Arid Zone Journal of Engineering, Technology and Environment. October, 2002; Vol. 2, 1-9

DEVELOPMENT OF AN INDIGENOUS RICE THRESHER IN NIGERIA

Daudu, S.M.[1] and D. Adgidzi [2]

Abstract

Rice threshing in Nigeria remains a problem to the average peasant farmer. The techniques for threshing rice are still the traditional method of hand beating. This method is laborious, time wasting and not economical. Also the co mmonly available rice threshers are the imported ones which are not affordable to majority of the farmers. In an attempt to address this problem, a rice thresher/cleaner was designed, fabricated and evaluated. Physical properties of Faro 51 rice such as length of ears, length and breadth of grain, grain/straw ratio and moisture content were studied. The thresher was evaluated in terms of threshing efficiency, cleaning efficiency and percentage grain loss. At an average moisture content of 13.83% (wet basis), and design cylinder speed of 556rpm, test results reveal that the thresher has a threshing and cleaning efficiencies of 98.01 and 99.32% respectively and total percent losses of 4.78%. The thresher has an output capacity of 267.9 kgh-1.

1. Introduction

Threshing is the first and most important post-harvest operation of grain crops. It involves the detachment of grain kernels from the stalk heads (Nkama, 1992). The traditional method of grain threshing in Nigeria is by beating with stick or hitting the grain stalk or pods on the floor. This method is not only inefficient but also very laborious and the output is low resulting in delay in handling large volumes of grain harvest and subsequently leading to losses. Mechanical or powered threshers have been introduced to overcome these difficulties, but local acceptability has been very low due to high cost and failure of the threshers to reach their rated capacities and efficiencies under continuous use in the field. The use of powered machines and equipment in Nigerian agriculture dates back to the early 1960s following the establishment of farm settlements in the eastern and western regions of the country (Chukwu, 1994). There is now a general awareness in Nigeria and other developing countries that rapid development of agriculture depends to a large extent on the successful introduction of modern indigenous agricultural machinery. In Niger State for example, most of the farm equipment presently used are of several makes as shown in Table 1 (Chukwu, 1994). As a result many problems such as non-availability of spare parts and inadequate provision of power drive are co mmon. Based on the above reasons, a rice thresher was developed and evaluated to meet some of the farmers requirements. Physical properties of rice crop and grain such as length of ears, grain length and breadth and grain/straw ratio were evaluated as they are necessary in machine development.

[1]National Cereals Research Institute, PMB 8, Bida, Niger State.
[2] Agric. Eng. Dept. Federal University of Technology, Minna, Niger State, Nigeria.

Table 1: Inventory of rice threshers in various establishments in Niger State in 1993

Establishment	Votex	FATE	Vicon	Akshat	Embee	Cecoco	Kubota	Alvan Blanch	Total by make
NSADP, Minna	-	-	1	-	-	-	-	-	1
NSADP, Bida	9	2	1	2	1	1	-	-	16
NSADP Kuta	2	-	-	-	-	-	-	-	3
NRBDA, Minna	-	-	-	-	-	-	3	-	2
FMANR, Minna	2	-	1	-	-	-	-	-	3
NSMANR, Minna	-	-	-	-	-	-	-	-	0
Sanbel Farms Ltd.	6	-	-	-	-	-	-	-	6
Bako Farms	3	-	-	-	-	-	-	-	3
U MMA Farms	2	-	-	2	-	-	-	-	4
Farm Ins't Tegina	1	-	-	-	-	-	-	-	1
NCRI, Badeggi	2	-	-	-	-	-	-	2	4
Total	27	2	5	2	1	1	3	2	43
% of Total By Make	62.79	4.65	11.63	4.65	2.33	2.33	6.97	4.65	

Source: Chukwu, 1994

2. Materials and methods

2.1 Design considerations

Before the design and development, it was necessary to consider some physical and engineering properties of the rice grain in order to select the best machine parameters such as sieve hole diameter, hopper size, concave clearance and thresher capacity. The grain properties determined included length of ears of rice, length of rice grain, breadth of rice grain, moisture content and grain straw ratio (Chabbra,1975).

2.2 Determination of physical and engineering properties of rice

The length and breadth of grain are used in selecting sieve hole diameters, while length of ears is used in selecting hopper size and the grain/straw ratio is for determining the theoretical capacity of the thresher. The grain size was determined by measuring the length and breadth of ten grains selected at random with a micrometer screw gauge while a tape rule was used to measure the length of ears of the crop. Grain moisture content was determined by oven drying method (A.O.A.C, 1984). All measurements were taken in the laboratory at a room temperature of 28°C. A cylinder speed of 556 rpm and fan air velocity of 4.46 m/s were selected and the concave clearance chosen was 40 mm. Sieve perforation diameters for top and bottom were 8 and 3 mm respectively (Hem, 1981; Ahuja and Sharma, 1989; The Food Agency, 1995).

2.3 *Design procedures*

The thresher was designed for a capacity of 250 – 300 kgh^{-1} of paddy and it has a 10.5 hp petrol engine as the power unit. The design consists of a frame, feeding hopper, threshing cylinder, concave, blower and reciprocating sieves. The various design parameters, namely; the threshing cylinder diameter and speed, concave width and construction, blower speed, number of sieves and sieve area were optimized with respect to output, threshing and cleaning efficiencies, breakage of grain and breakage of straw, by functional design methods.

2.4 *Construction and principles of operation of the thresher*

The main features of the rice thresher are the hopper, transmission unit, cleaning unit, straw and grain outlets and the supporting frame. The photograph and drawings of the thresher are shown in Figures 1and 2.

The hopper is trapezoidal in shape. It forms the feeding chute through which rice heads are fed into the threshing unit. The material of construction was gauge 16 mild steel sheet with all sides slanting inwards to enhance proper grain feeding. The transmission unit consists of five pulleys, bearings, shafts and v-belts. Two pulleys are mounted on the cylinder shaft, one on each side. The threshing unit consists of a cylinder, beaters and a concave made of mild steel iron rods and formed into semi circle with 8 mm spacing. The cylinder is placed above the concave, it is made of 37.5 mm mild steel flat bar rolled into circle of 300 mm and connected with eight rows of 37.5 mm flat bars. This arrangement and orientation is to aid the conveyance of the straw to the straw outlet. The beaters are made from mild steel iron rods and are spaced 100 mm from each other. The clearance between the free end of beaters and concave is maintained at 40 mm. The threshing unit is covered with a trapezoidal shaped steel plate (gauge 16) to prevent loss of grains. A reciprocating sieve unit (made of mild steel sheet arranged at a predetermined angle to allow free flow of paddy) is positioned 100 mm below the concave. Below the sieve unit is the clean grain outlet. An axial flow fan is placed below the first sieve to give a cleaning effect. The frame forms the mounting support for all other units of the thresher and is made of 50 mm angle iron. The overall dimension of the frame is 1700 x 1730 x 850 mm.

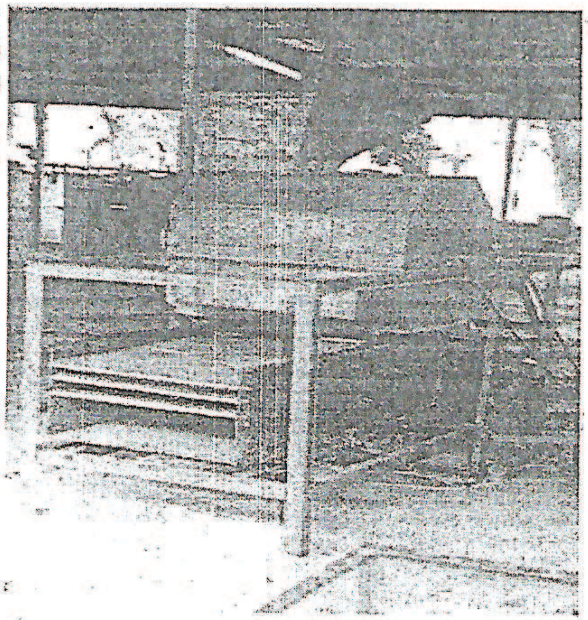

Figure 1: Picture of the Rice Thresher

Rice heads are fed uniformly into the hopper. The ear/heads fall by gravity on the rotating cylinder and are threshed by impact of the beaters and are whirled round between the concave and the rotating cylinder. The grains and chaff fall through the concave openings onto the reciprocating sieve plate. Just before falling into the collection chute/grain outlet, air stream from a blower blows off the chaff over the second screen, leaving behind clean grains. The sieve is automatically agitated to further grade the grain before collection at the grain outlet by the cam.

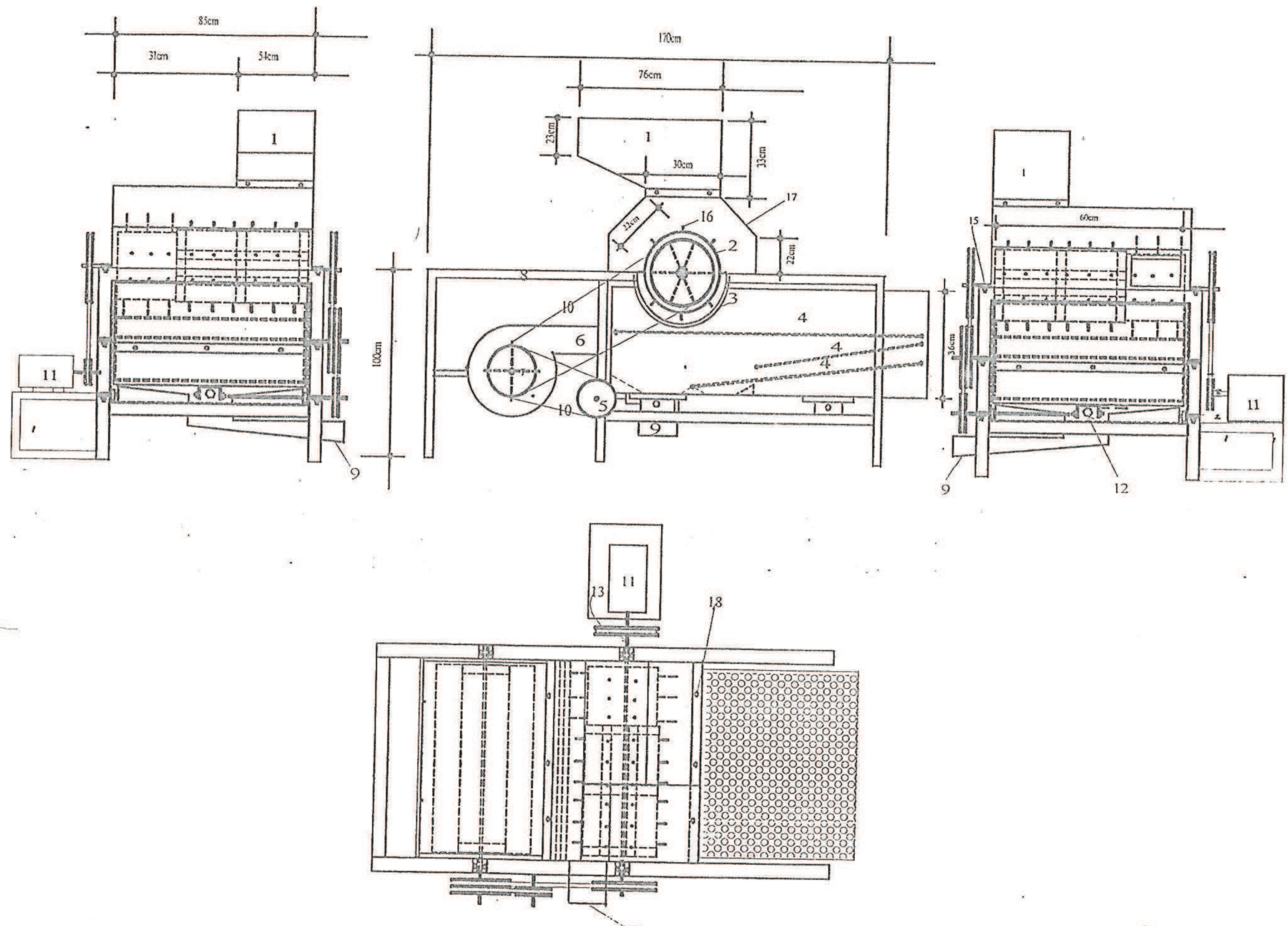

Fig. 2: Assembly Drawing of Rice Thresher

Legends for Fig. 2

S.no.	Description and specification
1	Trapezoidal feeding hopper (540x760x330 mm)
2	Threshing cylinder 2300x680 mm
3	Threshing concave semi circular 2460x380 mm
4	Sieve 28x1200x570 mm, 28x700x570 mm and 23x1000x570 mm
5	Pulleys 2120, 2300, 2190, 2120 and 2100 mm.
6	Fan housing 2450x530 mm
7	Fan blade 280x196x500 mm
8	Frame 50x50 mm angle bar
9	Grain outlet 2300x150 mm
10	v-belts AA 85, AA55 and AA38
11	Prime mover gasoline engine 10.5 hp
12	Cam
13	Shaft
14	Straw outlets
15	Bearings, FSP206, FSP205
16	Threshing teeth (beaters) 26x50 mm
17	Cover plate (trapezoidal) 220x300x220x600 mm
18	Bolts and nuts, 13 mm, 17 mm, 19 mm

2.5 *Performance evaluation*

Tests were carried out to obtain the total losses, threshing efficiency, cleaning efficiency, input capacity and output capacity (NCAM, 1990). At design cylinder speed of 556rpm, the threshed materials were collected at the outlet, cleaned and weighed. The unthreshed materials were separated from straw and weighed after hand threshing and cleaning in order to determine the threshing and cleaning efficiencies in terms of total grain received (Equations 1-5).

a) Determination of total losses (Lt)

$$Pu = \frac{qu}{Gt} \times 100 \quad (1)$$

$$Pc = \frac{qc}{Gt} \times 100 \quad (2)$$

$$Pl = \frac{ql}{Gt} \times 100 \quad (3)$$

$$Ps = \frac{qa}{Gt} \times 100 \quad (4)$$

$$Lt = pu + pc + pl + ps \quad (5)$$

where, Pu = percentage of unthreshed grain, %
qu = quantity of unthreshed grain obtained from straws , kg
Gt = total grain received at grain outlet, kg
Pc = percentage of cracked and broken grain, %
qc = quantity of cracked and broken grain from grain outlet, kg
Pl = percentage of clean grain, %
ql = quantity of clean grain obtained at straw outlet, kg
Ps = percentage of sieve loss, %
qa = clean grain at sieve overflow + sieve underflow + stuck grain, kg

b) Determination of efficiencies

Threshing efficiency (*TE*): this is the ratio of total weight of grains threshed to the total weight of grains fed into the thresher expressed as a percentage. It is also the difference between 100% and the percentage of unthreshed grain as (Equation 6).

$$TE = 100 - pu \qquad (6)$$

Cleaning Efficiency (CE): The ratio of the weight of clean grains that pass through the cleaning unit to the total weight of grains at the outlet of the grain retainer expressed as a percentage (Equation 7)

$$CE = \frac{Gc}{Gt} \times 100 \qquad (7)$$

where, Gc = clean grain received at grain outlet, kg.

c) Determination of output capacity

To determine the output capacity, the weight of threshed grain received at specified grain outlet per unit time was taken and recorded.

3. Results and discussion

The manual thresher requires three workers for continuous feeding to achieve maximum utilization. It was developed mainly for threshing rice, but has the potential of threshing other grain crops. The grain and environmental conditions were uniform at the time of testing the thresher. It was identified that grain moisture content, length of grain, grain number, speed of threshing drum, length of ears of crop and size of sieve aperture are some of the parameters that affect output capacity of the thresher. The grain number (which gives a measure of grain/straw ratio), which is different for different rice varieties, also affects the output capacity of the thresher.

The result of the physical properties of FARO 5I rice crop and grain are presented in Table 2. The average length of ears was 789 mm. For the length and breadth of rice grain, the average was 6.99 mm and 3.36 mm respectively. The grain/straw ratio was 1.22. Table 3 shows the general specifications of the rice thresher developed. At average moisture content of 13.83%

and cylinder speed of 556rpm, the threshing and cleaning efficiencies determined were 98.01 and 99.32% respectively. Total grain loss and output capacity were 4.78% and 267.9 kgh^{-1}.

Table 2:Some Physical Properties of Rice

S/N	Length of ears (mm)	Length of grain (mm)	Breadth of grain (mm)	Grain/Straw ratio
1.	900	6.30	3.36	1.22
2.	920	7.56	3.05	1.25
3.	800	6.76.	2.85	1.20
4.	700	7.84	3.14	1.23
5.	890	6.49	3.76	1.30
6.	780	7.14	3.82	1.18
7.	930	6.50	3.46	1.18
8.	560	7.56	3.22	1.22
9.	500	6.82	3.44	1.24
10.	910	7.00	3.55	1.20
Average	789	6.99	3.36	1.22

Table 3: General specifications of the rice thresher

Component/Parameter	Description
Prime mover	10.5 hp petrol engine (Montgomery, 3600 rpm) with overall dimension of 850 x 1700 x 1730 mm and weighs 237kg weight
Cylinder	680 mm wide and 300 mm in diameter with a housing 460 mm in diameter and 550 mm wide.
Blower	Has 3 blades
Concave	Stationary with a 40 mm clearance
Sieves	3 in number with dimensions of 1200 x 570 mm with 8 mm holes for upper 700 x 570 mm with 8 mm holes for middle 1000 x 570 mm with 3 mm holes for lower
Grain/straw ratio	1:1.22
Moisture content of rice handled	13.83 wet basis (average)
Threshing efficiency	98.01%
Cleaning efficiency	99.32%
Input capacity	480 kgh^{-1}
Output capacity	267.9 kgh^{-1}
Losses:	
➢ Unthreshed grain:	1.99%
➢ Cracked and broken grain:	0%
➢ Sieve loss	2.79%

4. Conclusion

A rice thresher was designed and developed to thresh the commonly available rice varieties in Nigeria. The machine can be used by both small and medium scale farmers. The thresher has an output capacity of 267.9kgh-1 at a cylinder speed of 556rpm and moisture content of 13.8%. The threshing and cleaning efficiencies were 98.01% and 99.32% respectively, and the total percentage loss was 4.78%. The parameters that affect the performance of this machine include condition of the paddy rice head, moisture content, grain/straw ratio, length of rice crop, grain length, cylinder speed, concave clearance and size of sieve aperture. The use of this thresher can reduce the demand of labour during peak threshing period.

References

A.O.A.C. (1984) *Official method of analysis* 14th edition. Association of Official Analytical Chemists, Washington D.C

Ahuja, S. S. and V.K.L. Sharma. (1989) Performance Evaluation of IRRI - PAK Axial flow thresher on wheat and paddy. *J. Agric. Engineering*, JAE, Vol. 23 (1) 18-23.

Chabbra, S.D (1975). *Studies on threshing of paddy and wheat by axial flow thresher.* M.Tech. thesis. Agric Eng'g. Dept. G.B pant Univ. of Agric. And tech. Pantnagar

Chukwu, O. (1994) *Technical Evaluation of Rice Threshers in use in Niger State Nigeria.* Unpublished M.Eng Thesis, Department of Agric. Engineering, Faculty of Engineering, University of Nigeria, Nsukka.

Hem, C.J. (1981) Design and selection of thresher parameters and components *AMA* spring 1981. Pp 61-70

NCAM. (1990) Test code for power maize shellers. Draft Nigerian Industrial Standard. Prepared by the National Centre for Agric. Mech., Ilorin, Nigeria 18 pages.

Nkama I. (1992) Local Rice Processing. A Paper Presented at a Monthly Technology Review Meeting for Taraba ADP 26th November 1992.

The Food Agency (1995). Rice Post-harvest Technology, Ministry of Agriculture, Forestry and Fisheries, Japan, Pp.167-179.