FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 7 No. 1, February, 2023, pp 35 - 39
DOI: https://doi.org/10.33003/fjs-2023-0701-1232

MODIFICATION OF AN EXISTING HOLD-ON RICE THRESHER

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ABSTRACT

Manual paddy threshing using metal drums with attendant low output and high losses is still being widely used in the Kano-Kura rice cluster. An existing stationary Hold-on thresher designed to address these, was modified and evaluated. The thresher was designed taking all peculiar technical considerations. It was then fabricated using available materials. Paddy Faro 44 variety at a mean moisture content of 13 % (w. b.) was used for evaluation in this study. The independent variables consist of three different speeds 500, 600 and 700 rpm and two feed rates of 200 and 300 kg/h were used. Factorial experiments were conducted in a completely randomized design with three replications. The performance dependent indices used were output capacity, threshing efficiency and cleaning efficiency. The analysis was done using GENSTAT statistical package. It was found out that the effects of variables on the performance indices were highly significant. The mean highest value of the output capacity was 229.09 kg/h at the combination of 700 rpm speed and 300 kg/h feed rate. The mean value obtained for the threshing was 99.99 % and is statistically similar for all the combinations. The cleaning efficiency indicate highest value of 85 % at the combination of 500 rpm speed and 200 kg/h feed rate. T-test for comparison between machine performance and manual threshing showed that the mean value for output capacity, threshing efficiency and cleaning efficiency for the machine are significantly higher than the manual threshing, the, the machine performance has promising prospect.

Keywords: modification, rice, hold-on rice thresher

INTRODUCTION

Over 3.5 billion individuals depend on rice for more than 20 % of their daily calories with Asia, South America, sub-Saharan Africa being the largest consuming regions (KPMG, 2019). More than 40 % of rice consumption in West Africa is imported which represents 2.75 million tons per year (Ani *et al*., 2020). In Nigeria, rice consumption far exceeds production with a yearly average production deficit of about 2.4 million tonnes recorded between 2007 and 2018. In order to meet the present deficit due to insufficient local production, Nigeria imports rice from several exporting countries to increase its total supply (Morse, 2020).

Rice processing machines produced in developed countries are mostly unaffordable by rural farmers, hence there is need for development of cost effective but efficient machines produced from local available materials (odey, *et al*., 2020). According to Okusanya and Oladigbolu (2020), threshing is the first and most important post-harvest operation of rice crop processing.

Paddy threshing involved the detachment of paddy grain from the panicles through rubbing action, impact, and stripping. Most mechanical threshers used impact principle for threshing, although some stripping action is involved (Limyeekai, 2016). In the throw-in type threshers, whole rice straws including the panicles are fed into the threshing drum. Straw chaff and grain kernels are separated and each goes through different outlet. But in the hold-on thresher type, the straws are being held manually while only the panicles are subjected to the exposed beaters of the threshing drum. The outlet is for the grains only. The operator discards the empty straws. Grain loss and damage are significantly affected by threshing performances (Alizadeh and Bagheri, 2009; Spokas *et al.*, 2008; Amare *et al.*, 2015)). Hence, many researchers put their efforts to investigate grain-threshing devices, and different kinds of grain threshers or threshing components have been developed since 1820s (Li *et al.*, 2012; Li *et al.*, 2017). Fu *et al.* (2018) stated that a higher level of threshing theory and technology are still the unswerving pursuit due to the fact that they always seriously affect grain loss and damage.

Harvest and post-harvest operations of rice production in the Kano-Kura rice cluster constitutes an appreciable percentage of production costs. The dominant techniques for threshing rice in the area are still the traditional method of beating rice straw against metallic drum. This method is laborious, time wasting and not economical. There were some attempts at development of conventional axial flow threshers that use the beater drum assembly and the concave sieves. However, the low outputs of these threshers did not encourage farmers. The threshers were not accepted. The idea of a hold on type thresher is aimed at drastically improving the output while the manual beating is eliminated. A hold-on rice thresher was developed (Ali *et al*, 2020). After evaluation, the output, though improved, was still lower than satisfactory. Again, there was much rice straw at the output. A lot of manual effort was needed to separate this from clean grain. The aim of this work was therefore to modify the existing hold-on motorized stationary rice thresher.

MATERIALS AND METHODS

Materials

Instrumentation

The instruments used were: Digital moisture meter (Farmcomp F1 04360), Electric oven (DHQ-9023), Stop watch (TECNO POP3), speed Digital tachometer (DT2234B), Weighing balance (Adam PMB53, resolution 0.01 g), Paddy rice (SIPI Faro 44 variety), Petrol, Engine oil (SAE 20W-50), Petrol Engine prime mover (HONDA 5.5 Hp).

The materials used for fabrication modified hold on thresher were: Mild steel (Assorted sizes), Angle iron (20 x 20 mm), Pulleys (ϕ 20 mm, ϕ35 mm), Bearings (B1302), v-belt (B65) and mild steel Transport wheels (ϕ 60 mm).

Cost of materials

The total cost of materials used in fabrication including the machine components such as pulleys, bearings, belts and the prime mover amounted to a total sum of one hundred and seventy five thousand Naira only (#175, 000:00). This amount has a benefit cost ratio of 1.4 and a payback period of two harvesting seasons.

Design

Before designing the hold-on thresher, various components necessary for the designing were considered such as; threshing drum and speed, power require for threshing and frame design. Threshing of rice paddy is based on the principle of impact force generated by the beating action of the spikes. The main design consideration for the entire machine include; overall height of the machine to facilitate ease of operation by a rural farmer of average height, overall width of the machine for the purpose of storage space in the rural farmer's granaries, weights of the equipment for easy portability during operation on and off farm, the price of the materials used and their availability. The machine was painted to prevent corrosion.

Selection of drum diameter was done Based on existing designs, the threshing drum is modified by arbitrary selection of a diameter of 180mm and length of 800 mm. the construction is made from a mild steel sheet metal with a thickness of 1mm and the total number of 79 wire loops.

Pulley sizes were determined according to Hannah and Stephens (1984), using equation 1:

$$N_1D_1 = N_2D_2 \quad (1)$$

Where,

N_1 = Speed of drive pulley, =1000 rpm (manufacturer specification)

N_2 = Speed of driven pulley = 700 rpm (selected based on experimental design)

D_1 = Diameter of drive pulley = 0.055 m (manufacturer specification)

D_2 = Diameter of driven pulley=0.039 (computed)

Centre distance between pulleys, C and length of belt, L_b were determined (based on equations 2 and 3) as 0.1445 m and 0.529 m, respectively.

$$C = \frac{D_2+D_1}{2} + D_1 \quad (2)$$

$$L_b = 2c + \frac{\pi}{2}(D_1 + D_2) + \frac{1}{4C}(D_1 + D_2)^2 \quad (3)$$

Belt tensions (T_1 = 984.45N and T_2 = 938.61N), belt power (132.019 W) and torsional moment ($75\ Nm$) were determined using Shigley and Mishke, (2001).

The drum shaft diameter was determined as 25.39 mm using equation 4 (Khurmi and Gupta, 2005) and the maximum bending moment theory.

$$d^3 = \frac{16}{S_s}\sqrt{(K_b\,Mb)^2 + (K_T M_T)^2} \quad (4)$$

Performance Evaluation

Performance parameters

The moisture content of paddy rice (% wet basis) was determined using oven drying at 105^{0}c for 12 hrs (FAO, 1996). According to Mohsenin (1980), moisture content wet basis, M is given by 5:

$$M = \frac{W_1 - W_2}{W_1} \times 100\ \% \quad (5)$$

Where,

W_1= weight of grain before oven drying (g)

W_2= Weight grain after oven drying (g)

Paddy rice Faro 44 variety at a mean moisture content of 13 % (w. b.) was used for evaluation in this study.

The output capacity, OC, The threshing efficiency, T_E and the cleaning efficiency, CE were calculated using Djidjoho and Shadrack, (2016) as presented below:

$$OC = \frac{Weight\ of\ total\ grain\ output\ at\ main\ outlet}{Time\ recorded\ (min)} x\ 60 \quad (6)$$

$$T_E = 100 - (\frac{unthreshed\ seed}{threshed\ seed}) \times 100 \quad (7)$$

$$CE = \frac{W}{Wa} x100 \quad (8)$$

Where

W = Weight of clean seed at main seed outlet per unit time (kg)

W_a = Weight of whole seed and chaff at seed outlet per unit time (kg)

Experimental design

Factorial (3 x 3) experiments were conducted in a completely randomized design with three replications. The independent variables consisting of three different speeds 500, 600 and 700 rpm and two feed rates of 200 and 300 kg/h were used. The Analysis of variance is presented in Table 1 below.

Table 1: Analysis of variance for performance evaluation experiments

Source of variance	Degree of freedom
Replication, r	r-1 = 3-1 = 2
Speed, S	s-1 = 3-1 = 2
Feed rate, F	F-1 = 2-1 = 1
SF interaction	(S-1)(F-1) = 2
Error	(r-1)(SF-1) = 10
Total	Rsf-1 = 17

The results were analysed using GENSTAT Statistical Package

RESULTS AND DISCUSSION

Fabrication of the Modified Hold-on rice thresher

Orthographic drawings of the fabricated modified hold-on rice thresher are represented in Figure 1. It was fabricated using locally available materials. The total cost was sixty five thousand naira only (N65, 000: 00).

Results of performance evaluation

The mean values of the performance indices at different combinations are presented in Table 2.

The mean values range from 67.00 – 229.09 kgh, 99.98 – 99.99 % and 2.30 -85.95 % for output capacity, threshing efficiency and cleaning efficiency, respectively. These values are similar to the findings of Ali, *et al.*(2020). Other research findings also have similar results (Sinha *et al.* (2014), Kumar *et al.*(2016), Kwadwo *et al.* (2017). Analysis of variance shows that the independent variables have a highly significant effect on output capacity and cleaning efficiency. (Table 3). The significant effect of these variables on the performance indices agrees with many research findings (Abarachi (2011) Dhananchezhiyan *et al.* (2013), Shadad *et al.*(2019). Their effect on threshing efficiency, however, is not significant. This could be due to the factor of the shattering tendencies of the rice variety even before the impact on the panicles during threshing.

Further tests for means that are significant were conducted using the LSD criterion. They show that the speed of 700 rpm gives the highest mean output capacity while 500 rpm gives the lowest mean output capacity. As speed increases the output is also increased. This agrees with the findings of Abarachi (2011). The increase of the machine output capacity with the increase in speed could be due to the fact that as the speed increases, the time taken for the operation decreases, thus increasing the output capacity. speed 3 (700rpm) gives the lowest cleaning efficiency while speed 1 (500rpm) gives the highest cleaning efficiency.

Table 2: Mean Values of Performance parameters

TREATMENTS		Output capacity kg/h	Threshing efficiency %	Cleaning efficiency %
Speed rpm	**Feed rate kg/h**			
500	200	67.00	99.99	85.95
500	300	128.63	99.99	75.13
600	200	78.53	99.99	78.32
600	300	156.76	99.99	72.29
700	200	186.08	99.99	68.61
700	300	229.09	99.98	62.30

Table3: Analysis of variance table for the performance parameters

Source of variation	Degrees of freedom	Output capacity kg/h	Threshing efficiency %	Cleaning efficiency %
Replication, r	2	0.1869 NS	0.4058 NS	0.7696 NS
Speed, S	2	<0.0001**	0.3775 NS	<0.0001**
Feed rate, F	1	<0.0001**	0.3868 NS	<0.0001**
S x F	2	<0.0001**	0.4470 NS	<0.0001**
Error	10			
Total	17			

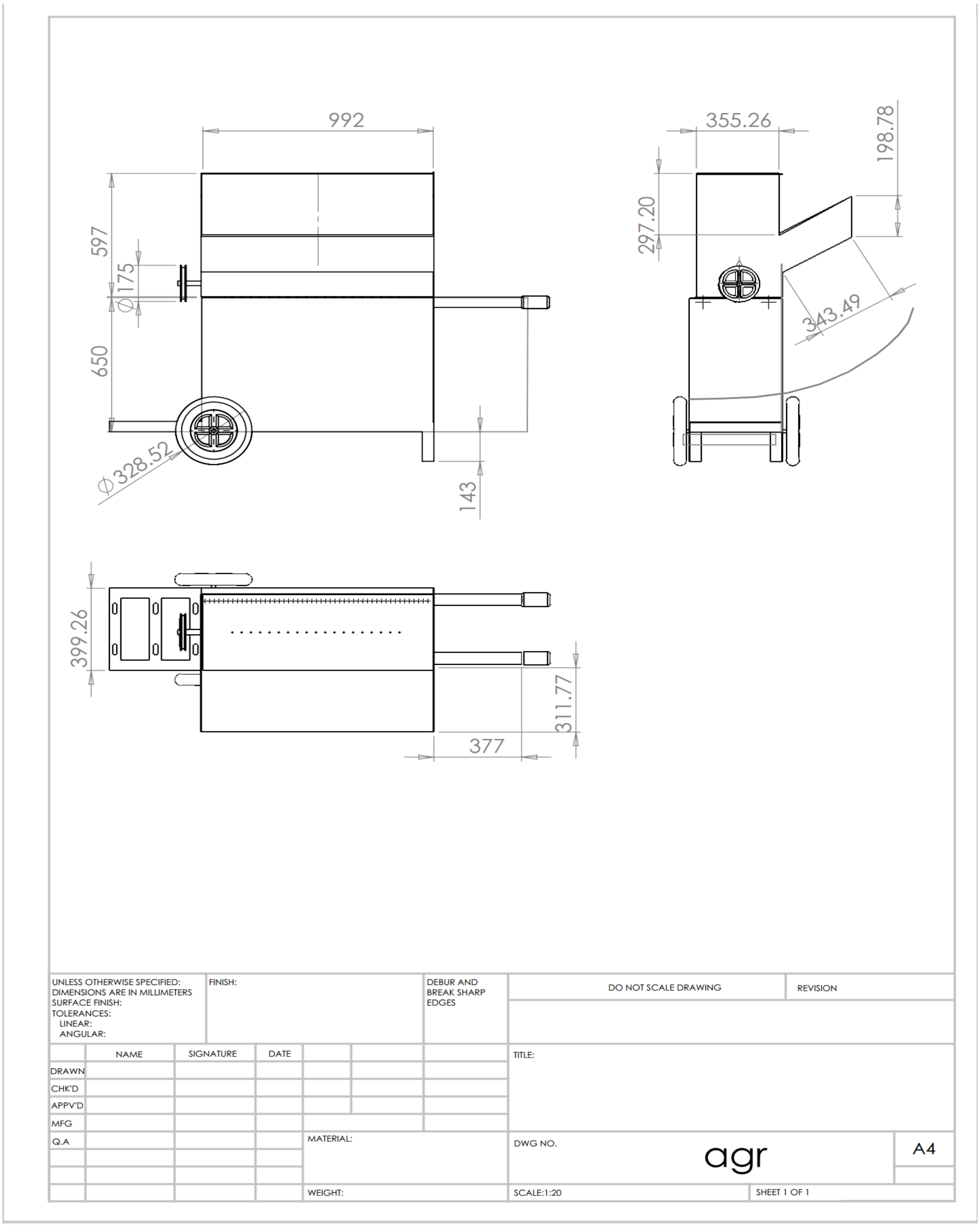
The increase in the cleaning efficiency with decrease in the drum speed may be attributed to the reason that as the speed decreases, the rate of grains separation decreases the buildup of materials other than grains (chaff). This enhances cleaning. This agrees with the findings of Olayanju *et al*. (2019)

CONCLUSION

In this research, the design of a Hold-on rice thresher was modified, the thresher fabricated and its performance was evaluated. The combination for the best operation of the thresher have been established. The mean highest value for the machine output capacity is 229.09 kg/h at the combination of 700 rpm speed and 400 kg/hr feed rate. The threshing efficiency mean value of 99.999 % was at par for all the combinations. The cleaning efficiency indicate higher value of 85.95 % at the combination 500rpm speed and 200 kg/hr feed rate. Thus the machine performance has promising prospect.

RECOMMENDATIONS

It is recommended that the engineers, relevant institutions and authorities, private and public sector should collaborate in the development, evaluation, utilization and adaptation of the rice processing machineries for optimum quantity and quality of produce through appropriate funding of research, sufficient linkage between the designers and the industries.



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