International Journal of Scientific Research and Engineering Development-– Volume 6 Issue 2, Mar-Apr 2023

Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

Design and Fabrication of Automated Sugarcane Harvesting Machine with High Operational Efficiency

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Abstract

Sugarcane is more important crop among the other crop cultivations in the India as it is important source of sugar and sugar based products which results in economic benefits to the country and farmers. With Fast growing demand in the agriculture industry and inadequate knowledge of the small farmers in fast production and trading of agriculture products, motivated us to fabricate a new design for automated sugarcane harvesting machine to eliminate the large exposure large insects and reduces labor cost especially during shortage of employees in various climatic conditions. However recent progress has made to fabricate the automated model but it results in various challenges in terms of operating efficiency on various climate and realistic conditions. In order to overcome those challenges , a new automated sugarcane harvesting machine has to be designed and fabricated as small scale machine suitable under various realistic condition and resulting good operating efficiency and robustness. Further model is modeled with electric power supply through batteries as it offers the model at affordable price , reduced size and provides environment protection as it operates with electric motor instead of disease or petrol engine . In addition , it saves operating cost as electricity is provided free to many small scale farmers in India. Initially model designed using CATIA v5 software for selecting suitable and optimal materials to cutting the sugarcane in field on achieving operating efficiency. Experimental analysis and performance analysis with respect to operating power and operating time, proposed model proves that it provides high efficiency and less maintenances on compared with conventional models.

keywords : Sugarcane Harvesting, Automation , Electric Power Supply, Design and Fabrication , Power Efficiency, Agriculture

1. Introduction

Due to increase of population around the world, demand for agriculture products is gradually increasing. Especially it is requires more adoption of technology to increase the cultivation of the food sourcing crops and to increase precise harvesting of the crop without damages. In specific, sugarcane is becoming vital crop as there is a high demand for sugar and sugar related products. Automation of cultivation and harvesting of crop is becoming mandatory to eliminate the large exposure of human beings to large insects and to reduces labor cost especially during shortage of employees in various climatic conditions[1] Hence in order to increase the harvesting cycle of the sugarcane to reach the market due fast growing demand. Automated harvesting machine has to be designed and fabricated. In recent years , many machines has been arrived in the market but still it faces more challenges in terms of operating efficiency on various climate and realistic conditions[2].

In this paper, a new automated sugarcane harvesting machine has to be designed and fabricated as small scale machine suitable under various realistic condition and resulting good operating efficiency and robustness[3]. Further model is modeled with electric power supply through batteries as it offers the model at affordable price , reduced size and provides environment protection as it operates with electric motor instead of disease or petrol engine[4] . In addition , it minimizes the operating cost as electricity is provided free to many small scale farmers in India. Initially model designed using CATIA v5 software[5] for selecting suitable and optimal materials to cutting the sugarcane in field on achieving operating efficiency.

Experimental analysis and performance analysis with respect to operating power and operating time, proposed model proves that it provides high efficiency and less maintenances on compared with conventional models. Rest of the paper is sectioned is as follows, section 2 describes the principle objective of the work, section provides the proposed methodology containing components used and working principles. Section 4 mentions design calculation of the model and section 5 represents the fabrication model and in section 6 testing of model is carried out on various performance parameters. Finally section 7 summarizes the model.

2. Principle Objectives

The main objective of this work is to design the sugarcane harvesting machine at optimal operating condition is as follows

- It is to design and fabricate the small scale sugarcane harvesting machine[6] as battery operated machine to increase the efficiency of the system and protect the environment against the vehicle pollution
- It is to select suitable and optimal materials to cutting the sugarcane in field on achieving high operating efficiency and reduced operating cost and maintenances

3. Methodology

In order to design and fabricate the optimal model, systematic plan on selection components , its working condition and optimal design for modeling using catia software has to be carried out . Figure 1 represents the flow of the designing process

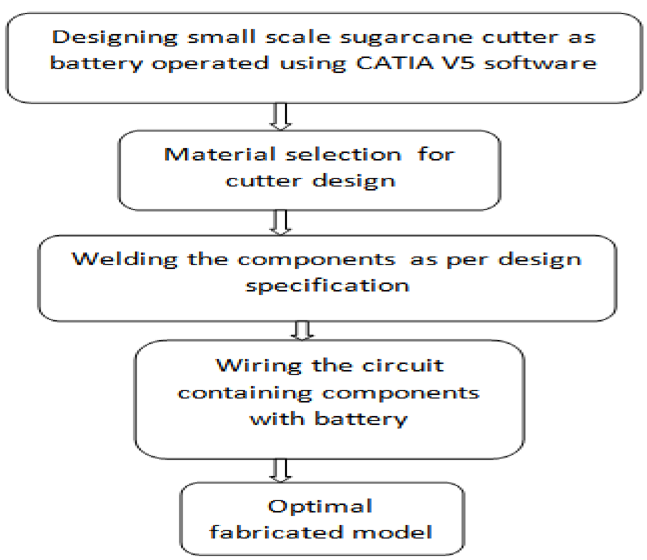


Figure 1: Flowchart of proposed design

3.1. List of materials

In this section , list of materials used for fabrication of model is specified with no of quantity, materials used for components and components[7]. Table 1 represents the list of materials for fabrication of sugarcane harvesting machine.

Table 1: List of Materials

S.NO	COMPONENTS	MATERIALS	QUANTITY
1	Frame	Mild steel	1
2	DC. Motor	Electrical	1
3	Battery	Electrical	1
4	Shoulder Bag	Leather	1
5	Wire	Copper	As per requirement
6	Nut	Steel	1
7	Cutter blade	Stainless steel	1

3.2. Component Description

In this section , component description is provided on the basis of the material properties and its details on various aspects as follows

3.2.1. Frame

For machining of the sugarcane cutter, the metal frame as illustrated in figure 2 is usually built of mild steel bars that are suited for lightly stressed components like studs, bolts, gears, and shafts. To enhance wear resistance, it can be case hardened. Bright rounds, squares, and flats, as well as hot rolled rounds, are all available[8].

Figure 2-Metal Frame

Bright-drawn mild steel is a higher-quality product with higher tensile strength and a more constant hardness which has been cold processed (drawn or rolled) to size and is free of scale. It's made to very tight tolerances in terms of dimensions and superior to straightness and flatness. It's better for precise machining with a lot of repetition and if desired, precision turned or ground bright steel can also be obtained[9].

3.3.2 Metal sheet

Metal steel as represented in figure 3 is known as cold rolled strip which is a steel product composed of pickled hot rolled strip. After that, the coil is reduced in a single stand cold roll steel mill, a reversing mill, or a tandem mill consisting of several single stands in a sequence. It is selected on the specification of containing Length of 5029m, Width: 609.6mm and Thickness: 4.76mm[10]

Figure 3- Metal sheet

3.3.3 Hollow Pipe

A hollow bar is always circular and can resemble a pipe or tube as represented in figure 4 although the walls are usually much thicker. Tubes are measured by their outer diameter and will have a wall thickness, typically measured in inches or fractions[11].

Figure 4: Hollow pipe

3.3.4 DC Motor

A DC motor is represented in figure 5 is an electric machine which converts electrical energy into mechanical energy[12]. DC motors use direct current to convert electrical energy into mechanical rotation. Magnetic fields created by electrical currents are employed in DC motors to power the movement of a rotor mounted within the output shaft. The output torque and speed are computed by the electrical input as well as the motor's design. It is selected with specification of 12v, 1000 rpm

Figure 5 – DC Motor

3.3.5 Battery

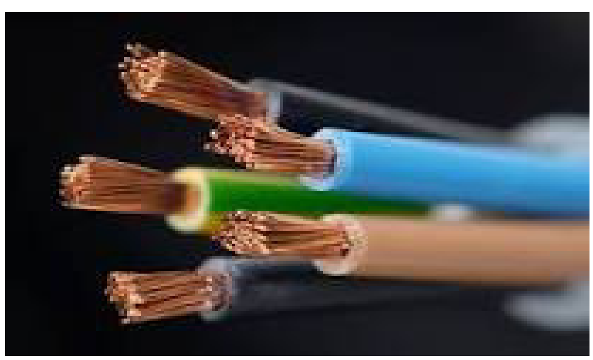
A battery is represented in figure 6 is a device that converts chemical energy to electrical energy in a direct way. It is composed of several voltaic cells, each of which is made up of two half-cells connected in series by a conductive electrolyte that contains anions and cations[13].

Figure 6– Battery

The electrolyte and the electrode to which anions migrate, the anode or negative electrode are in one half-cell and the cathode or positive electrode, are in the other half-cell. Cations are reduced at the cathode while anions are oxidized at the anode, in the redox reaction that drives the battery. The electrodes do not come into contact with one another, but the electrolyte connects them electrically. A separator between the half cells allows ions to pass while preventing electrolyte mixing. The ability to drive electric current from the cell's interior to the cell's exterior determines the electromotive force of each half-cell.

3.3.6 Wire

Copper is used as an electrical conductor in a variety of electrical wiring types as represented in the figure 7. Copper wire is used in a wide range of applications, including power generation, transmission, distribution, telecommunications, electronics circuitry, and a wide range of electrical equipment[14].



. **Figure 7– wire**

4.3.7 Cutter Blade

A sugarcane cutting tool is represented in figure 8, is a hardened metal tool that is used to cut, shape, and remove material from a work piece using machining and abrasive tools via shear deformation. The majority of these instruments are made specifically for working with metals. These motions provide the necessary cutting velocity, feed velocity, and depth of cut[15]. A rotary blade cutter is used for fast cuts, a tangential knife for details, and a creasing tool for setting fold lines. A rotary blade cutter is employed for fast cuts, a tangential knife for details, and a creasing tool for setting fold lines.

Figure 8 :Cutter Blade

The cutting tool itself cannot provide any such move as it is rigidly mounted on the tool holder in the machine tool. All necessary motions are supplied by machine tools using various arrangements.

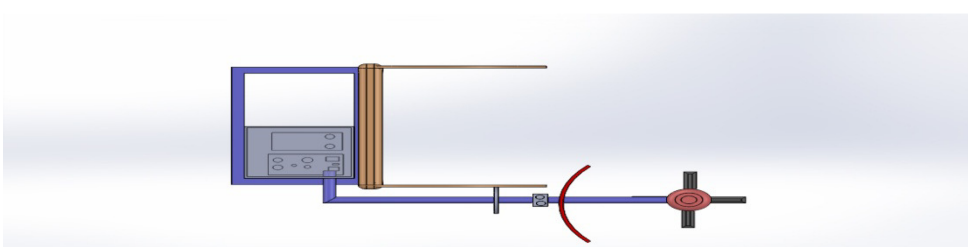
3.4 WORKING

The battery and motor are the most significant components of the particular model which is connected to power source is installed on the field for sugarcane harvesting activity. The battery which serves as power source is recharged using a battery to provide a continuous power supply to the machine. The wires that link the motor and battery. The wire travels through the hollow pipe that connects to the motor between the battery and the engine. On igniting the electricity, the motor shaft and cutter blade both begins to rotate and it cuts the sugarcane through the cutter blade..

3.5 CAD DESIGN

CAD design[15] of the various view of sugarcane harvesting machine is designed and represented in the following sections

3.5.1. TOP VIEW



The top view of the sugarcane harvesting machine is represented in the figure 9

Figure 9 - TOP VIEW

4.5.2. ISOMETRIC VIEW

The isometric view of the sugarcane harvesting machine is represented in the figure 10

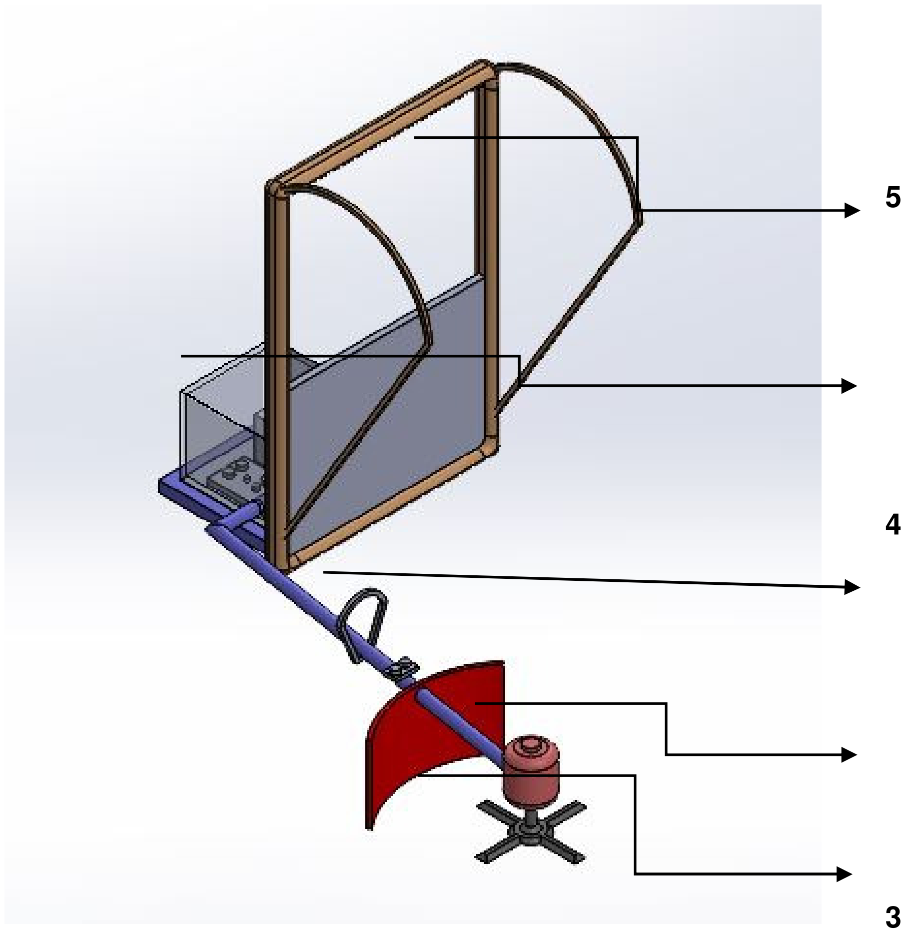


Figure 10- ISOMETRIC VIEW

3.5.2. SIDE VIEW

The side view of the sugarcane harvesting machine is represented in the figure 11

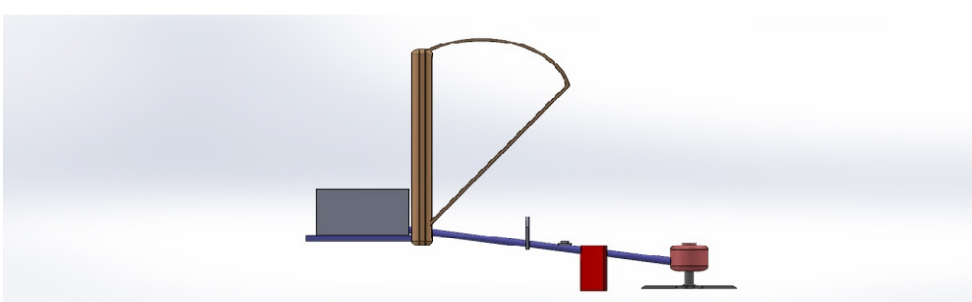


Figure 11 - SIDE VIEW

4. Design Calculations

For the design of the equipment, a circular hollow pipe is used. The outer diameter and inner diameter of the circular pipe are given below,

Inner diameter, d_i = 22mm

Outer diameter, d_o= 25mm

l =1000mm (approximate)

Moment of inertia:

I= $(d_0^4$-$d_i^4)$ ÷ 64

I= $(25^4$-$22^4)$ ÷ 64

I= 2443.6mm^4

By Euler's Method:

E = $(200*10^3)$ (constant value for Mild steel)

$P_e = \pi^2 EI \div l^2$

= $\{(3..14)^2 *(200* 10^3)*2443.26] \div (1000)^2$

= 4817.91 N

Area of hollow pipe

A = $\frac{\pi}{4} * (d_0^2 - d_i^2)$

= 0.7853 * $(25^2 - 22^2)$

A = 110.72mm^2

Stress S= p_e÷ A

S= 4817.91÷ 110.72

= 43.51 N/mm^2

Yield stress of Mild stress = 250 N/mm^2 (constant value for Mild stress)

Factory of safety = yield stress/stress

= (250 / 43.51)

FOS = 5.74

Cutting tool calculation:

Specifications (std):

Diameter	=	350 mm
Cutting Tool Thickness	=	2.0 mm
No. of teeth		
T	=	60 teeth

The cutting tool speed calculation;

D = 350 mm

V_c= 300 m/min

N =?

Formula:

V_c= (π * D * N) ÷ 1000

= (3.14 * 350 * N) ÷ 1000

N = (300 * N) ÷ (π * 350)

= 272.83 = 280 rpm

N = 280 rpm

V = ω x r ω = 2Πn

V = 2 x 3.14 x 16.738 / (175/1000)

Velocity, V = 600 m/min

P = 2Πnt / 60

$P = 100$ w

$100 = 2 \times 3.14 \times 280 \times T / 60$

Torque, $T = 3.412$ Nm = 4Nm

Tangential force, F_t

$T = F_t \times r$

$4/0.175 = F_t$

$F_t = 22.8$ N

We know that the force required to cut is given by

F = Area x Shear stress

Where A = area of sugarcane

& $A = \pi /4\ d^2$

and d = dia. of sugarcane = 30 mm (Approximately)

and considering the shear stress of sugarcane is 2 N/mm^2

Force $F = A \times f_s$

$= \pi /4\ d^2 \times f_s$

$= \pi /4\ (30)^2 \times 2$

= 1413.71 N

Parameters for Selection of Battery

- Load type (ampere or watt): Select the load in amperes or watts.
- Load (watt): If the load type is a watt, enter the load in watts else use average value cyclic load
- Load (ampere): If the load type is the ampere, enter the current in amperes, such as 10 A.
- Voltage (Vdc): If the load type is a watt, specify the battery voltage in volts DC.
- Required duration (hours): Indicate how long the load must be supplied.
- Battery type: Choose a battery type. Lead-acid or lithium-ion batteries

5. Fabrication model

Fabrication model of automated sugarcane harvesting machine composed of cutting process, welding process and grinding process. Cutting of a metal sheet and the square pipe was carried out by using a cutting machine for the required dimensions. After cutting a square pipe and metal sheet as we required, we need to join the separate parts of rods into a single part by wielding process Angle grinders are usually used to remove excess metal from parts of metals that are otherwise difficult to reach or work on, as well as for grinding and polishing. It is represented in various view is depicted as follows

5.1. TOP VIEW

The top view of the sugarcane harvesting machine is represented in the figure 12

Figure 12 - TOP VIEW

5.2.ISOMETRIC VIEW

The top view of the sugarcane harvesting machine is represented in the figure 13

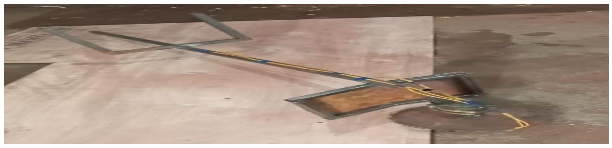


Figure 13 – ISOMETRIC VIEW

Preliminary Test

It is made for the working model as follows these steps:

- Every step of fabrication will be followed by testing the mechanisms or component.
- After all mechanisms are fitted properly, the machine will be given power and the machine will be tested.
- If everything goes as specified the machine will be ready for demonstrate ion and final presentation.

Conclusion

The design and fabrication of the sugarcane cutter have been designed and fabricated on design calculations of various parts using design software for feasibility testing of the various parts of the sugarcane cutter machine. Further assembly drawings are created as per the designed dimensions and design created using Standards. Hence designs produce high optimal operating efficiency and robustness on compared with conventional models on using electrical power supply. Performance is achieved on basis of collected materials and components based on the needs of the fabrication process and also used standard equipment on the various climate and realistic conditions. Finally model is offered with affordable price , reduced size and less maintenances with environment protection

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