FABRICATION OF LOW-COST MANUALCROP HARVESTING MACHINE

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ABSTRACT: *Harvesting is the important part in the agricultural industry.Modernharvesting technology is increasing day by day. But the cost of the harvestingmachines is high. So, these can be only limited and suitable for the farmers having large agricultural land area i.e., more than two hectares.So, the farmers having less cultural area cannot rent (or) buy these harvesters for cutting ofcrops. So,the main aim of our project is to fabricate "Low Cost Manual Crop Harvesting Machine" which is efficiently suitable for the farmers having less area i.e.,less thantwo hectares for cultivation. This machine uses the power to drive the cutters from the wheels of the vehicle itself.Thecutting motion to the rotary blades is obtained through the bevel gears (or)crown wheel and pinion arrangement.By this project we can reduce the difficulties faced by farmers having less cultivation area by increasing productivity, time taken for harvesting and mainly overallcost for harvesting is minimized. Along thesethe difficulties faced due to scarcityof labour in these areas can also be reduced. In this project an attempt is made to design, develop and fabricate a low-cost manual harvesting machine which increase the overall productivity of the small scale farmersfor harvesting paddy crop in less time.*

Key Words: *harvesting machine, low cost fabrication, crop harvesting, Agricultural*

1. INTRODUCTION

Grain harvesting is the important part in agricultural mechanization.Theuse of the automated harvesting machine is widely used in the developed countrieswhich will results in the economic development of the agricultural production. Thefarmers having large acres of cultivation area in India are using this Modern equipment, but the small acre area farmers are facing a lot of problems with manualworking process with sickles which is too time taking process and leads to lessproductivity.In India rice and cereals are widely produced by cultivation.

Mechanized agriculture is the process of using agricultural machinery to mechanize the work of agriculture, greatly increasing farm worker productivity. In modern times, powered machinery has replaced many jobs formerly carried out by manual labour or by working animals such as oxen, horses and mules. The history of agriculture contains many examples of tool use, such as the plough. Mechanization involves the use of an intermediate device between the power source and the work. This intermediate device usually transforms motion, such as rotary to linear, or provides some sort of mechanical advantage, such as speed increase or decrease or leverage. Current mechanized agriculture includes the use of tractors, trucks, combine harvesters, airplanes (crop dusters), helicopters, and other vehicles. Modern farms even sometimes use computers in conjunction with satellite imagery and GPS guidance to increase yields.Rice is one of the most important crop and staple food of millions of people which is grown in many countries of the world. The total area planted under rice crop in India is 42.20 million hectares. Improved weeded reduces weeding cost by 79-90%. Walking type vertical conveyer reaper, power tiller and tractor front mounted reaper save 50-60% labour and harvesting cost by 60-70% as compared to manual harvesting. Combine harvesting save 40-50% cost as compared to manual harvesting and threshing by power thresher. Use of pedal operated thresher, motorized hold on thresher reduce time, labour, cost of threshing to a great extent.

1.1 LITERATURE REVIEW

C. G. Sørensen [1] studied efficiency of different harvesting machines in terms of cost reduction and workability. Prof. P.B.Chavan, et al., [2] developed a low cost manually operated reaper to cut different types of crops with in less time. They used different cutting mechanisms based on the crop type. Pavanraj s. Khade*, et al., [3] reviewed available harvesting methods and different mechanisms for harvesting while designing a low-cost harvesting machine.Dr. U.V. Kongre et al., [4] fabricated a human powered multi crop cutter to cut the crop using rotary cutters. It is helpful to reduce the cutting time and labour required for harvesting. A study of existing cutters and cutting mechanisms for crop cutting was done by Dr. U.V. Kongre et al., [5] to select the suitable cutter and mechanism for multi crop cutter. Abhishek Pratap Singh, et al., [6]

constructed a low-cost crop cutting machine to decrease the labour cost in crop harvesting for small scale farmers. O. E Akay et al., [7] developed a harvesting machine for chili pepper using a four-bar mechanism and chain drive unit, which when applied in fields collected 80% pepper and 8% foreign material. Dinesh B. Shinde e t al., [8] designed a small-scale harvester machine to cut grains in scissoring type of operation up to two rows and driven by petrol engine. Vilas S. Gadhave et al., [9] fabricated Multi Crop Cutter which runs with the help of Electric Motor to cut the crop in a scissoring type of motion. They have also provided crop collection mechanism with pulley arrangement. Neha Kaushik et al., [10], studied and compared manual methods and application of different technologies used in robots that helps in agriculture, based on six parameters. P. Narasimhulu and N. Jaya Krishna [11], fabricated a pedal operated multi crop cutter to cut different types of crops with low cost. This is helpful for formers who have less than two acres. Tesfaye OlanaTerefe[12] designed and developed a manually operated reaper machine for grain harvesting to help the farmers having less land area. In this project different designs were explained for grain harvesting. PrajaktPaithankar et al., [13], designed and analysed a crop cutting machine that is used to cut crops like Jawar, tuar, &bajar,etc. which runs with battery. They found that two workers can be replaced with the designed machine. Tejaskumar Patel, et al [14] designed and analysed a Reaper and Binder Machine which cuts as well as bineds the crop with an arm. They analysed the design with Ansys and some modifications were also done for binding arm. A crop cutter to cut up to two rows of soybean plant was developed by Amar B. Mule, et al., [15], in scissoring type of motion. It runs on two stroke petrol engine. Roshan Ghodkhande, et al., [16] Designed a crop cutting machine that runs with petrol engine cut two rows of soya bean. They used belt driven and sliding cutter mechanisms to cut the crop with in less time and low cost.
From the above literature review it was under stood that most of researchers tried to use belt drive mechanism which has slippage problem.Scissoring mechanisms also applied for cutting the crop. In this project an attempt is made to apply rotary blades to cut grains four rows at a time that run with the help of a chain drive.

2.METHODOLOGY

In this project the main goal is the development of manually driven reaper by reviewing the previous reapers used for grain harvesting and drawbacks of the reapers. The objectiveidentified to accomplish the goal were:
- Studying and identifying the present mechanisms,
- Identifying the potential problem through abstraction,
- Collecting useful data,
- Interpreting data as the problem definition,
- Developing conceptual design and selecting optimum design,
- Finally preparing the embodiment design of the product.

2.1. Harvesting

It is the operation of cutting, picking, plucking digging or a combination of these operations for removing the crop from under the ground or above the ground and removing the useful part of fruits or grains from plants. i.e; collecting the mature crop from the field.
Harvesting action can be done by four ways:
1. Slicing action with a sharp tool,
2. Tearing action with a rough serrated edge,
3. High velocity single element impact with sharp or dull edge.
4. Two elements scissors type action.

When to harvest rice
- 20-25% grain moisture
- 80-85% straw coloured and
- The grains in the lower part of the panicle are in the hard doe stage,
- 30 days after flowering

2.2. Method of Harvesting

Manual harvesting

The crop should be harvested immediately after maturity. There is no need to wait for stalks and leaves to dry as the plants of hybrid sorghum appear green even after the crop maturity. The right time for harvest is when grains become hard and contain less than 25% moisture. Generally 2 methods of harvesting i.e. stalk cut and cutting of earheads by sickles are adopted. However, in foreign countries, sorghum harvesters are used. In case of stalk cut method, the plants are cut from near the ground level. The stalks are tied into

bundles of convenient sizes and stacked on the threshing floor. After 2-3 days, the earheads are removed from the plants. In other method, earheadsonly are removed from the standing crop and collected at the threshing floor for threshing after 3-4 days of sundrying.
Threshing of earheads is done either by beating them with sticks or by trampling under bullock feet. The latermethod is quicker and adopted by majority of farmers. Threshing is also done with the help of threshers. The threshed grain should be cleaned and dried in sun for 6-7 days to reduce the moisture content down to 13-15% for safe storage.
The labour required for manual harvesting is 48person days/ha and has advantage of effective in lodged crop and less weather dependent. But has the dis advantages of highlabour cost,labour dependent, competes with other operations in peak season, winnowing/cleaning necessary.

Combine harvester

The moderncombine harvester, or simply combine, is a versatile machine designed to efficiently harvest a variety of grain crops. The name derives from its combining three separate harvesting operations like reaping, threshing, and winnowing into a single process.
Oats, rye, barley, corn (maize), sorghum, soybeans, flax (linseed), sunflowers and canola are harvested crops with this machine. The separated straw, left lying on the field, comprises the stems and any remaining leaves of the crop with limited nutrients left in it: the straw is then either chopped, spread on the field and ploughed back in or baled for bedding and limited-feed for livestock.
In market various combine harvester are available having 2-5m cutter in length. However, there is need of small combine harvester specially for small and medium farmers. A combine harvester is used to cut, thresh, sort and clean grain/seed. The main units of harvester are header unit, threshing unit, separation unit, cleaning unit and grain collection unit. The header cuts the crops and collect them for threshing. The crops get threshed between cylinder and concave. The cleaning mechanism consists of two sieves and a fan. The grain is conveyed with a conveyor and collected in a grain tank. And sorting is done to provide final grains.The capacity of this machine is 4-8ha a day.But because of high cost and skilled labour requirement farmars having less than two acres didn't found its use economical.

2.3 Crop Cutting Blades:

The Crop cutting blades are two types they are given below
- Rotary blades
- Reciprocating blades

Rotary Blades

A rotary cutter is a tool as shown in fig 1 generally used by quilters to cut fabric. It consists of a handle with a circular blade that rotates. Rotary cutter blades are very sharp, can be sharpened, and are available in different sizes: usually smaller blades are used to cut small curves, while larger blades are used to cut to straight lines and broad curves. Several layers of fabric can be cut simultaneously with a sharp (fresh) blade, making it easier to cut out patchwork pieces of the same shape and size than with scissors. Quilters use rotary cutters with specially designed templates and rulers made of approximately 1/8-inch thick clear or color-tinted plastic.

The first rotary cutter was introduced by the Olaf company in 1979 for garment making, however, it was quickly adopted by quilters.

In our project we have aimed the special rotary cutters to cut the crop,this can be done by providing the large sized tooth on the blade. so that the cutting action can be achieved, the knife edges are provided between the cutters to make the cutting action complete.

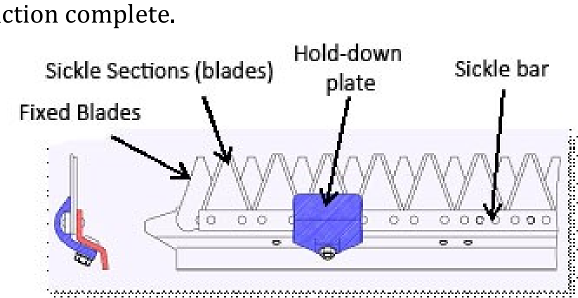

Fig 1: circular cutter Fig 2: Reciprocating Blades

Reciprocating Blades

A reciprocating saw is a type of saw in which the cutting action is achieved through a push-and-pull ("reciprocating") motion of the blade is as shown in fig2.

The term is commonly applied to a type of saw used in construction and demolition work. This type of saw, also known as a hognose has a large blade resembling that of a jigsaw and a handle oriented to allow the saw to be used comfortably on vertical surfaces. In this system the cutting action takes place between the movable and fixed blades.

CAD Design Models

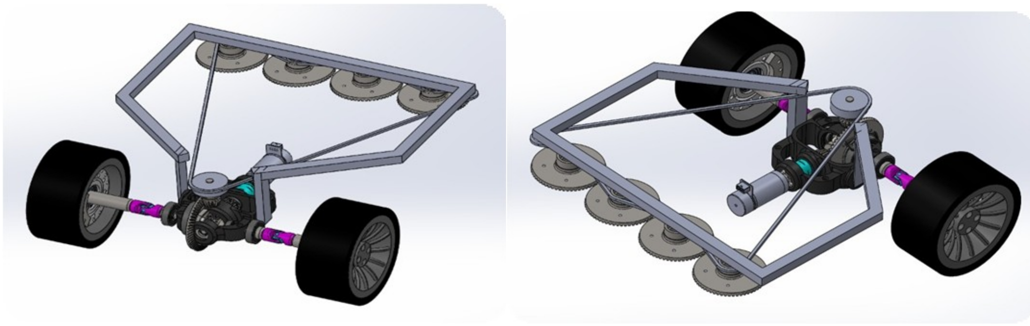

Fig 3: CAD Design Models

3.3 WORKING PRINCIPLE

The motion from the wheels is utilised to drive the cutters which is powered by pushing force of the operator. Initially the motion from the wheels is transferred through the axle to a crown wheel (largebevel gear) which rotates when the axle is rotated,so the crown wheel is rugged fit to the axle. The crown wheel transmits the motion to the pinion bevel gear upon which a sprocket is provided. The motion from the rear sprocket is transmitted to the front sprockets through the chain drivewhere the cuttersrotate and cutting action takes place.

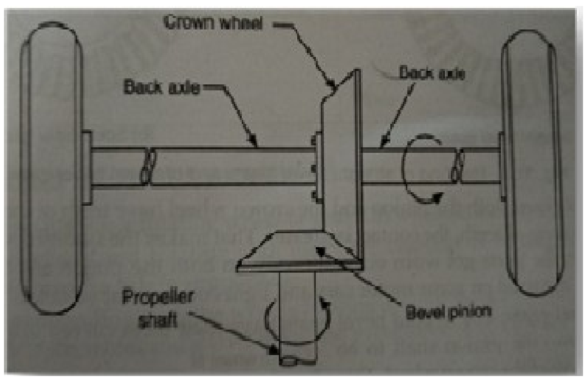

Fig 4: drive from wheels to gears

COMPONENTS OF DESIGN MODEL AND THEIR FUNCTIONS

1. Frame,
2. Crown wheel and pinion,
3. Sprockets,
4. Chain drive,
5. Circular Cutters,
6. Bearings,
7. Wheels.

1. Frame:

- ✓ To support the vehicle's mechanical components and body
- ✓ To deal with static and dynamic loads, without undue deflection or distortion.

- **Box section**

The box cross section provides better strength in lateral and vertical directions and in torsion.The box sections are either built-up are welded, and are quite popular on medium and commercial vehicles,So box section type frame. Having a cross section of 2*1 inch is used here

Fig 5: Frame

2.Crown wheel and pinion

Mechanical drive

Belt, chain,gear drives are often called as mechanical drives. A mechanical drive is defined as a mechanism, which is intended to transmit mechanical power over a certain distance, usually involving a change in speed and torque. In general the mechanical drive is required between the prime mover and the part the operating machine.

Mechanical drives are classified into two groups according to their principle of operation. The two broad groups are as follows

i. Mechanical drive that transmits power by means of friction e.g. belt drive and rope drive.
ii. Mechanical drive that transmits power by means of engagement e.g. chain drives and gear drives.

- **Straight bevel gears**

Both the pinion and crown wheel employ bevel gear of straight teeth i.e, a bevel pinion meshes with bevel gear of the crown wheel. At any one instant, there is contact only between one pair of teeth or pinion and crown wheel.

Straight bevel gears are generally used only at speeds below 5 m/s (1000 ft/min), or, for small gears, 1000 RPM.so for the capacity of our design we have chosen the straight tooth bevel gears.

$$\text{gear ratio} = \frac{\textbf{no.of teeth on driver}}{\textbf{no.of teeth on driven}} = \frac{41}{10} = \mathbf{4.1}$$

Fig 6: Crown wheel and pinion

3. SPROCKETS

A sprocket or sprocket-wheelis a profiled wheel with teeth, or cogs, that mesh with a chain, track or other perforated or indented material. The name 'sprocket' applies generally to any wheel upon which radial projections engage a chain passing over it. It is distinguished from a gear in that sprockets are never meshed together directly, and differs from a pulley in that sprockets have teeth and pulleys are smooth.

No. of teeth on sprocket (freewheel) = 18
No.of teeth on driving sprocket = 44

Fig 7: Sprocket Fig8: Driving Sprocket

4.CHAIN DRIVE

A chain drive consists of an endless chain wrapped around two sprockets.it is a series of links connected by pin joints.it has some features of belt drives and some of gear drives.chain drive can be used for long as well as short centre distances and they have good flexibility in all directions.

Chain drives compared with belt drives

i. Chain drives can be used for long as well as shortcenter distances. They are particularly suitable for medium center distance, where gear drives will require additional idler gears. Thus, chain drives can be used over a wide range of center distances.
ii. a number ofshafts can be driven in the same or opposite direction by means of the chain from a single driving sprocket.
iii. chain drives have small overall dimensions than belt drives, resulting in compact unit.
iv. a chain does not slip and to that extent, chain drive is a positive drive.
v. the efficiency of chain drives is high. For properly lubricated chain, the efficiency of chain drive is from 96% to 98%.
vi. chain does not require initial tension. Therefore, the forces acting on shafts are reduced.
vii. atmospheric conditions and temperatures do not affect the performance of chain drives. They do not present any fire hazard.

Hence chain drives were selected for this project

The velocity ratio i of the chain drives is given by,

$$i = \frac{n_1}{n_2} = \frac{z_2}{z_1}$$

where

n_1, n_2 = speeds of rotation of driven and driving shafts (rpm)

z_1, z_2= number of teeth on driven and driving sprockets.

The average velocity of the chain is given by,

$\mathbf{v}=\frac{\pi DN}{60*10^3}\mathbf{v}=\frac{zpn}{60*10^3}$

Where

V is the average velocity of in m/s,

The length of the chain is always expressed in terms of the number of links;

$L=L_n*p$,

Where;

L=length of the chain,

L_n=length of the links in the chain;

Fig9. Chain

5. Circular cutter

The cutting action takes place between the pair of the cutters and the knife edge section.The diameter of the cutter we have used is 110mm dia. The material of the cutter is steel.

6. Bearings

Bearing is a mechanical element that permits relative motion between two parts, such as the shaft and the housing, with minimum friction. The functions of the bearing are as follows:

- The bearing ensures free rotation of the shaft or the axle with minimum friction.
- The bearing supports the shaft or the axle and holds it in the correct position.
- The bearing takes up the forces that act on the shaft or the axle and transmits them to the frame or the foundation.

In this project roller bearings,of pillow block bearings and cone hub type block bearing were used.

Fig10: P-204

Fig 11: FL-205

7. Wheels

In its primitive form, a wheel is a circular block of a hard and durable material at whose centre has been bored a circular hole through which is placed an axle bearing about which the wheel rotates when a moment is applied by gravity or torque to the wheel about its axis.Metal welded wheels as they easily move forward in agri field due to their own weight were used in the project.

Fig 12. Wheels

FABRICATION

1. Fabrication of the frame structure,
2. Fabrication of the pillow block bearings to the frame,
3. mounting the wheels on the axle by interference fit,
4. Mounting and aligning the crown wheel to the rear axle centre,
5. Inserting the axle through the pillow block bearing hubs,
6. Aligning and fabricating the pinion to the crown wheel,
7. Mounting the cutters and sprockets over the hub,
8. Placing and aligning the chain over rear and front sprockets,
9. Fabricating the handle to the frame.

FABRICATED DESIGN MODEL OF THE MACHINE

Fig 13. Final model of the machine

CALCULATIONS AND RESULTS

S.NO	COMPONETS	NUMBER	WEIGHT IN KG
1	Crown wheel	1	1
2	Pinion	1	0.5
3	Sprockets	6	2.5
4	Cutters	5	0.2
5	Bearings	3	1
6	Frame	1	5
7	Disc / caster wheels	3	5
8	Chain	1.5	0.45
9	Axle / shaft	1	2

Total weight of the vehicle approx.. = 17.65 kg

Results for harvesting done by the designed machine

assuming vehicle is maintained at 40 RPM

Diameter of the driving sprocket = 0.18m

Diameter of the driven sprocket = 0.084m

gear ratio of the crown wheel and pinion = 1: 4.1

speed of the crown wheel =40r.p.m

speed of the pinion= speed of the driving sprocket (n_2) = 40*4.1 = 164r.p.m

velocity ratio of chain drive = $i = \frac{n_1}{n_2} = \frac{z_2}{z_1}$

$i = \frac{44}{18}$ = 2.444

From this the speed of the cutter is determined = n_2 = 400 r.p.m

Total width of the vehicle = 0.65m,

Total length of the vehicle = 0.65m.

Diameter of the axle wheel (d) = 0.3m

Distance travelled by the vehicle for one revolution of the wheel =πd

= $\pi * 0.3$

= 0.95m.

1 hectare (ha) = 10000 sq.m = 100*100 m

No.of revolutions made by wheels to cut 100 m length = 106

No.of rows the vehicle has to travel to cover 100m length = 167

Total no.of revolutions made by the wheel to cut 1ha = 106*167

=17702 rev

If the vehicle is maintained at 40 r.p.m speed,

The time taken to cut 1 ha is = $\frac{\text{Total no.of revolutions made by the wheel to cut 1ha}}{speed\ of\ the\ vehicle}$

=$\frac{17702}{40*60}$ =7.38hr.

Harvesting done by traditional method (sickle)

Amount paid to the labour for one day= Rs. 300

Total number of labours required to cut the crops from 1ha of farm = 4

Total amount paid to the four labours for one day= 4*300

=Rs.1200

In the traditional method 4 persons are required to harvest 1ha land, but by the machine 1 person can harvest the same land in less time as compared with the traditional method.

The harvesting machine is experimented in grain fields and found that it has good cutting efficiency.

ConclusionThe harvester we have designed is with a new concept of power transmission mechanism.we aimed to design the harvester for the small-scale land farmers.

The design is compact, easy to operate,low cost and efficient working. The small-scale farmers can use this machine if it further upgraded with small change in the type of cutters used. The cutter we have placed are to be upgraded with design and analysis process. So the final cutting process can be achieved with better performance. This conceptual design is very helpful for the farmers for better productivity. This machine can be operated by the single labour. This is very useful in the areas where labour scarcity is there, and more over skilled labour is not essential for operating the machine.so everyone can use and operate it easily.

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