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Development and Performance Evaluation of a Motorized Millet Thresher

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ABSTRACT
A thresher was designed for threshing, and cleaning millet grain. The major components of the machine include threshing separation and cleaning units. The threshing operation is achieved by rotational motion of a cylinder fitter with beater angle iron above a stationary grid, whichresults in the removal of the grain from the panicles and their separation from the bulk of the straw. After being beaten out the grain fall through a concave grid into the cleaning units which consists of a sieve that is stationary and the grains drop in the sieve. Constant blast of air is sent through the chamber.A 2HP diesel prime mover (820rpm) powers the machine. The machine has reduced drudgery associated with the traditional method of threshing millet. The results shows that threshing millet at 13% moisture content with the speed of 800rpm produced the highest efficiency of 63.20% while threshing at 17% moisture content at the speed of 600rpm produced the lowest efficiency of 40.68%.
KEYWORDS: Design, fabrication, testing, millet threshing

I. INTRODUCTION

Millet (Pennisetumglacium) is one of the oldest food and believe to be the first domesticated cereal grain (Crown ford 2003) Ikwelle et al (1993) ranked pearl millet as the most important cereal in the Southern Sudan and Northern Guinea. Milletis the principle food source in arid and semi-arid region of the world. It is stable food of millions of people in drier parts of tropical Africa. It has been reported that the air dried grain of millet contains approximately 12.4% water, 16.6% protein, 5% fat, 65% Carbohydrate, 1.2% fibre and 2.7% ash (Onwueeme and Sinha, 1991).

Millet isa good source of minerals such as calcium, iron, zinc, copper and manganese (Hulse et al (1980). Products from millet vary depending on people taste and cultural preference. One of the common traditional product made from millet in Nigeria is "Kunu" a non-alcoholic beverage, it is of low viscosity and has sweet sour taste, milky cream appearance and is popular with people of northern Nigeria (Adeyemi and Umar, (1994). The most important characteristics of millet are its unique ability to tolerate and survive under adverse condition of continuous or intermittent drought as compared to most cereal like Maize and sorghum (LCRI, 1997).

At present Nigeria is the third leading millet producing country in the world after India and China with production capacity of about 4 million tons which is about 134% of total world population (FAO, 1996). In order to increase millet production, it is necessary to modernize the production techniques and optimize the processing condition with a view to realizing some basic quality requirements such as improved flavor and increased shelf life. Millet is threshed both mechanically and traditionally.

In mechanized threshing, two main type stationary threshing machines have been developed, the machine of western design is known as through flow thresher because stalks and ears pass through the machine. It consists of a threshing device with pegs, teeth or loops and in more complex models a cleaning winnowing mechanism based upon shakers sieves and centrifugal fan. In the 70s an axial flow thresher was developed which has been widely adopted in many millet growing areas (Policarpio and Mannamy, 1978). The simple design and work rate of this machine seem to meet the requirement of rural communities. However, the main disadvantages of these machines are that they have complex feature and are in most cases fragile hence not easily adoptable in developing countries.

The traditional method is generally done by hand bunches of panicles are beaten against hard element (wooden barlog, staff bamboo table or stone). In many countries in countries in Asia and Africa. The crop is threshed by being trodden underfoot by humans or animals. This method results in some losses due to the grain being broken or buried in earth. This process is slow and energy consuming. Often this method of processing the crop leads to low quality produce due to the presence of impurities like stone dust and chaff. Threshing and separation of the grain from these impurities requires modern technology that can easily maintained and repaired for effective utilization in developed and developing countries. The motorized millet thresher designed has a high threshing efficiency of 63.20% and 62.7% cleaning efficiency which is capable of meeting the demand of farmers.

II. MATERIALS AND METHODS

2.1 Operational Principle

The Millet thresher consist of shaft, pulley belt and a generator. During the operation a belt providing a convenient means of transmitting power to the shaft and pulley to carry out the Mechanical operation. The millet is fed through a hopper into the threshing unit. The beater are rotating in a clockwise direction with a required speed to thresh the millet stalks, the angle Iron beat the millet stalk mechanically. The millet grain is separated from its shaft passes through the sieve shaker in which the blower fan blows out the shaft and clean grain passes through the outlet collection. Clearance of 6mm between beaters and threshing chamber is providedin order to thresh all the millet stalk and to avoid damage of grain.

2.2 Design Consideration and Calculation

Result of preliminary experiment are;R_b = Radius of Angle iron = 0.035m, R_p = Radius of threshing pulley = 0.0225m, R_c = Radius of threshing chamber = 0.049m, D_c = Diameter of threshing chamber = 0.098m, D_d = Diameter of threshing pulley = 0.043m, D_p = Diameter of drive pulley = 0.032m

2.3 Determination of Angular Velocity

The angular velocity (w) of the shaft is determined from the equation.

W = 0.1n – --------------2.1

Where n = number of revolution per minutes.

2.3.1 Determination of force Acting on the beater Angle iron.

The sum of forces acting on the 7 angle iron beater is given by:

$\sum F = ma + maf + AW$ …………………………….. equation 2.2

Where m = Mass of the millet and chaff inside the threshing chamber = 9kg for each operation, a = Acceleration due to gravity = 9.81m/s, f = Coefficient of friction 1.7 and A = Coefficient of Angular Velocity, W = Weight of grain

2.3.2 Determination of Toque (T)

Toque on shaft can be determined by

$T = \sum F x R_b$ of beater …………………………….. 2.3

Where R_b = Radius of beater angle iron.

2.3.3 Determination of shaft Diameter

The approximate diameter of central shaft is determined using the energy distribution formular given as

$D = C_1 \text{ x } (T)^{0.22}$………………………………………. 2.4

2.3.4 Determination of power required to operate the machine.

The power is obtained from

$P = F_p \text{ x } W \text{ x } R_p$ ………………………. 2.5

Where F_p = Force on threshing pulley, W = Angular Velocity and R_p = Radius of the threshing pulley.

2.3.5 Determination of Concave Radius

The radius of Rc is determined by the following expression as used by Dangora (2006)$R_c = R_b + H_e + B_c$, Where; R_c = Radius of concave (mm), R_b = Radius of beater (mm) 35mm, H_e = height of threshing Chamber (mm) and B_c= Beater angle iron and threshing chamber clearance.

2.4 Materials Selection

The machine was developed using locally available materials. The materials were selected based on availability, mechanical properties and cost Mild Steel, Galvanize metal sheet (3mm), Angel iron (4” & 2”), Bearing, Shaft, Pulleys and Prime Mover were the materials and components selected.

2.5 Machine fabrication

The fabrication sequence of the millet thresher is as follows:

Construction of frame using Angle Iron, Construction of the hopper, Construction of the threshing chamber, Fabrication of shaft for power Transmission, Coupling of pulley and bearing, Construction of seed/grain collector,Finishing and painting.

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2.6 Operating Mechanism

The threshing operation is achieved by rotational motion of a cylinder fitted with beater angle iron above a stationary grid which result in the removal of the grain from the panicle and their separation from the bulk of the straw. After being beaten out the grain falls through a concave grid into the cleaning units which consist of a sieve that is stationary and the grain eventually to drops on the sieve. A constant blast of air is being sent through the machine to blow out the chafts.

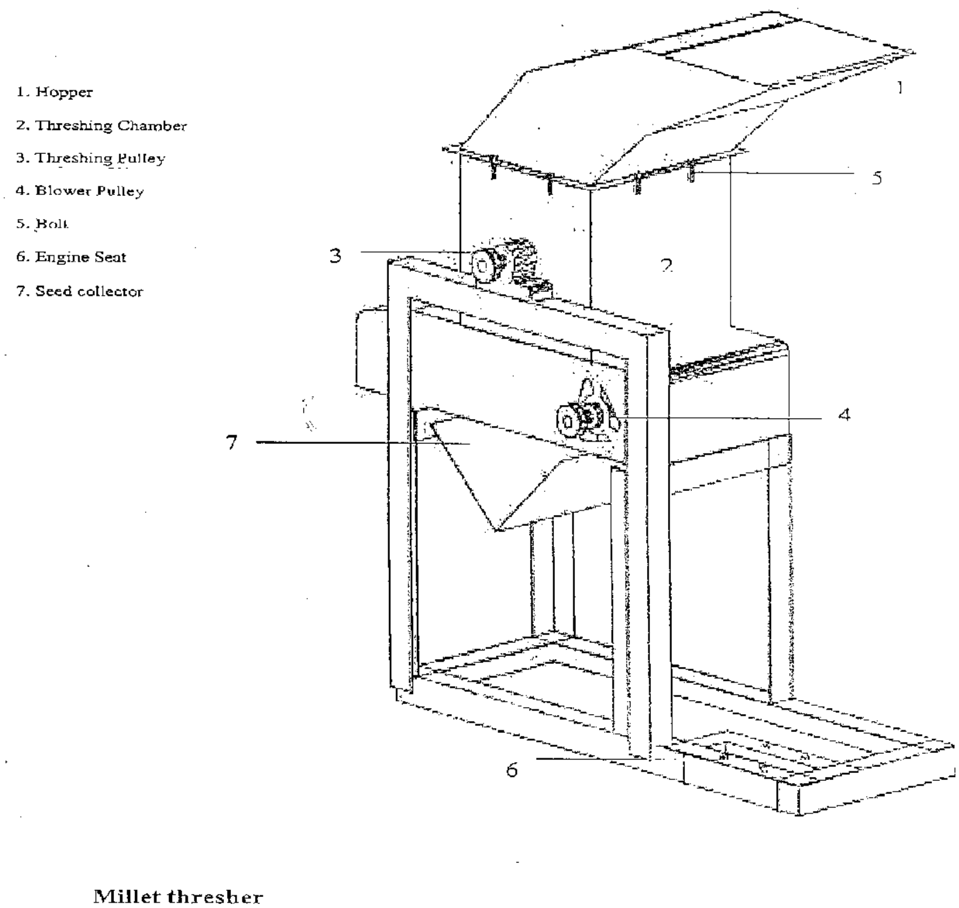

Fig. 1 Motorized Millet Thresher

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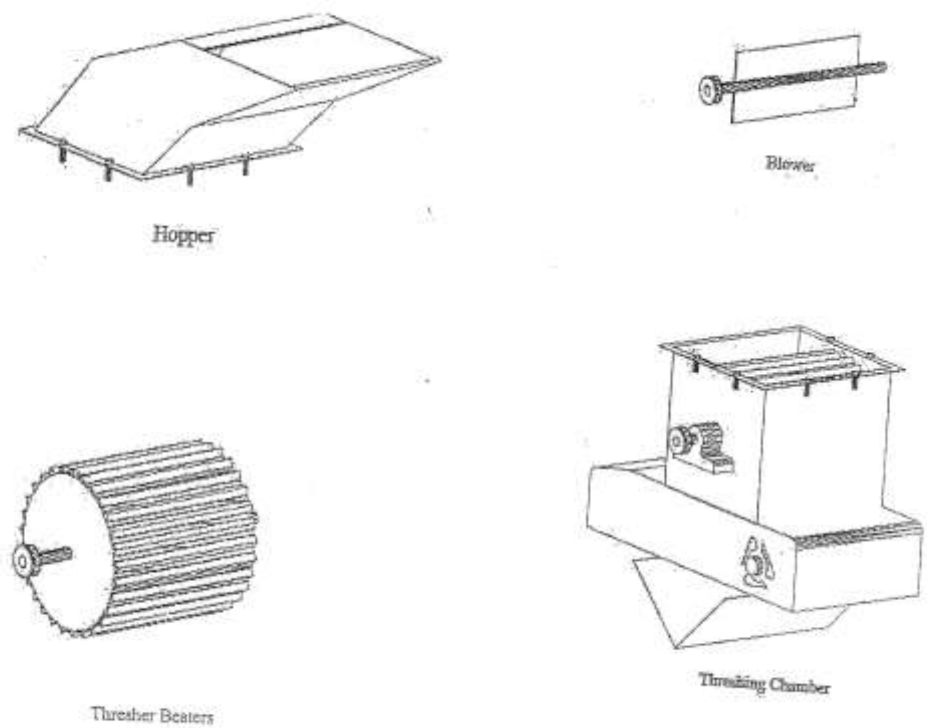
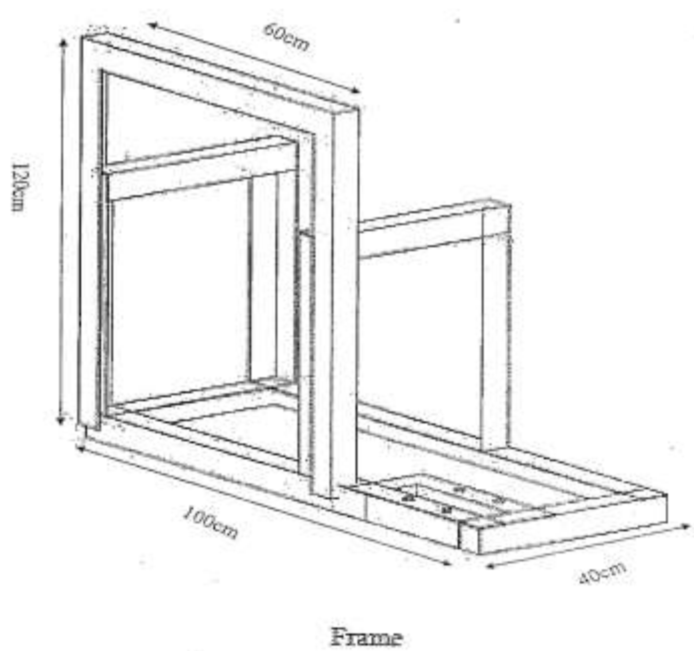
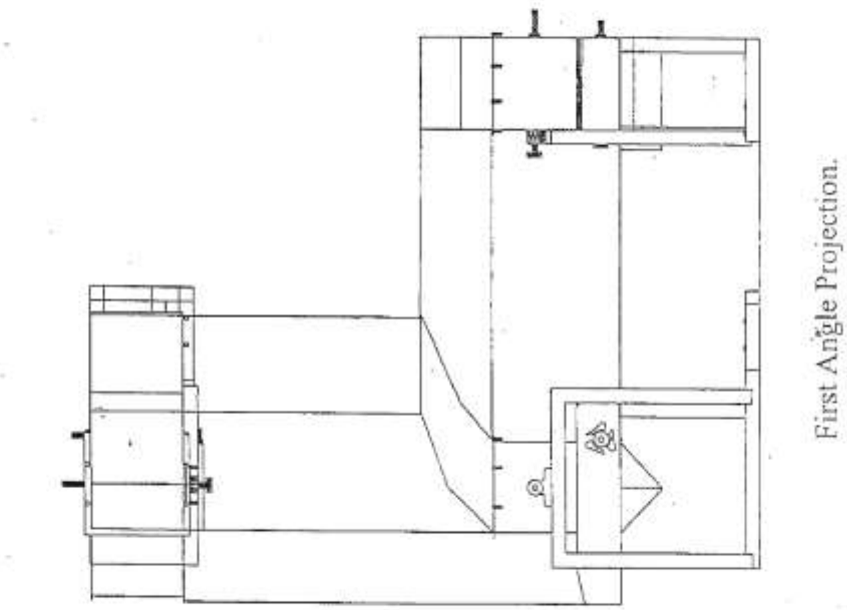


Fig. 2: Detailed drawing





III. RESULTS AND DISCUTION

The result and performance evaluation are shown in Table 1

Threshin speed	M.C	Mass of grains panicle [M_A(g)]	Avg. mass of threshed grains [M_T(g)]	Avg. mass of unthreshed grain [M_{UT}(g)]	Avg. mass separated impurities [M_{SI} (g)]	Avg. mass of unseparated impurities [M_{UI} (g)]	Avg. qty of recovered grains [M_{RG} (g)]	Qty of loss grains [M_{LG}(g)] 1840 1925	Threshing efficiency (TE%)	Cleaning efficiency (CE%)	Percentage loss (%)
800	13	5000	3160	1840	190	110	3160		63.2	62.7	36.8
	15	5000	3075	1925	182.5	117.5	3075		61.5	60.2	38.5
	17	5000	2910	2090	180	120	2910	2090	58.2	59.4	41.8
700	13	5000	2850	2150	175.05	124.95	2870	2130	57.4	57.8	42.6
	15	5000	2685	2315	165	135	2685	2315	53.7	54.5	46.3
	17	5000	2526	2474	154.85	145.15	2526	2474	50.52	51.1	49.48
600	13	5000	2620	129.52	170.48	129.52	2380	2620	48.19	56.3	47.6
	15	5000	2526	142.4	157.6	142.4	2474	2526	43.04	52	49.48
	17	5000	2416	148.3	151.7	148.3	2584	48.32	40.68	50	51.68

Threshing Efficiency

The results of threshing efficiency of the machine are presented in Table 1. Threshing millet at 13% moisture content with a speed of 800 rpm produced the highest efficiency of 63.20% and threshing millet at 17% moisture content with the speed of 600 rpm produced the lowest threshing efficiency of 40.68%. This could be as a result of more dryness of the millet stalk which allowed easy dislodging of the grains from the stalk and high speed of rotation of the threshing drum that resulted in more impact of beaters on the millet stalks. This agreed with the result of an earlier study by efficiency. The threshing effectiveness was also found to be affected by the cylinder speed, the concave clearance, feed rate of crops, the number of rows of concave teeth used with spike tooth cylinder, and the type of crop.

Cleaning Efficiency

The results of cleaning efficiency of the machine are presented in Table 1. From the results, the highest values of cleaning efficiency range from 56.3 to 62.7% when the millet was processed with 13% moisture content. The lowest values of cleaning efficiency range from 50 to 59.4% when processed at 17% moisture content. A speed of 800 rpm produced the highest cleaning efficiency of 62.7% and lowest efficiency of 56.3% at a drum speed of 600 rpm. Where cleaning efficiencies was found to be increased by increased of drum speed and decreased by increasing both the feed rate and seed moisture content. The increase in the percentage of threshing and cleaning efficiencies by increasing drum speed was attributed to the high stripping and impacting forces applied to the black seed materials, which tend to improve the threshing operation and increase threshing and cleaning efficiencies.

Percentage Loss

The results of percentage losses of the machine are presented in Table 1. Threshing millet at 17% moisture content and speed of 600 rpm produced the highest value of percentage loss of 51.68%. This could be as a result of high moisture content of the seed that produced resistance to dislodging as such more of the seed were lost with the stalk. It was also observed that the percentage loss decreased with decreasing in moisture content of the seed and increased with increasing in seed moisture content.

IV. CONCLUSION

The highest threshing efficiency of the machine was 63.20% when millet was threshed at 13% moisture content with a drum speed of 800 rpm while the lowest threshing efficiency of 40.68% was recorded when threshed at 17% moisture content with drum speed of 600 rpm.

The highest machine cleaning efficiency of 62.7% was achieved when the millet was threshed at 13% moisture content at a drum speed of 800 rpm and the lowest cleaning efficiency of 50% was obtained at 17% moisture content with drum speed of 600 rpm.

The highest percentage loss of 51.68% was obtained when the millet was threshed at 17% moisture content with drum speed of 600 rpm and the lowest percentage loss of 36.8% was realized when millet was processed at 13% moisture content with drum speed of 800 rpm.

Generally, the millet thresher works more efficiently as the moisture content decreased and the threshing drum speed increases. Since the average threshing and cleaning efficiencies were about 63.0 and 62.7%. respectively, the optimum operating parameters of the thresher are demonstrated at 13% moisture content (wet basis) and 800 rpm threshing drum speed.

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