THE DESIGN AND FABRICATION OF A MAIZE HARVESTING MACHINE

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Abstract

Farmers have recently experienced shortage of skilled labor for agriculture purpose. Because of this, most farmers have transitioned to using mechanical means to achieving continuous production of agricultural products. Maize harvester is rampant amongst maize producers but the purchase cost seems high for small and medium scale producer. This work is intended to make available affordable and efficient maize harvester for small and medium scale farmers. The designed maize harvester comprises of three sections which are as follow; The prime mover (petrol engine of 11hp), the gear box which help to transmit drive from the prime mover and a shaft having a solid square rod helically arranged on it which receive it drive from the gear box to harvest maize by separating the cob from the stalk. The fabricated harvester is provided with tyres for mobility both at the rear and front for easy maneuverability. The design power of the harvester is calculated to be 3.45kw; the cutting force of the stalk cutter is also calculated to 31.39N while the output power is obtained to be 9.13kw.

Keywords: Harvester, Compact, affordability, medium-scale.

Introduction

Corn is the most important cereal grain in the world, after wheat and rice, providing nutrients for humans and animals and serving as a basic raw material for the production of starch, oil and protein, alcoholic beverages, food sweeteners and, more recently, fuel (Adewale & Babajide, 2015). Maize is an important cereal grain used as food sources and now has becomes the most important raw materials for animal feed harvesting (Pimentel & Patzek, 2005).
In Africa, maize is used in various forms to alleviate hunger, and such forms include pap or ogi, maize flour, and etc. The problem of poverty, hunger and malnutrition would be alleviated if there is adequate production of corn. Corn also called maize plays an important dietary role in most parts of Africa, It is grown virtually everywhere, in tropical, subtropical and temperate regions where rain and irrigation is adequate (Messiaenan & Ayeniko, 1992). As the demand for maize increase, mechanized maize harvester is widely accepted and used by farmers in the world.
Maize Harvesters are readily available for purchase in different outlets but low medium scale farmers cannot afford them due to relatively high initial cost. However, agriculture groups make these available for rent on an hourly basis. But the small holding farm owners generally do not require the full-features of combine harvesters because they are not economical for their usage. More so, these combine harvesters are not available in all parts of rural areas due to financial, technical and transportation reasons. The major steps involved in the processing of corn are harvesting, drying, de-husking, shelling, storing, and milling. All these processes are costly and for the rural farmers to maximize profits on their produce, appropriate technology that suites their needs must be used. Thus, there is need for a compact and efficient combine harvester which would be more accessible and also considerably cheaper.

MATERIALS AND METHODS

Description of the harvester

The harvester was designed to be simple, easy to operate and efficient. It comprises of three major sections that is: The prime mover, the gear box and a two shafts. The prime mover is a four stroke single cylinder petrol engine, the gear box is made up of different sizes of helical gears, arranged on two different shaft. There are two shafts on which solid square rod are arranged inform of a helix, as the two shaft rotates counterclockwise, it creates a conveyor kind of effect that transport the maize stalk inwardly to where it would eventually be cut.

The shafts are arranged to offset its centers and beside one of the shaft having a lower height is placed a bucket made of metal to collect the separated maize from its stalk. A frame in form of chassis is made to rigidly hold all the components of the harvester. The harvester has tyres at the front and rear for easy maneuverability.



Figure 1: Maize Harvester

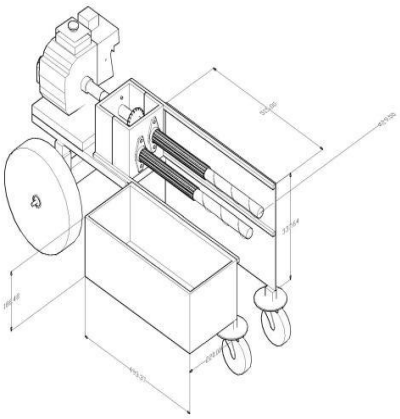


Figure 2: Isometric view of Maize Harvester

The harvesting machine is made up of various components which are:

- **Petrol engine:** The four stroke single cylinder petrol engine of ELEMAX GX270E having maximum Power of 11 BHP at 3600 RPM and maximum torque of 9.3N-m.

Table1: specification table for the petrol engine

Length x width x height	(400 x 430 x407)mm^3
Dry weight	24.5kg
Displacement	270cm^3
Bore x stroke	(77 x 58)mm^2
Max. output	11bhp(9.3kw) at 3600rpm
Max. torque	19.1Nm at 2500rpm
Fuel consumption	258g/kwh
Cooling system	Forced air
Ignition system	Transistorized magneto
PTO shaft rotation	Counterclockwise

- **DRIVE SHAFT:** The drive shaft is a mechanism having an assembly of a square section rod arranged helically round it. It also have on it 4 (four) knifes with polygon geometry arranged symmetrically on the shaft. The helical arrangement on the shaft drive the stalk of the maize inward according to the design and rotation in order to remove the maize from the stalk and transfer it into the container. This section comprises of a hollow shaft of 30mm diameter, a square rod of side 6mm and a knife blade made of flat plate (guage 5mm)

- **Chassis:** This is the main supporting structure of the maize harvester on which all another components are attached and it is made of mild steel. The chassis was designed such that both static and dynamic loads do not result to undue deflection.

- **Tyre:** The mini maize harvesting machine are design in such a way that wider footprint area provides better flotation characteristics than compaction, respecting the soil and preserving its organic life by minimizing mechanical damage caused by compression. This results in higher farm productivity and excellent saving in

terms of fuel consumption and tractor efficiency.

- **Gear Box:** It is a box consisting series of gears that varies the speed and rotation of the shaft for optimum performance. The gear box is square in geometry having a dimension fo320mm x 320mm, made from a metal plate of 6mm gauge.

- **Main frame**: The frame is made up of mild steel. The overall dimensions of frame are 400mm length, 800mm width and 400mm height.
The entire assembly was fastened together by both temporal and permanent fasteners (i.e bolt and nut and welding).

Table 2.0: DESIGN CALCULATION

S/N	PARAMETER	FORMULAR	WORKINGS	ANSWER
1	Drive gear speed	$N_1d = N_2D$ $N_2 = N_1d/D$	{3600 x 25}/55	N_2 =1309.09 rpm
2	Speed ratio {S_r}	N_1/N_2	3600/1309.09	S_r = 2.75
	Driven gear speed	$N_2T_2 = N_3T_3$ $N_3 = N_2T_2/T_3$	{1309.09 x 50}/65	N_3 = 1006.99rpm
3	design power	S_r x S_f	= 2.75x1.25	= 3.45kw
4	Chain length {L}	KP $K = \frac{T1+T2}{2} + \frac{2x}{p} + [\frac{T2-T1}{2\pi}]^2\frac{p}{x}$ $P = D\sin\frac{180^\circ}{T2}$	K = 58.9mm P = 4.21mm KP=58.9x4.21	L = 247.97mm = 24.80cm
5	Force (F)	Ma	= 3.9x1.53	F = 5.97N
6	shear stress(τ)	$\frac{F}{A}=\frac{4F}{\pi d^2}$	{4x5.97N }/{3.142x0.029^2}	τ = 9.04N/m^2
7	Torsion{T}	$\frac{\pi}{16}\tau d^3$	{3.142x9.04 x0.029^3}/16	T = 0.0000433 m^4 T = 0.0433 mm^4
8	Bending Moment {BM}	$\frac{\pi}{32}\tau d^3$ $=\frac{1}{2}T$	0.0433 mm^4/2	BM = 0.022Nmm

9	Angular speed(ω)	$2\pi N_3/60$	2x3.142x1006.99/60	ω = 105.47rad/s
10	Power	Tω	86.52x105.47	P = 9125.42W P = 9.13KW
11	Cutterforce,	Max M=mass a=acceleration x=number of blades	0.4x8x1.53	F_{cutter} = 4.70N

WORKING PRINCIPLE OF THE HARVESTER

The two tyres attached to the front of the harvester enable it to move towards different desired directions and also bring about ease of maneuverability. The 11Hp petrol engine generates the rotary motion which is then transferred to other members via set of industrial sprocket, chain, helical gears and shafts. The different sizes of gears and sprockets ensures reduction of engine speed to the required for optimum machine performance. As the harvester is been pulled forward, the V-like front assures that maize stalk is guarded through the clearance between the two counter rotating shafts. The helical arrangement on the shaft then ensure that the stalk is dragged downward so that the stalk is pulled against the maize cob thereby causing separation between the maize and it stalk. A rectangular bucket is positioned beside the lower part of the shaft to collect the harvested maize cob and once filled to capacity, it is offloaded and then the cycle continues. Also attached to the shaft towards its end are set of sharp edge knife that are polygon in shape, they are used to cut the maize stem after the entire corn is harvested on it.

CONCLUSION

Based on the Bill of Engineering Measurement, the fabricated maize harvester is far cheaper than the existing already made maize harvesters found around. This is solely because materials for it construction are locally sourced for and are readily available at markets where scavenged materials are been sold. M ore so, the technology in it construction is localized making it user friendly and it production replicable such that other local fabricators could get the assembly without much bottle neck.

RECOMMENDATIONS

The following are recommended in other to optimize the potentials of this work.

1. The machine should be evaluated in other to determine it efficiency.
2. Evaluate the shaft operational speed for optimal performance.
3. Evaluate the throughput to ascertain output per working hour.

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