DEVELOPMENT OF GRAIN THRESHING TO ENHANCE THE ECONOMY OF POSTHARVEST PROCESSES

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ABSTRACT

Northern Nigeria is blessed with many varieties of grains. The chief of them in Bauchi state are rice, millet, sorghum, soybeans, maize, and wheat. Because of the basic differences in the properties of each of these crops, different machines are being used for threshing each. For instance, on the one hand, rice (paddy) is a grass crop. Its grains are held by a thin branch on the stalk. As for wheat, the grain is like rice, but it is rather shelled in a fabric. Soybean is held in a pod and is often harvested together with its hard stalk. Maize on the other hand, is fixed in a cob. The variations in the geometry and structure of the grain crops are the reason for variations in the design of the threshers used for threshing them. Moreover, most farmers plant several crops. Therefore, they spend lot of money to rent or procure many threshers thereby increasing the cost of processing the grains. Nonetheless, there are many similarities in the components of the existing machines used in threshing some group of grains. Of prime interest to farmers in Bauchi state are rice, maize, sorghum, and soybean. It is Therefore proposed in this work to develop a thresher that can thresh these five crops (rice, maize, sorghum, millet, and soybean). Locally available and affordable materials are considered for the production. Besides, replicability of the manufacturing process and maintainability are considered. The machine consists of two main units. The threshing unit contains a drum, fitted with spikes or rasp bars while the cleaning unit has fan and crank controlled shaker. The straws or cobs are fed into the threshing chamber via a hopper. The spikes or raps bars are designed such that they continuously beat the straws or cobs to separate the grains from the straw or the cobs. The threshed materials flow through a perforated sheet under the chamber. Separation of the crushed straws or cobs and the grains is done by the cleaning unit. The suction fan removes the straws and other particle while the clean grains are received via the output port of the shaker. The new design expected to *reduce the cost of farming and increase productivity by making more money available for other activities. Hence making farming more profitable.*

INTRODUCTION

Among the post-harvest processes on crops, threshing is the first and most valuable. This is because in most cases, it entails lots of drudgery. Besides, it determines the quality of the grain. Nonetheless, majority of the farmers in Nigeria up to the last two decades still thresh manually [1]. The situation is improved in the recent time. Many farmers have procured threshers from China. Nevertheless, personal discussions with many of such farmers reveal that most of the imported machines are not durable, hardly lasting more than two seasons.

Many attempts have been made locally to replicate these imported machines. Though they are made of material of higher quality, the efficiency of such machines is still low [2], manifesting as poor material flow rates, threshing, cleaning and excessive breakages. This reduces the market value of the grains. Besides, the mostly poor farmers must procure or rent different machines for threshing different crops. Although the different crops have some dissimilarity in their physiological make and structures, they maintain some similarities regarding threshing parameters hence most of the existing threshers have components that can perform threshing operations on many of the crops with minimal alteration.

In this effort, the focus is to develop a threshing machine that can thresh rice, maize, sorghum, millet and soyabeans with minimal replacement or adjustment of the parts. It is equally aimed to consider a blend of efficiency, cost, safety, and maintainability in evaluating the concepts. Many threshing machines exist for different crops and these machines have been locally manufactured in Nigeria. Though some of the imported threshers claim to process several crops, they are short in supply and expensive. Besides, the local manufacturing is still lacking adequate thresher that can combine threshing many crops effectively. Therefore, the development of a thresher that can process rice, maize, soybeans, sorghum, and millet is proposed in this work.

To identify the different components that can perform the various threshing operation for five different grains. To design and fabricate multigrain threshing machine. To determine the efficiencies of the machine.

LITERATURE REVIEW

The main unit of any threshing machine are the threshing unit and the cleaning unit [3]. Threshing is achieved by beating the crop within a chamber. The beaters could be rasp bars or spikes [1]. Raps bars are more effective in maize, sorghum and millet threshing while spike have more applications in rice and wheat threshing. Nonetheless, either of them can be used for any of the crops [4].

Furthermore, the inputted unthreshed grains are different, so are the inputting ports. For rice in most designs the input port is a gate at one end [5]. While for crops like maize and most others, the feeding is via hoppers fitted at the top of the machine [6]. The cleaning units for most of the grains all also different. Depending on the volume of shaft or stalks that are to be separated from the grain. Fans are used to separate the light stalks from the grains. The fans are either suction or blowing fans [7]

Combination of the units is based on selection of the components that is common to all the grains to be threshed with little compromise to each of the grains. The overall benefit of such design is the cost effectiveness of the machine and its availability [4].

METHODOLOGY

The study is be carried out based on the flowchart in Figure 1.

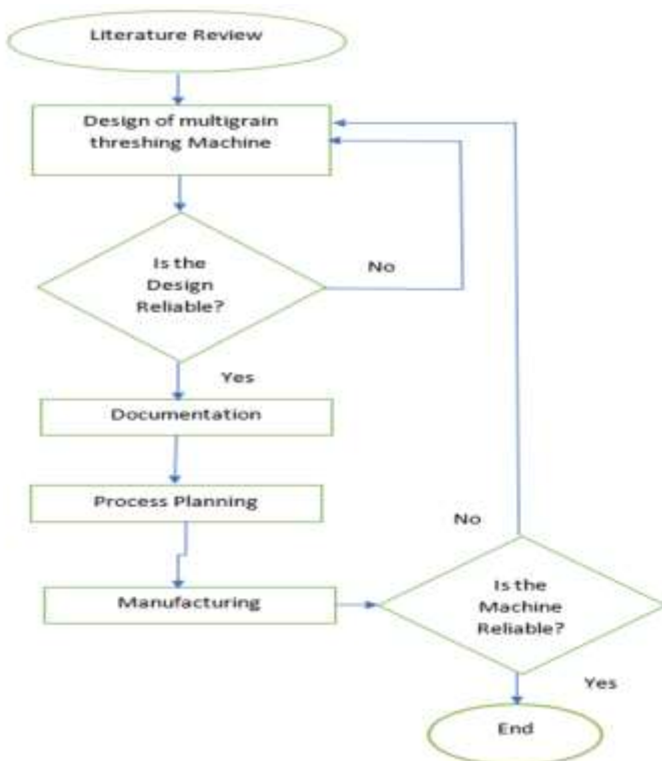

Figure 1: The Methodology for Development of multigrain threshing Machine

Methods

1. Review of the production process of meat floss: the local production process will be studied from literature and the producers the floss.
2. Design of the elements in the threshing unit as shown in appendix 1 will be carried out with selection of materials and manufacturing methods.
3. Design of the elements in the grain cleaning unit will also be carried out with selection of materials and manufacturing methods.
4. Production of a physical model to test the reliability of the design. A miniature of the Machine will be produced to gain idea on the work of the machine.
5. Selection of material and production process of the machine. The appropriate stock will be selected based on cost, manufacturing consideration and availability.
6. Manufacturing of components of machine and assembly
7. Testing each unit of the machine by comparing the production time
8. Computation of threshing and cleaning efficiencies for each grain.

Instrument

1. Interview
2. Use of CAD and design analysis
3. Use of material like mild steel and plastics to produce a model
4. Using materials stated in appendix 1 to produce the machine
5. Use of the different grains to test the machine
6. Use of Cohen’s kappa coefficient to compare the product with that of the conventional manually produced meat floss

Description of the Machine

The multigrain threshing machine designed for this work comprises of three units which are: The input unit, the threshing unit, and the cleaning unit. The input unit is the hopper at the side of the machine where the unthreshed grains are inputted into the machine. The grains are threshed inside the chamber by continuous beating by the spikes. The base of the chamber is lined with perforated sheet that enable the material to get out of the it only when it is fully threshed. Two flywheels are attached to the threshing shaft to reduce the energy needed for threshing. Furthermore, three suction fans are fitted. Each of the fans removes chaffs of different sizes. Two agitated inclined sieves are fitted under the machine for separation of particle larger and smaller than the grains. A gate is at the inlet port of the one of the fans. The gate is closed for al other grains but opened for maize threshing.

Design Analysis and Selection of Material

The design analysis and selection of material comprises of specification of design para meters and analytical synthesis of components.

Design Parameters.

A through put of 20kg of grains is considered. This exerts a force of 196.2N in service. For every batch of 20kg an average of 2 minutes is expected to be expended.

Design of threshing

The design and analysis of some of the parts that are to be manufactured are discussed in this Section.

Design of Spikes

The spikes are designed as cantilever beams subjected to uniformly distributed static load and a variable load due to rotation. Cylindrical bars were selected for the beaters to enhance the working surface. Diameter of the beaters was determined from equation 1 using bending equation [3].

$$d = \sqrt[3]{\frac{32M\ F.S}{\pi\ \sigma}} \qquad 1$$

Where σ = bending strength =510 MPa for stainless steel; $F.S$= factor of safety, 3 was selected for factor of safety and M= bending moment = 21.4N/m^2. A diameter of 10.8mm was obtained but 15mm was selected to enhance its impact on the boiled beef.

Design of Shafts

The digester shaft is subjected to combine bending and twisting moments with fluctuating loads. The diameter of the shaft was determined based on ASME Code from equation 2 [8].

$$d = \sqrt[3]{\frac{16\sqrt{(K_b \times M)^2 + (K_t + T)^2}}{\pi\tau}} \qquad 2$$

Where; $\tau = 42MPa$; K_b = combined shock and fatigue factor for bending = 1.5 for medium shock load; K_t = combined shock and fatigue factor for torsion = 1 for medium shock load; M = maximum bending moment = 85.2Nm; T= torque =68.4Nm for

Therefore, based on ASME code diameter obtained is 26mm

Besides, based on torsional rigidity the diameter was determined from equation 3.

$$d = \sqrt[4]{\frac{32 \times T \times L}{\pi \times G \times \theta}} \qquad 3$$

Where L=0.45m; G= Modulus of rigidity = 90×10^9N/m^2; θ = 0.0044rad.

Therefore, based on torsional rigidity diameter obtained is 30mm

The shaft was also designed based on critical speed by considering operation speed to be 70% of critical speed from equation 4 [2].

$$\frac{2\pi N}{60} = \frac{70}{100} \times \frac{30}{\pi} \sqrt{\frac{g}{\delta_{max}}} \qquad 4$$

Where N= speed in rpm=600rpm; g=acceleration due to gravity = 9.81; δ_{max}=$8.7 \times 10^{-8} \times d^{-4}$ for digester shaft and $2.3 \times 10^{-8} \times d^{-4}$. Based on critical speed diameter obtained is 30mm. therefore 30mm is selected as diameter of the shaft.

Selection of Bearing

Single row deep groove ball bearings were considered for the supports of shafts due to their availability and capacity to support radial loads. Since the shaft diameter 30 mm the bearings with 30 mm bore 206, 306 and 406 are considered. The basic dynamic load (W) for the bearings and design basic radial load capacity (C_D) are obtained from equations 3 and 4 respectively [2].

$W = X.V.W_R + Y.W_A$ 3

$C_D = W.K_S$ 4

Where X=radial load factor; V= rotation factor; Y= axial load factor; W_R=radial load; W_A= axial load; and K_S = service factor. The design basic radial load capacity of 24.6 for the shaft bearing. Therefore, bearing numbers 406 was selected respectively from manufacturer's catalogue.

Selection of Belts and Pulleys

Power required for running the equipment was designed to be from a single prime mover. A compound belt and pulley system were adapted to run the various units concurrently. Power required for running each shaft was obtained from equation 5 [4].

$$P = \frac{2T\pi N}{60C_S} \quad 5$$

Where; C_S= service factor =2. Power of 2.1KW and 0.8KW were obtained for the shedding shaft and fry spinning shafts respectively. therefore, belt types B and A were selected respectively. Pitch length of belt was determined from equation 6 [4].

$$L = \frac{\pi}{2}(d_2 + d_1) + 2x + \frac{(d_2 - d_1)^2}{4x} \quad 6$$

A pitch length of 1208mm was obtained for the digester while 1002mm was obtained for the shredding shaft and the fry spinning shaft. Therefore, based on IS: 2494-1974 standard, the nearest standard lengths are 1212mm and 1026mm respectively. Pulley diameters of 180.and 120mm were also selected respectively.

Selection of Prime Mover

Total power required to run the equipment is the sum of powers transmitted by all the shafts in the equipment. Therefore, total power transmitted by the shafts is 4.5kW. The speed ratio of shaft is 2:1 and speed of 1200r.p.m was selected for the prime mover. The power in horsepower was obtained from equation 7.

$$P_{Hp} = \frac{P_W}{750} \quad 7$$

Petro engine of 6Hp at 1200r.p.m was selected as the prime mover.

MANUFACTURING PROCESS

S/NO	*PART NAME*	*MATERIAL*	*MANUFACTRING PROCESS*	*EQUIPMENT/TOOL REQUIRED*
1	Threshing shaft	1) ø40mm mild steel round bar 2) ø2mm mild steel round bar 3) 50×65mm rectangular	1) Turning; the ø40mm round bar will be turned to ø30mm and 1150mm length 2) Cutting; ø12mm round bar will be cut to 150mm length	1 Lathe machine 2 Cutting machine 3 Axil 4 Welding machine

		bar of 5mm thick 4) 100×50mm rectangular bar 5mm thick	3) Cutting; the rectangular bar will be cut to 50×60mm and 100×50mm 4) Twisting; the 100×50mm rectangular bar will be straight at angle 15° 5) Joining; the bar plates will be welded to ø30mm bar as shown in Appendix 2	
2	Threshing chamber	1)mild steel sheet 2mm thick	1) Shearing; **(a)** The sheet will be cut to 600mm×1050mm rectangular slap **(b)** Two circular plates of ø304 with center hole of ø40 will be cut **(C)** Folding; the 600×1050mm sheet will be folded into cylindrical shape with open ends on its surface and circular ends and weld as shown in appendix 3 (**d**) Joining; the parts will be joined by welding	1) Sheet shear 2) Sheet rolling machine 3) Welding machine

3	Threshing screen	1 mild steel sheet 2mm thick	1)folding; The sheet will be folded as shown in Appendix 3 2) perforation; the folded sheet is perforated such that the holes in them can allow the grain to freely pass to the cleaning space. The holes are made bigger than the size of the largest grain.	1 Sheet rolling machine 2 Cutting machine 3 Welding machines
4	Support frame	Mild steel angle bar 50×50mm	1) Cutting; The angle bar will be cut to lengths of 1100mm,1000mm and 1300mm 2) Joining; The components will be made by forming the angle bar using electric arc welding as shown in appendix 7	1) Cutting machine 2) Welding machine
7	Machine assembly	1)All parts are assembled	1)Joining; (a) The threshing drum will be assembled and placed in the threshing chamber by mounting it on rolling contact bearings. (b) The bearing will be held on the frame	1) power wrench 2)Spirit level 3) Rolling contact bearing 4)Bolt and nuts (M17)

	using M17 bolt and nuts (c) The sanction fans will be fitted to one end as shown in Appendix 1 (d) The cleaning unit will be assembled e) The prime mover will be fitted, and belt and pulley transmission system will be installed.	

RESULT AND DISCUSSION

The machine was designed and constructed based on the engineering specification given. Furthermore, it was tested for functionality and found to thresh five grains effectively. The five grains are rice, maize, sorghum, millet, and soybeans. For each of the grains, the machine is capable of threshing one tone in an hour. The production rate and versatility of the machine makes it economically viable for use by both small and medium scale farmers.

CONCLUSION

It can be concluded that the objectives of this study have been achieved. The machine as been developed to thresh five grains with little adjustment. Effectively, it has been able to fulfil this function.

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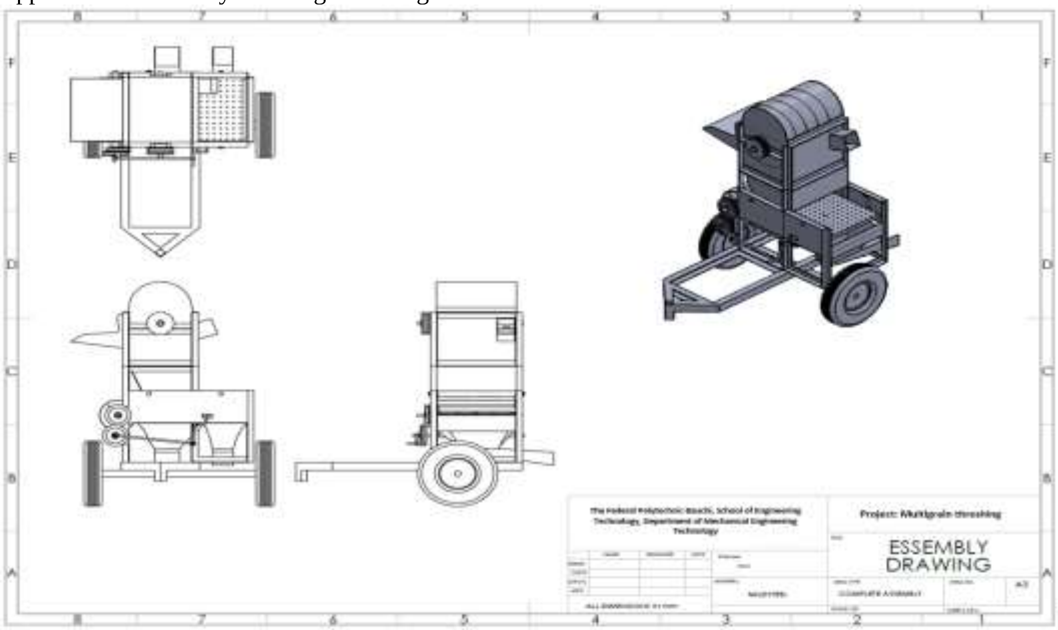
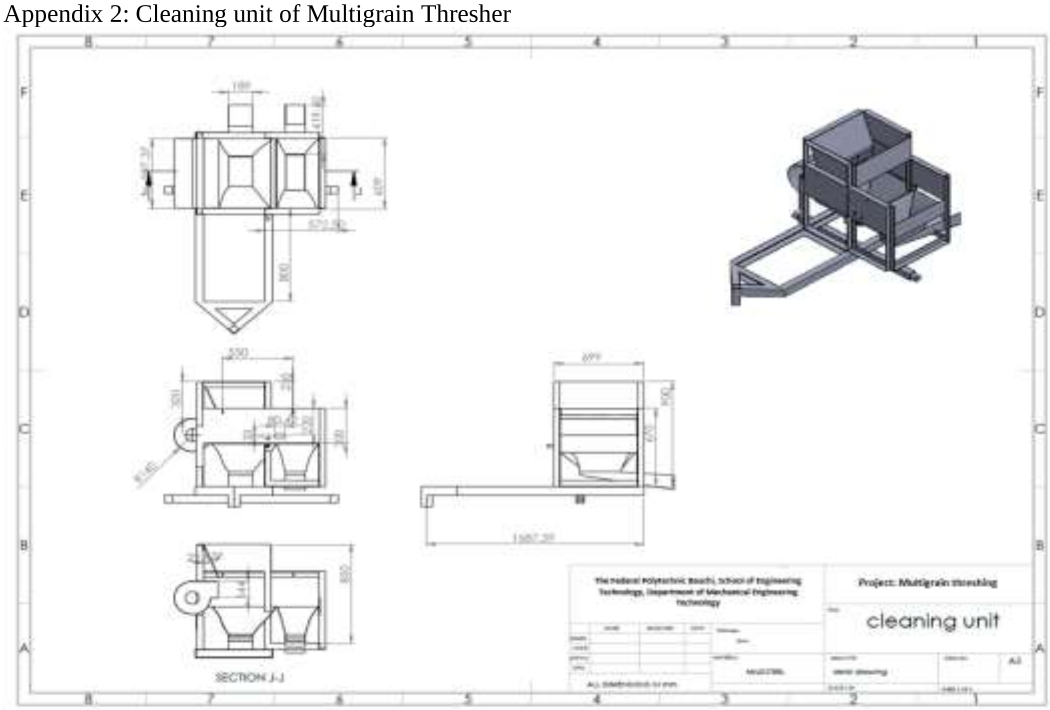
Appendix 1: Assembly Drawing of Multigrain Thresher



Appendix 2: Cleaning unit of Multigrain Thresher



Appendix 3: threshing chamber of multigrain thresher