M., Oke A. M., Aremu D. O. and Ogunlade C. A. “Critical evaluation of locally fabricated maize shelling machine”. *International Journal of Engineering Science and Innovative Technology*, 4(2), (2015), 67-73.

[4] De Lucia, M. and Assennato, D. “Post-harvest operations and management of foodgrains”. *Agricultural Engineering in Development, FAO Agricultural Services Bulletin, No. 93*.

[5] Kyung-Min L., Timothy J. H., Lloyd R., David S. J, Jane Lingefelser, K. D. R., John M., Chris I., Linda B., Charles R. H. J., Lawrence A. J. and Steven R. F. “Corroborative study on maize quality, dry-milling and wet-milling properties of selected maize hybrids”. *Journal of Agricultural and Food Chemistry*, 55(27), (2007), 10751-10763.

[6] FAO. “Maize in human nutrition”. (1992), Rome.

[7] Nwakaire J. N., Ugwuishiwu B. O. and Ohagwu C. J. “Design, construction and performance analysis of a maize sheller for rural dwellers”. *Nigerian Journal of Technology*, 30(2), (2011),49-54.

[8] Nkakini, S.O., Ayotamuno, M.J., Maeba, G.P.D., Ogaji, S.O. and Probert, S.D. “Manually powered continuous flow maize sheller”. *Applied Energy*, 84, (2007), 1175-1186.

[9] Pavasiya, U. N., Patel, H., Patel, K., Sumant, M. M. and Sutariya H. R. “Design and fabrication of a motorized maize shelling machine”. *Journal of Material Science and Mechanical Engineering*, 15(1), (2018), 5-12.

[10] Girish K., Jangali S. J., Anjali K., Roopa L. and Samear S. “Crank operated maize sheller” *International Journal of Science Research Development*, 13(4), (2015), 561-564.

[11] Aru O. E., Adimora K. and Nwankwo F. J. “Investigating the impact of 5G radiation on human health using machine learning”. Nigerian Journal of Technology, 40(4), (2021), 694 - 702.

[12] Osayi A. O., Lawal S. A, Ndaliman M. B. and Agboola J. B. “Performance evaluation of rubber seed oil based cutting fluid in turning mild steel”. Nigerian Journal of Technology, 40(4), (2021), 648 - 659.

[13] Ajayi O. K., Olaniyan M. O., Ayodeji A. J. “Design and fabrication of a domesticated maize shelling machine” *International Conference of Science, Environmental Science and Engineering Technology (ICONSEET 2016)*, Federal Polytechnic Ede, (2016).

[14] Olaniyan M. O. and Ayodeji A. J. “Design and fabrication of a domesticated maize sheller”. *NDII project*, Federal Polytechnic, Ede, (2015)..