

Design and Analysis of Universal Reaper Machine

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ABSTRACT

In today's scenario, many research's are been done in the agriculture field and there is also a wide scope for more advancement in the technology. So therefore our objective is to design and fabricate agricultural reaper machine which would be used for cutting various crops like wheat, rice, etc. The reaper machine is being designed to compensate the increasing demand of workers for harvesting of crops. The machine would cover a large area and will require a person for handling. The CAD model is being prepared in SOLIDWORKS 2018 considering AA 6063 tubes. In this machine 4 wheels are been used. And considering various loads and forces the analysis of the machine has been done. The FEA has been done on SOLIDWORKS 2018 Software.

KEYWORDS: FEA, Reaper, Harvesting, CAD

How to cite this paper: Sachin Kumar Sharma | Gautam Kumar | Saurabh Awasthi | Prashant | Vivek Tyagi | Vineet Pal | Saurabh "Design and Analysis of Universal Reaper Machine" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-4 | Issue-4, June 2020, pp.1543-1547, URL: www.ijtsrd.com/papers/ijtsrd31590.pdf



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1. INTRODUCTION:

In country like India, the major source of income in rural areas is from agricultural practices. Majority of crops like wheat and rice are grown here. The farmers are heading towards advanced technologies for irrigation and usage of fertilizers for good cultivation of crops but the reaping procedures of crops are not updated as farmers are cutting the crops with the same old indigenous tools due to which they require more time and labour for cutting of crops. So technology for cutting should be improved so that it would be economical and more productive. So we are designing a Reaper and Binding machine that would cut the crops like, wheat and rice. This machine would require only one person for its operation for both the processes. Power to the blades and conveyer would be transmitted by electric motor which is connected to a battery.

2. LITERATURE REVIEW

Various researches are been done on this topic like as:

Ramiah. R. V ^[1] worked on various effects of tire size on overall stability of reaper machine considering rolling resistance, also estimated effects of Indian conditions on machine.

Mollica. C ^[2] worked on a project of formation of small scale harvester which was a reaper and binder combined, the project prospects cutting of small scale grains.

Chavan P. B et al ^[3] worked on modification of manually operated Reaper and also evaluated the performance of modified manually operated reaper.

Dauda S. M et al ^[4] worked on the effects of cutting Speed and cutting Power, from his experiments it could be deduced that the best rotational speed must be ranged between 600 to 700 rpm. At speeds less than 600 rpm, the cutter tends to crushes the smaller stems rather to trim them. This possibly occurs due to the fact that at lower speeds, the cutting impact is less, causing tissue fracture in the stem.

Patel .T et al ^[5] worked on Design and Analysis of reaper and binder machine by analysis on arm of reaper machine and providing steering mechanism for controlling of machine.

Ghumadwar et al ^[6] worked on the concept of designing and analyzing the crop cutting machine. Harvesting crops is one of the major part in agricultural process. At present in India most of the farmers use conventional method i.e. manually cutting by employing labours but it is an exhaustive method and is more time consuming. His project prospects the designing and analysis of small field reaping machine. It reduces farmer's work and increases rate of harvesting crop.

Olana. T ^[7] worked on developing conceptual design and selection based on the digital logic approach method of product design and development and eventually worked on manufacturing of the embodiment product.

Gupta. M. K et al^[8] Worked on designing and fabrication of multi crop cutting machine which would help Indian farmers to harvest on their own land and it will help to reduce the cost of harvesting crops in field. It will be beneficial for Indian farmers in increasing their income.

Kiran. I. K. M et al^[9] worked on developing and evaluating performance parameters of battery powered small-scale reaper and analyses cutting speed, cutting efficiency and Power requirement for the reaper machine.

Bhabad. A. R et al ^[10] worked on design and fabrication of agricultural crop reaper considering different types of cutting mechanisms for efficient cutting of crops.

Ghodkhande. R et al ^[11] worked on design and fabrication of multi crop cutting machine considering the reviews and demand of local farmers.

Vignesh worked on design and fabrication of agriculture reaper and binder which would cut and tie the cut crop and considering all the life cycle of gears and various stresses on the shaft.

Lakshmi M. R et al^[12] worked on fabrication of low cost manual crop harvesting machine which could be afforded all small scale farmers in which the power is been transmitted from wheels to the cutter blades by movement of machine.

Guo .Y worked on establishing relation between the cutting forces on the stem of crop. The paper provided ample calculations in this field, in his paper Soybean was compared with some other grains..

Patel et al worked on reaper machine that can harvest the crops and simultaneously bind them to batches so farmer can easily lift them up.

3. PROBLEM DESCRIPTION:

3.1. STATEMENT OF THE PROBLEM:

1. Time Consumption - If the farmer starts using the reaper machine then the time consumption required for cutting of crops will be reduced as compared to manual cutting.
2. Labour Cost - The labour required for cutting of crops will be reduced as compared to the manual cutting which will be economical to the farmer.
3. Multiple Work – this machine will also will collect the crops side by side after cutting with the help of a conveyer connected on the top of the machine.

4. OBJECTIVES:

1. Designing of CAD model of the reaper machine and analysis of torque, life cycle of gears and analysis of shafts on which various loads are acting.
2. Fabrication and testing of reaper machine in fields.

5. MATERIAL SELECTION:

Material selection consist of analysis of various materials and selection of a material which would be light in weight and would contain sufficient strength to resist the various forces that would be experienced on the frame of the machine.

For material selection various materials were considered like AA6063, AISI 1020 and AISI 4130. There is a table considering strength and various factors of the materials.

PROPERTIES	AISI1020	AISI4130	AA6063 T6
YIELD STRENGTH	351.57MPa	460 MPa	251 MPa
DENSITY	7900kg/m ³	7850kg/m ³	2700kg/m ³
YOUNG'S MODULUS	205 GPa	205 GPa	68.9 GPa
TENSILE STRESS	420.51 MPa	731MPa	240MPa
BENDING STRESS	561.13 N-m	734.19 N-m	1425.25 N-m
BENDING STIFFNESS	4155.35N/m ²	4155.35N/m ²	8702.07 N/m ²
MOMENT OF INERTIA	2.027*10 ⁻⁸ m ⁴	2.027*10 ⁻⁸ m ⁴	1.263*10 ⁻⁷ m ⁴

Table1: Properties of Materials

After considering all these materials, various analysis were been done taking various dimensions of tube and weight in consideration and that analysis is been listed below for different materials.

Material – AISI 4130			
O.D. \ Thickness	1 mm	1.25 mm	1.5 mm
1 inch	1.2	1.4	1.5
	1.20×10 ⁻² N/m ²	1.23×10 ⁻² N/m ²	6.32×10 ⁻² N/m ²
	31.08kg	37.60kg	43.98kg
1.5 inch	2.6	3.2	3.8
	7.54×10 ⁻⁴ N/m ²	7.48×10 ⁻⁴ N/m ²	6.82×10 ⁻⁴ N/m ²
	44.71kg	54.65kg	64.45kg
2 inches	4.6	5.6	7.3
	1.009×10 ⁸ N/m ²	8.172×10 ⁷ N/m ²	6.27×10 ⁷ N/m ²
	57.88kg	71.11kg	84.17kg

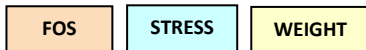
Table2: AISI 4130

Material – AISI 1020			
O.D. \ Thickness	1 mm	1.25 mm	1.5 mm
1 inch	0.88	1.1	1.2
	9.36×10 ⁻³ N/m ²	1.654×10 ⁻³ N/m ²	1.006×10 ⁻² N/m ²
	31.27kg	37.84kg	44.26kg
1.5 inch	2	2.5	3
	7.23×10 ⁻⁴ N/m ²	8.56×10 ⁻⁴ N/m ²	4.88×10 ⁻⁴ N/m ²
	44.99kg	55kg	64.86kg
2 inches	3.4	4	5
	2.56×10 ⁻⁴ N/m ²	1.76×10 ⁻⁴ N/m ²	2.91×10 ⁻⁴ N/m ²
	58.25kg	71.56kg	84.70kg

Table3: AISI 1020

Material – AA 6063 T6				
O.D.	Thickness	1 mm	1.25 mm	1.5 mm
1 inch		0.54	0.66	0.76
		$1.27 \times 10^{-2} \text{ N/m}^2$	$1.22 \times 10^{-2} \text{ N/m}^2$	$7.51 \times 10^{-3} \text{ N/m}^2$
		10.69kg	12.93kg	15.13kg
1.5 inch		1.2	1.5	1.8
		$7.05 \times 10^{-4} \text{ N/m}^2$	$9.14 \times 10^{-4} \text{ N/m}^2$	$7.43 \times 10^{-4} \text{ N/m}^2$
		15.38kg	18.80kg	22.17kg
2 inches		2.1	2.5	3
		$2.56 \times 10^{-4} \text{ N/m}^2$	$2.60 \times 10^{-4} \text{ N/m}^2$	$1.51 \times 10^{-4} \text{ N/m}^2$
		19.91kg	24.46kg	28.95kg

Table4: AA 6063-T6



After various analysis following results were been concluded:

1. AA 6063 T6 tubes with dimension 1 inch O.D. and 1.25mm is appropriate for the frame.
2. The factors like weight, FOS and stress are according to our need as not too much load will be experienced by the machine.

6. DESIGN PROCEDURE

6.1. MODELLING:

Considering all the parameters and synthesis of the previous design a design is been created on SOLIDWORKS 2018 software while taking AA 6063 T6 tubes for design



Figure 3: Front View

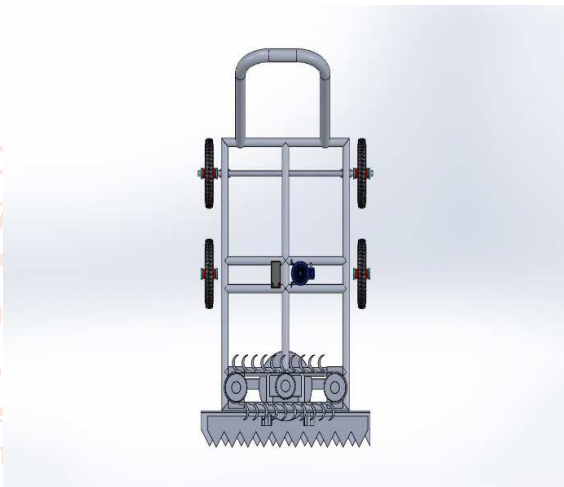


Figure4: Top View

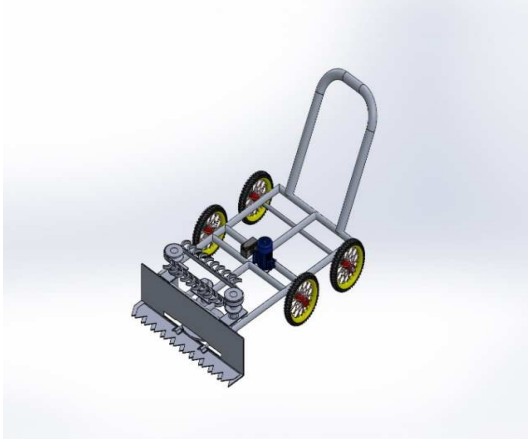


Figure1: Isometric View



Figure2: Side View

6.2. CALCULATIONS:

6.2.1. Scotch Yoke Mechanism

Assumptions:

1. The pitch of blades is assumed to be 3 inches
2. Total span of machine is 1000mm
3. Radius of pulley is 40mm
4. Motor has 11 toothed sprockets.
5. Pulley is rotating at 300rpm.

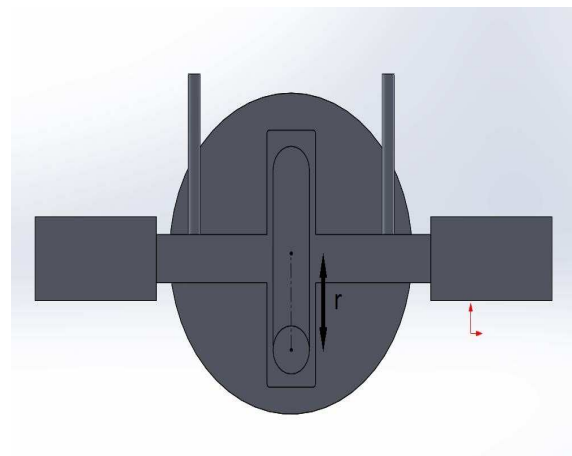


Figure4: Scotch Yoke Mechanism

Pitch of blades = $\pi * r$

$3 = \pi * r$

$r = 0.95 \text{ inch}$

From standard norms:

Blade speed should be 8-10 travels/sec

So, 2 travels = 1 revolution

1 travel = 0.5 revolution

Total Travel/minute=8*60

=480 travels

480 travels=240 revolution/minute

So, Main Shaft and Scotch must rotate at 240rpm

6.2.2. Conveyor Mechanism

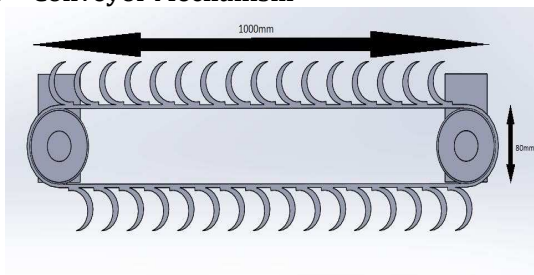


Figure5: Conveyor Mechanism

1 revolution of pulley=2*π*r

=2*π*40

=250mm/revolution

Total face width = 1000mm

So 4 revolution of pulley yield 1 complete revolution of conveyor belt.

Belt revolution=300/4

=75rounds per minute

7. COMPONENTS USED:

1. FRAME

A frame is defined as a structure, made up of several elements joined with permanent or temporary fasteners. The elements can be various cross-sectional channels, seamed/seamless tubes, and are termed as members of the frame. The frames may be categorized into two groups:

1. Perfect frame
2. Imperfect frame

A perfect frame comprises of members enough to be in static equilibrium, without any change in its shape on action of load. The condition for stability for Perfect truss is given by $m = 2j - 3$

Where,

m = No. of members

j = No. of joints.

Perfect truss is also called statically determinate truss.

2. WHEEL

A wheel is a thin cylindrical element of an automobile which moves the vehicle on ground. Wheels supported on axles aids in transporting heavy loads. Wheels can also have other applications such as steering wheel of an automobile, flywheel to store mechanical energy. Commonly wheels are used in transporting industry. A wheel has reduced friction as it deals with rolling friction, which is clearly lesser than sliding friction.

3. SHAFT

A shaft is a machine element, generally having circular cross section, which is used for transmission of power between two elements. Shafts can have pulleys, gears, belts mounted on them.

4. CHAIN DRIVE

Chain drive is one the system of power transmission that consists of series of chain links connected with thin rollers to form a chain that meshes with sprocket. Sprockets are mounted on driving and driven shaft. Chain drive can have idler gears to compensate slack, if present in system. The links of the chain meshes with the tooth of the sprocket and this operation provides transmission between the driver and driven sprockets. The efficiency of power transmission is also around 90%.

Chain Drive Advantages

1. There is less slippage in chain drive.
2. The efficiency of transmission is around 90%.
3. Chain drives are more effective at low speeds.
4. Chains can operate effectively at elevated temperatures provided it is lubricated.

5. DC MOTOR

A DC Motor is a device which converts DC electrical energy to a mechanical energy in the form of rotations of axle. It consists of armature coil and permanent magnets. The magnetic effect of electric current moves the coil between two curved permanent magnets. The coils are wrapped around soft iron core with axle in middle. The rotation of axle is harnessed as output of DC motor.

6. SCOTCH YOKE MECHANISM

The Scotch Yoke mechanism has two sliding and two turning pairs. It converts rotary motion from the crank into reciprocating motion of the yoke. Other linear parts may be directly coupled to the yoke with a pin which act as rotating part.

7. CONVEYOR MECHANISM

The conveyor belt is used to carry harvested crops adjacent to field. Collection of crop reduces the amount of grain unused during harvesting. Thus implementation of conveyor increases the overall efficiency of harvester. The conveyor belt consist of series of half cup shaped hands that execute removal of crops as they are trimmed as well as they tend to provide a hand to stabilize the crop while being cut. Lead Acid batteries are suited better in existing technology as they can deliver high output because they can store high power per unit mass of battery, making them to be lighter and smaller than conventional square batteries.

8. WORKING:

1. The machine performs two operations of agricultural industry namely cutting and binding of the crops.
2. The motor is mounted via nuts and bolts with some washers on the frame.
3. With the help of chain, sprocket of motor and input shaft (of scotch yoke) with other sprocket mounted on it is connected.
4. The input shaft is further connected to two auxiliary shafts via chain drive.
5. The yoke of Scotch Yoke mechanism is connected to one of the moving trimming blades that reciprocate. This is done via two small rod bolted on either side of yoke.
6. The auxiliary shaft has two pulley mounted on top of them with circlips.
7. The belt is inserted between the two pulleys which act as a conveyor.

8. Thus with right combinations of sprocket tooth on various shafts we could get different speed of conveyor belt as well as trimming blades.

9. RESULT AND DISCUSSION:

From the work the following result were deduced that the requirement of labour to harvest 1acre of field is much reduced in case of using a reaper machine. Also throughout the day a man gets exhausted while a machine can work for hours and hours without any fatigue. Thus time can also be reduced in harvesting by using the reaper machine. It is concluded that the machine is economical as the cost of building is reasonable.

10. CONCLUSION:

It can be concluded that the reaper machine is portable and easy to operate. This machine is able to run on field with minimal effort and thus strain on farmers is reduced significantly. The harvesters present in market are generally suited for very large farms or they may require big tractors in order to operate, so this can be one of the best harvesting cum binding machine for the Indian farmers with small farmland.

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