Design and Fabrication of Agricultural Crop Reaper

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Abstract

This machine targets the small-scale farmers who have land area of less than 5 acres. This machine is compact and can cut up to two rows of maize. It has cutting blades, which cut the crop in a scissoring type of motion. The cutting blades are fixed on metal strips; upper strip will be reciprocate by scotch yoke mechanism. It runs on 80 cc engine drive. The power of engine drive is provided to the cutting mechanism through belt and gear drive arrangement to the cutter. The scotch yoke mechanism also known as slotted link mechanism converts rotary motion into reciprocating motion. A collecting mechanism is also provided for collection of crop to one side after cutting Speed given to collecting mechanism is more than the reciprocating mechanism in order to avoid hindrance. This reaper machine focus mainly on reaping of crop in less time and at low cost with ease of operation.

Keywords: Crop Reaper, Scissoring Motion, Collecting Mechanism, Scotch Yoke Mechanism

1. Introduction

Recently it has seen a shortage of labours available for agricultural work. Because of this shortage the labours have transitioned to using reaper machines. These machines are available for purchase but because of their high costs, they are not affordable. However, agriculture groups make these available for rent on an hourly basis. But the small holding farm owners generally do not require the full-featured crop reaper machines. Also, these machines are not available in all parts of rural area due to financial or transportation reasons. Thus, there is a need for a smaller and efficient crop reaper machine which would be more accessible and also considerably cheaper. The mission is to create a portable, user-friendly and low cost crop reaper machine. The crop for which the machine is to be fabricate is maize having height generally 180 cm and stalk diameter 20–30 mm. The machine is manually operated and unskilled operator can also operate this machine with ease.

1.1 Objectives:

☐   To create an idea to suit our required functionality that is to reap the crop.

☐   Design of various components in reaper mechanism.

☐   Modelling and analysis of reaper blades.

☐   Fabrication of reaper machine.

1.2 Scope:

☐   It is compact in size.

☐   It require small area for movement.

☐   It is easy to operate.

☐   It is portable.

2. Project Methodology

Firstly we design machine by considering all parameter of maize crop along with the design of the mechanical components. The modelling and analysis is also done for reaper blades. After that, we will manufacture/fabricate experimental setup and test.

Phase 1

i.   Market survey- During this period, detail market survey has been done to learn available crop reapers and its difference have been observed. Took the reviews of the small-scale landholder farmers who produce maize as a commercial crop and studied their difficulties regarding reaping of this crop.

ii.   Identification of problem- The problems regarding the existing reaper machines have been found such as cost, operating skills required, size, efficiency, etc.

iii.   Idea of project- Brain storming of problem, find the feasible, and optimize solution to overcome the problem.

iv.   Literature survey- Discuss the work done so far by researchers in the domain and their significant conclusions. Understand there researched topic and there advantages and disadvantages.

Phase 2

v.   Conceptual design- Taking problem statement from above and studying the fundamental engineering concepts regarding reaping operation and mechanisms are prepared. Among those best concepts, design has been selected.

vi.   The design of mechanical components- It includes the frame, belt and pulley drive, shaft, bevel gear, scotch yoke mechanism, reaper blades, collecting mechanism, bearings, etc. of crop reaper.

vii. Modeling of design – Putting the ideas on the modeling software for visualization of prototype, making it more compatible for design queries, and manufacturing complexity.

viii. Analysis of design- This step includes the analysis of reaper blades using ANSYS 19.2 software and make experimental validation.

Phase 3

ix. Fabrication of components and assembling – This phase includes the fabrication of machine in workshop from procured material. It also includes assembling of all the sub parts, also makes the arrangement of engine and its fuel tank.

x.   Testing- Take the testing of reaper machine and finalize the project for submission.

3. Literature Review

Manjeet Prem, et al. has research on a critical study on crop harvesting machines. From this paper, we can get the traction force produced in the ground wheels of the machine is not sufficient to cut and convey the crop [1]
Tesfaye Olana Terefe, et al. has research on design and development of manually operated reaper machine. From this research, paper the rotary motion of wheels is used to drive the reaper mechanism hence increases manual effort [2].
Shravan U. Burade, et al. has research on design and fabrication of agricultural crop reaper. In this paper they have discusses the design of rotary type of blade for reaping the crop [3].
A. R. Bhabad, et al. has research on design and fabrication of agricultural crop reaper. In this paper, the mounting of belt drive is vertical and the chances of slip of belt is more in vertical mounting [4].
R. Jaya Prakash, et al. has research on performance evaluation of reaper binder in rice crop. This paper gave an idea about the reaping and binding of rice but the cost of this machine is very high and maintenance cost is also high [5].
P. B. Chavan, et al. has research on design and development of manually operated reaper. From this paper, we can get the reaping of crop on uniform land [6].

4. Design

xi. Engine – Selection of engine i.e. power drive is related to the driving mechanism. The capacity of this engine is 80 cc. The engine is single cylinder four stroke spark ignition engine.

xii. Pulley -There are two pulleys used in this machine of 50mm and 255mm. the pulleys are made of cast iron.

xiii. Belt – Belt used in this machine is of trapezoidal cross section and the total included angle is 40^0. The material of belt is lather.

xiv. Shaft – The shaft used in this machine is made of mild steel of EN8 series. The diameter of shaft is 20mm and total length is 540mm. Angle of twist of this shaft is 3^0. The modulus of rigidity of this shaft is 79.3 GPa.

xv. Bevel gears – Bevel gear is used to transmit power to scotch yoke mechanism. Bevel gear is used to transmit power through 90^0.

xvi. Scotch yoke mechanism –Scotch yoke mechanism is used to convert rotary motion into reciprocating motion.

xvii.   Frame – Mild steel is iron containing a small percentage of carbon, strong and tough but not readily tempered, also known as plain carbon steel and low carbon steel ,is now the most common form of steel because its price is low. Mild steel is very strong due to the low amount of carbon contains. Mild steel has high resistance to breakage. It has high tensile and impact strength. Higher carbon steels usually shatter or crack under stress, while mild steels bends or deforms.

Table No. 1 Chemical composition of mild steel

Properties	Values (Metrics)
% Carbon, C	0.14 – 0.20
% Manganese, Mn	0.60 – 0.90
% Iron, Fe	98.81- 99.26 (remainder)
% Phosphorous, P	≤ 0.040
% of Sulphur, S	≤ 0.050
Yield tensile strength	370 GPa
Modulus of elasticity	205 GPa
Poisson's ratio	0.29

xviii.   Bearings –

Bearings used are made of Babbitt metal. The bearing used is deep groove ball bearing.

5. Calculations

xix. Engine Specifications:

Type: I.C. Engine, Single cylinder, four stroke. Capacity: 80cc

Power = 3506.2 watt Maximum speed = 5600 rpm Torque developed = 5.98 Nm

xx. Belt and Pulley Calculations:

N_1 = speed of driving pulley = 5600 rpm D_1 = diameter of driving pulley = 50 mm D_2 = diameter of driven pulley = 255 mm

N_2 = speed of driven pulley = $(D_1/D_2)*N_1$ = 1098 rpm

Length of belt,

$L = (2*C) + \pi*(D_1 + D_2) + ((D_1 + D_2)^2/4*C)$

$L = (2*400) + \pi*(50 + 255) + ((50 + 255)^2/4*400)$ L = 1816.32 mm

Angle of contact = $\Theta = 178^0$

Belt tensions,

Tension in tight side T_1 = 315.57 N

Tension in slack side T_2 = 76.41 N xxi. Bevel Gear dimensions: Diameter of driving gear = 44 mm Diameter of Driven gear =

90 mm

Number of teeth on driving gear = 20

Number of teeth on driven gear = 40

Gear ratio = G = 2

xxii.   Scotch Yoke Mechanism:

Crank or radius of scotch plate = R = 37.5 mm

Total stroke length = 2*37.5 = 75mm

Speed of scotch plate = 549 rpm xxiii.   Reaper blade:

Linear velocity of reaper blade, $V_b = R* \omega = R*(2* \Pi*N/60)$

$V_b = 0.0375*(2* \Pi*549/60) = 2.16$ m/s

Force exerted by reaper blade

F = T/R = 5.98/0.0375 = 160 N
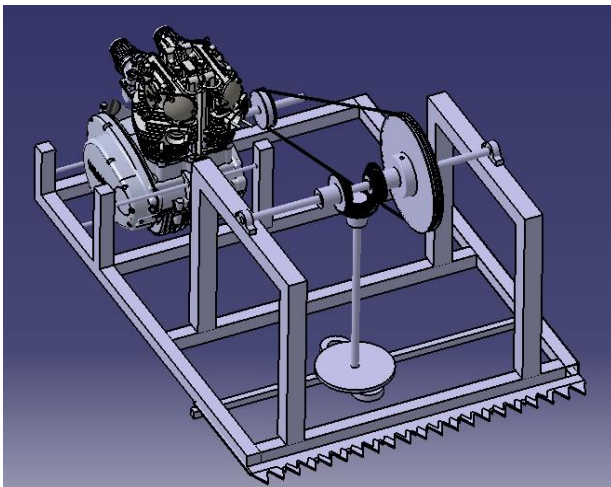
xxiv.   Working model

Fig. No. 1 CATIA model

6. Future Scope

Next phase is to make the modelling and analysis of the reaper blades using ANSYS 19.2 software under different shear forces.

7. Conclusion

From this experiment, we perform the reaping operation in effective way for small-scale farmers. This reaper machine easily affordable to small-scale farmers. Make the market survey and literature survey of reaper machines. Decide the making of working prototype of mechanism. Refer and study various design aspects in designing machine. Refer various handbooks and Data books.

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