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Design, Fabrication and Analysis of Battery Operated Brush Cutter

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Chapter 1

Introduction

Crop harvesting involves either removing the plants after they have been torn out or cutting the crops close to the earth. It entails cutting coral crop stems, such as tuar, Jawar, Bajra, and maize, close to the ground. In our nation, a sharp sickle is typically used to cut things. Mainly, small-scale rice farmers are using conventional methods or, we could say, traditional methods in farming. The reaping process of the rice crop is very time-consuming as well as it requires more human effort.

The labour required for farming is also more compared to other crops. So, the development of mechanical operated reaper is come but the reapers are costly for the use for the farmers those farms are small in size. They cannot afford harvesters and other expensive machinery. So, we have developed a small and low-cost solar assisted rice reaper machine which runs on electricity by use of batteries.

Previous rice reaper machines used engines. That means again, the price, increases and use of fuel are not so economical. But we are using electric energy, which is also one of the cheap forms of energy available, and the weight of the rice reaper also decreases as compared to other rice reaper machines. If we start using cheap and effective machines on the farm, it will also lead to an increase in productivity as well as also increase the profit of the small-scale farmers. In India, around 55% of the population depends on agriculture, which is the foundation of our nation's economy.

As a result, as these fields develop, so does our nation's economy. So, there are fields of scope in these fields for development of more feasible as well as affordable farm equipment, so they can be beneficiary to small scale farmers. They cannot afford harvesters and other expensive machinery. So, we have developed a small and low-cost solar assisted rice reaper machine which runs on electricity by use of batteries. Therefore, creating new equipment entails giving our farmers more sophisticated and advanced tools, which would reduce the overall time needed to complete the operation and make it more convenient.

Fig.1.1 Harvesting of Crop

1.1 Conceptual Background

In the 14th century, Leonardo Da-Vinci was a man who was an architect, engineer, geologist, and painter. He is shown various inventions and thought through his drawing and we take our project concept from this picture.
This picture shows war when the horse is running, the wheel is rotated in a circular motion and this motion. The gives the cutter through the propeller shaft by using the bevel gear which is connected to the wheel of chariot. This cutter acts like a weapon and it is used in war. So, this concept we use for the agricultural approach, we decided to create a new invention in agriculture and we made a demo model.

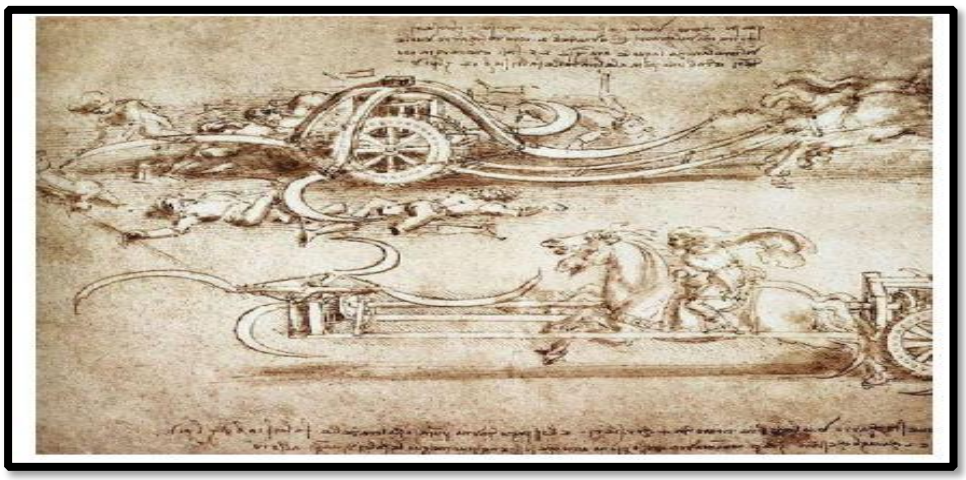

Fig.1.2 Da-Vinci War Model Chapter 2

Literature Survey

Mahbub Alam Zamil et.al Author represents a study comparing the performance of Chinese and Bangladeshi reapers in order to evaluate harvesting costs.[1]

Prof. P.B. Chavan1 et.al Author have created a little reaper machine for a testing ground. According to their study of the data, the following conclusions can be made: The manually operated reaper is very labour-efficient machinery that uses only 20 man-hours per hectare. Harvesting with this manually driven reaper costs 1250.4 Rupees per hectare, while doing so traditionally costs 2000 Rupees per hectare. Based on a study of the findings, the following shortcomings seen during the operation were identified as negatives:

1. It is inappropriate for uneven land.
2. Because of its weight, a lot of electricity is needed.[2]

Laukik P. Raut et.al Author. This equipment is intended for small-scale farmers with less than 2 acres of land, according to experiments. This device can cut up to two rows of soybean plants and is portable. They came to the conclusion that utilizing this machine to harvest is far less expensive than harvesting by hand. This may be the best tool for farmers with small farms because the harvesters now on the market are designed for huge farms.[3]

Sharmin Alam Brishti et. al Authorities studied that reapers have a functional issue. To gather the primary data, specialists created a questionnaire. In Bangladesh, there were found to be about 93 reapers. They have predicted issues such as the recently added engine's extreme vibration, the usage of a subpar guide spring to toss crops away, and the larger gap between the cutting blade and base plate. It was found that the forward speed was low. The majority of reapers have cutter bars with an effective width of 1.2 meters. With a field efficiency of 77.22% and the highest effective field capacity of 0.3 ha/hr. among the imported reapers, Kubota stands out. Grain loss was 2.43% and labour was 8.5 man-hr./ha.[4]

Ephrem Zeleke Kassa et.al author, published a research paper on Analysis that was done on the deflection angle and deflection force acting on a group of crop stalks during a combined harvester reel's collection operation. A mechanical crop model based on the bending theory in relation to an elastic beam was employed in this experiment. The model mimics how crop weight, flexural rigidity, and reel force affect the angle at which the stalk of a tef crop deflects. The model's mathematical relationships have been compared to empirical data that was gathered by calculating the deflection of a crop's stems and counting the number of tine bars on the reel. Earl Ziegler, Christopher Molica, Ian Jutras, and Christopher Boyle. Creating a grain harvester on a modest scale. This project will assist small-scale grain farmers in meeting the rising demand for variety by creating an area-per-binder machine, local grains.[5]

S. Jarolmasjed et.al authors, have published a paper on harvest loss, which is a sort of loss that reduces the final output's efficiency. Combine harvesters experience a variety of losses, including natural loss, header loss, threshing loss, separation loss, and quality loss. The large loss is caused by header loss. They have concluded that decreasing header loss requires increasing the combined harvester's travel speed within a specific range—between 0.8 and 2.4 km/h.[6]

Arjya Utkalini Sahoo, Hifzur Rehman et.al A battery-operated walk-behind type vertical conveyer reaper (electric reaper) was designed and developed for harvesting cereal crops with reduced environmental pollution and cost of harvesting. It comprised a cutting unit, a conveying unit, a propelling unit, two DC motors and lead–acid batteries. A standard cutter bar with a total cutting width of 600 mm was used as the cutting unit. DC motors with controllers powered by batteries were used to operate the knife and propel the e-reaper fitted with 4.00–8 pneumatic wheels. The total weight of the e-reaper was 135 kg. The reaper could cut the paddy crop satisfactorily at a stubble height varying from 50 to 80 mm and convey it to fall in a windrow. The field capacity of the electric reaper at an average forward speed of 1 km/h was found to be 0.06 ha/h with a cutting efficiency of 98% and a field efficiency of 66%. The total power consumed by the e-reaper in carrying out the harvesting operation was found to be 872 W. The reaper was operated continuously for 2 h without any power breakdown. For recharging all the batteries, a total time period of 2 h was required. Noise and vibration produced by the electric reaper during harvesting of paddy crops were measured to be 9.9 m/s2 and 88 dB(A), respectively. It required three workers to cover one hectare with a total cost of harvesting Rs. 2933(41 USD). Thus, it saved about Rs. 5161 (72.25 USD) per hectare compared to manual harvesting.[7]

By referring above research papers, we conclude that the farming equipment are very expensive for small scale farmers. Manual process of reaping crop is time consuming and very tiring to the farmers. So, for small scale farmers a low budget, easy to operate and time saving rice reaping machine is convenient to use.

Fig.2.1 Convectional Reaper Machine

Chapter 3
Problem Statement

3.1 Problem Identification

In India, where agriculture is the new focus, it has many advantages and benefits, particularly for our politics, economy, and social system. One of the newest agricultural targets is paddy and wheat, a sector in which few manufacturers and researchers are currently active. From there, a number of issues arise, including how to maximize profit, how to boost productivity, and how to cut costs. Harvesting is a significant task in the paddy and wheat industries. Due to the increased cost of transportation, this harvesting operation requires 50% of the investment made in the specific crop. In labor costs and a decline in the number of workers available, which has increased demand for labor. Therefore, the project to address all of these issues where the new invention for harvesting machinery is able to reduce workers comes from ideas to reduce dependence on workers. Machines and other tools can increase productivity, decrease labor costs, and increase profit by reducing reliance on human labor. The primary goal of this project is to design and build a prototype motorized cutter that can harvest crops for commercial use.

3.2 Farmers Survey

The need for a small, reasonably priced harvester served as the foundation for this machine's design. Only through direct interactions with small-scale farmers could this demand have been observed. Small-scale farmers make up the majority of the farms in or near Dhule city. The objective of this visit was to observe and learn more about the harvesting equipment that farmers use. The below mention farmers guide us and give us the important information regarding our project.

1. Yunus Khatik [Vadjai].

2. Babu Shaikh [Bagadi].

3. OM Bhamre [Dhule].

The main information we require is to know the distance between the rows of crops on the farm. They told us that there is no such fixed distance between the crops. The distance between the rows changes as per the type of crop. So, we used rotary cutting blades in our project as these blades are available in different diameters also.
Main Problems Faced by Farmers.

- Heavy and costly reaper machines.
- If they manually reap, then it will take more time and human efforts.
- Day by day, the increase in the cost of the price of farming equipment.
- If they use the harvester machine which can get on rent, its charges are very high, which is not feasible for small-scale farmers.

From the above discussion with farmers, we conclude that we have to develop a small and affordable machine which can be used by each and every farmer at all scales. Design and Fabrication of Electric Crop Reaper Machine.

3.3 Project Objectives

- To formulate an idea to suit our requirement functionality that is to reap the crop.
- To develop an idea to suitable mechanical principles and to design the idea to practice.
- To fabricate the design with the knowledge and the selected material which are cost effective.
- To design and develop the reaping machine in affordable cost.
- To develop a machine which is battery operated.
- To reduce time required for reaping process.

Chapter 4

Design of System

4.1 Design Methodology

The primary objective of this project is the development of a manually driven reaper by analysing the shortcomings of the existing mechanical reapers that were previously used for harvesting grains.

The target's objective chosen to achieve the goal were:

1. Examining and Determining the current mechanisms.
2. locating the potential issue by abstraction.
3. collect useful information.
4. Using data interpretation to define the issue.
5. Creating conceptual designs and making decisions based on a digital logic approach to product development.
6. Creating the product's embodiment design is the last step.

Study on the design and development of rice rotary cutters. The vibration design of the cutter blade is minimized as the vibration is the cause of the damage to the combined harvester, which can cut rice rotary regularly and to fit the physique of the farmers. The main components are as follows.

Necessary Requirements for the project are as follows:

1. The structural characteristics of the rotary cutter shape are available in various standard dimensions. The material of the cutter is high speed steel (HSS) because it does not rust, has light weight and has straps to fit user behaviour.
2. The power pack uses a DC Motor fitted into the structure of the machine to balance the frontback.
3. DC Motor which is used compared to conventional reaper is 400W,14V to 500W,14V, 4000 Rpm.
4. A 24-volt 20Ah lead acid battery is used for optimum output at a little less cost, which is suitable for this project.
5. Charge Controller to handle power. To prevent batteries from being overcharged, a charge controller, also known as a charge regulator, basically regulates voltage and/or current.

4.2 Design

From the market survey, study and we prepared some designs and after decoding their pros and cons, we finalized the final design. From the above activities, we finalized that we have to develop a machine which is

- Compact in size.
- Easily movable or transportable.
- Cheaper than other machinery.
- Easy to handle.

4.2.1 Proposed Design

As shown in the schematic diagram, all the attachments get input from the wheel. The basic structure will consist of a pair of wheels which transfers the power to the other attachments through belt drives or chain drives.

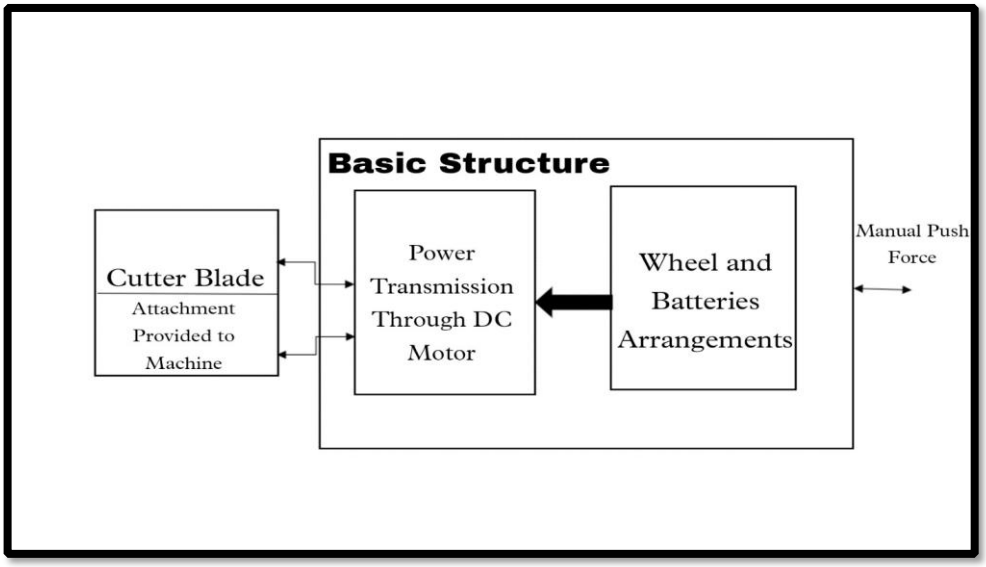

Fig 4.1: Schematic

4.2.2 Chassis Design

As shown in the Chassis Model, all of the Chassis' body is made up of hollow pipe on which turning, drilling and welding operation is to be performed. Further, the attachment section is given to installing wheels and support wheels. A base plate is attached to install the battery setup on it.
And, further, a section is given for motor attachment.

Fig 4.2: Isometric View of Model

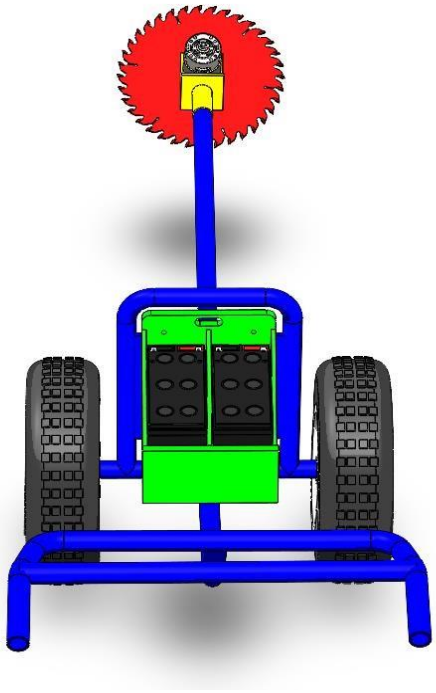

Fig 4.3: Top View of Model

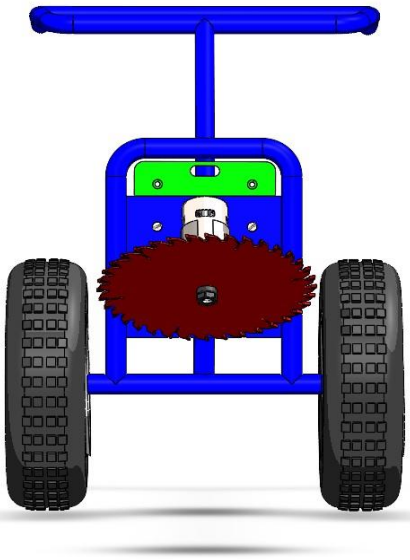

Fig 4.4: Front View of Model

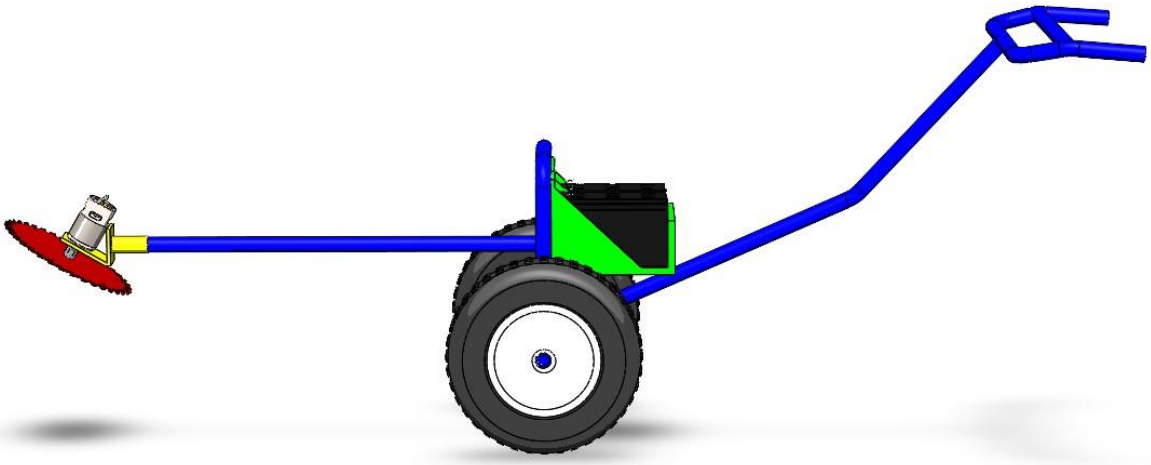

Fig 4.5: Side View of Model

4.2.3 Design of Components

Design of the Basic components of the Project is given below: -

1] Motor Speed Calculation:

To determine the Cutting Speed of Blade, we need to calculate the angular velocity of Motor Shaft.

The Formula to Calculate Angular Velocity is,

$$\text{Angular Velocity } (\omega) = (2 \times \pi \times N) / 60$$

Were,

ω = Angular Velocity in Rad/sec

N = Motor Speed in RPM

Therefore,

$$\text{Angular Velocity} = (2\times 3.14 \times 7000) / 6 =$$

$$\omega = 733.97 \text{ Rad/sec}$$

Since we have the Angular Velocity, we need to find Power Developed,

Therefore,

$$\text{Power} = \text{Voltage Input} \times \text{Current}$$

$$= 12V \times 12A$$

$$= 144 \text{ Watt}$$

Therefore,

Now let's find the Torque Obtain from Motor,

$$\text{Torque} = \text{Power} / \text{Angular Velocity}$$

$$= 144 / 733.97$$

$$\text{Torque} = 0.1968 \text{ N/m}$$

2] Battery Capacity Calculation:

To Estimate the operating time of Reaper Machine, we need to calculate the battery Capacity Required.

Since, the Battery Capacity in mentioned on Battery we can say that it is 26 Ah of Battery,

Therefore,

Operating Time = Battery Capacity in (Ah) / Current Drawn from Motor (Amp)

= 26 Ah / 3 Amps

Operating Time = 8.67 Hrs.

3] Blade Tip Speed Calculation:

The Blade Tip Speed is essential parameter in Designing the Cutting Machine, It determines the efficiency and performance of Reaper Machine.

The Formula to Calculate the Blade Tip Speed is:

Blade Tip Speed = $(\pi \times D \times N) / 60$

Were,

D = Diameter of Blade in Inch

N = Motor Speen in RPM

Blade Tip Speed = $(3.14 \times 7 \times 7000) / 60$

Blade Tip Speed = 1311.67 Inch/min

4.2.4 Efficiency of the Reaper Machine

Now the area to be covered by Reaper Machine to Cut an Acre of Corn Crops Plantation.

Therefore,

Since the Accurate data is not Available let's assume the Average Corm Stem Thickness is 3cm.

1] Blade Linear Speed:

$$\text{Blade Linear Speed} = \text{Blade Tip Speed} / (2 \times \pi \times r)$$

Were,

Blade Tip Speed = 1311.67

Blade Radius = 3.5 Inches or 8.89 cm

Therefore,

$$\text{Blade Linear Speed} = 1311.67 / (2 \times 3.14 \times 8.89)$$

Blade Linear Speed = 3328.94 cm/min

2] Time taken by Blade to cut 1 Stem of Corn:

Time = Thickness of stem / Linear Speed of Blade

= 3 (cm) / 3328.94 (cm per min)

Time = 0.0011 min. [To cut 1 Stem of Corn]

Let's Assume that there are approx. 43000 of corn stem are planted in One Acre of the Land which we have to cut by Reaper Machine.

Therefore,

Total time = Time taken to cut 1 Stem × No. of corm Stem

= 0.0011 × 43000 Total time = 47.3 Min.

Therefore,

Based on estimated cutting time for Single Corn Stem, it would take approx. 47.3 Minutes to cut the crops in 1 Acre which will have 43000 plants Approximately.

Note: - Reaper Machine Push Speed and Travel time is not included in above estimation.

Now,

Let's consider the approx. freely moving speed of machine is 60 meters per Minutes at constant Speed.

Corn Stem Density (per Square Meter) = Corn stem Density (per Acre) / 4047

= 43000 / 4047

Corn Stem Density (per Square Meter) = 10.63 (Stem per Square Meter)

3] Time taken by Machine to cover 1 Acre:

Distance travelled per corn Stem = 1 / Corn stem Density (per Square Meter)

Now,

Time per Corn Stem = Distance travelled per corn stem / 60

= (1/10.63) / 60 Time per Corn Stem = 0.00156 Min.

The Total Time to cover 1 Acre = Time per Corn Stem × No. of corn Stem

= 0.00156 × 43000

The Total Time = 70 Mins

The time taken to cover 1 acre by Machine is Approx 70 Minutes at Constant Speed,

The cutting speed and time may vary with respect to moving speed, type of crops, Human Factor and Tolerance.

So, let's consider 20% of tolerance factor in time Calculation.

Therefore,

Time after Tolerance (for 1 Stem) = Time per corn Stem × tolerance factor

= 0.00156 × (1+0.2)

Time after Tolerance (for 1 Steam) = 0.00187 Mins.

Therefore,

Final time for 43000 Stems = 0.00187 × 43000 Final time for 43000 Stems = 80 Mins.

Therefore,

The total time Required to cut the Plantation of 1 Acre by Electric Crop Reaper:

Total Time = [Time taken by Blade to Cut 43000 Stem + Time taken to cover 1 Acre

+ Fina time with Tolerance]

= [47.3 + 70 + 80]

Total Time = 197.3 Mins or 3.28 Hours

Therefore, the total time taken by Reaper Machine to Harvest 1 Acre of crops is Approximately around 3.2 Hours or 197 Minutes.

4.2.5 Standard Components

1. **Motor**: The motors which are used in these projects are DC motors which are directly connected to the control charge panel by means of wires. The used motor gives 3500 RPM speed in ideal condition. We used radiator motors which use in the automobile because we require a high-speed operation, generally at a speed of 2600-3000 RPM. That speed is quiet enough to cut the crop, so we used this type of motor in our project.

Specifications of Motor -

- Voltage: 12 volts
- No-Load Current: 1 ampere
- Speed: 7000 RPM
- Torque: 0.1968 NM
- Loaded Speed: 4500-5000 RPM
- Wattage: 56 - 144 Watt
- Rated Current: 3 amp
- Efficiency: 70%
- Weight: 0.5 Kg

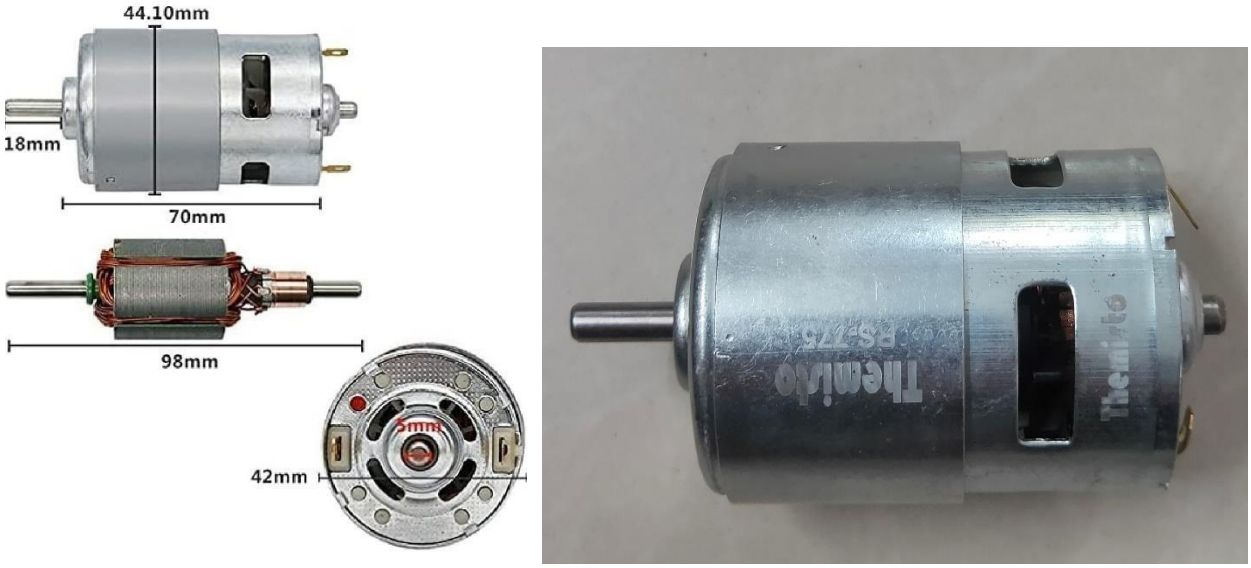

Fig 4.6: DC Motor

2. Battery: The batteries which are used in the project are lead acid type battery which are easily available in the market. We required such a battery which gives optimum output at much less cost, so we used the batteries which are being used in Auto Rickshaw or Cars vehicles. We use 12-volt 26Ah, which is the optimum for our project requirement. Battery Type - (Lead Acid)

Specification

1) Battery Type

- 12 volts 2) Capacity
- 10-hour rate (650 ma) 14 Ah

- 20-hour rate (350 ma) 26 Ah 3) Dimensions
- Height: 175 mm
- Length: 167 mm
- Width: 126 mm

• Approx Weight: 9 kg

Fig 4.7: Battery Used

3. Motor Shaft Coupler Sleeve: This sleeve is installed on motor to connect Cutting Blade directly on motor. Motor shaft coupler sleeve; (M10-5mm) (M10-8mm) (M10-10mm) (M10-12mm) as per Hole Diameter on cutting Blade.

Fig 4.8: Coupler Sleeve Set

4. Cutting Blade: The cutting blades which are used in the project are wood cutter blades. The distance between the two crop lines can vary according to the type of crops which depend upon the farmers. So, we have to consider these things while selecting the cutters. The wood cutter blades can be available in different diameters,

such as 4 inches to 12 inches. The cutting blades are so chosen that if the distance between the two crops varies, we can just change the blades to carry out our task. In other words, we can say that we have chosen the interchangeable blades and these will be very helpful for the reaper to do the operation types of crop fields.

Fig 4.9: Cutting Blade

5 Process Sheet and Cost Estimation

In Table 5.1, different components like frame, battery, motor, shaft and, Cutter are as shown in the table. We will use steel pipe materials to make the frame. For battery and motor connection, soldering operation is used.

5.1 Table of Process Sheet:

Sr. No	Name of the Parts	Operation	Machining and Equipment
1	Hollow Pipe Frame	Turning, Drilling, Welding	Lathe, Arc Welding Machine
2	Plate Cutting	Cutting	Power Cutter
3	Motor	Fastening, Soldering	Nuts and Bolts
4	Battery	Fastening	Nuts and Bolts

5.2 Different Operation Performed:

Fig 5.1: Pipe Cutting

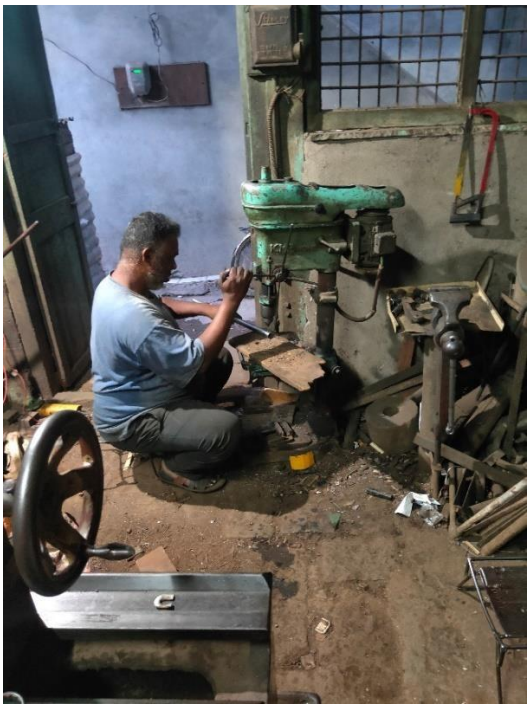

Fig 5.2: Plate Drilling

Fig 5.3: Pipe Drilling

Fig 5.4: Welding

5.3 Table of Cost Incurred:

Sr. No.	Name Of the Parts	QTY.	Material	Amount (Rs)
1	Hollow Pipe	1	CSR	1100
2	Battery	1	-	4000
3	DC Motor	1	-	3000
4	Wheel	2	-	1300
5	Cutting Blade	1	HSS	850
6	Controller	1	-	300
7	Auxiliary		-	600
	Total	8	-	11,150 (Rs)

6 Project Management

The project timeline to perform the overall activities done in the project and tentative dates to complete this particular activity.

- The group was formed in Month of (Sept, 2022)
- The group members choose the topic, Surveyed and started Literature Survey. This took the time span of 1 month (October, 2022)
- Based on Survey a Concept model was made on Solid Works (December,2022)
- The Manufacturing process will begin in (January 2023), after SEM-7. And testing will be done further on field.
- The Report Writing phase started in month of March, 2023.

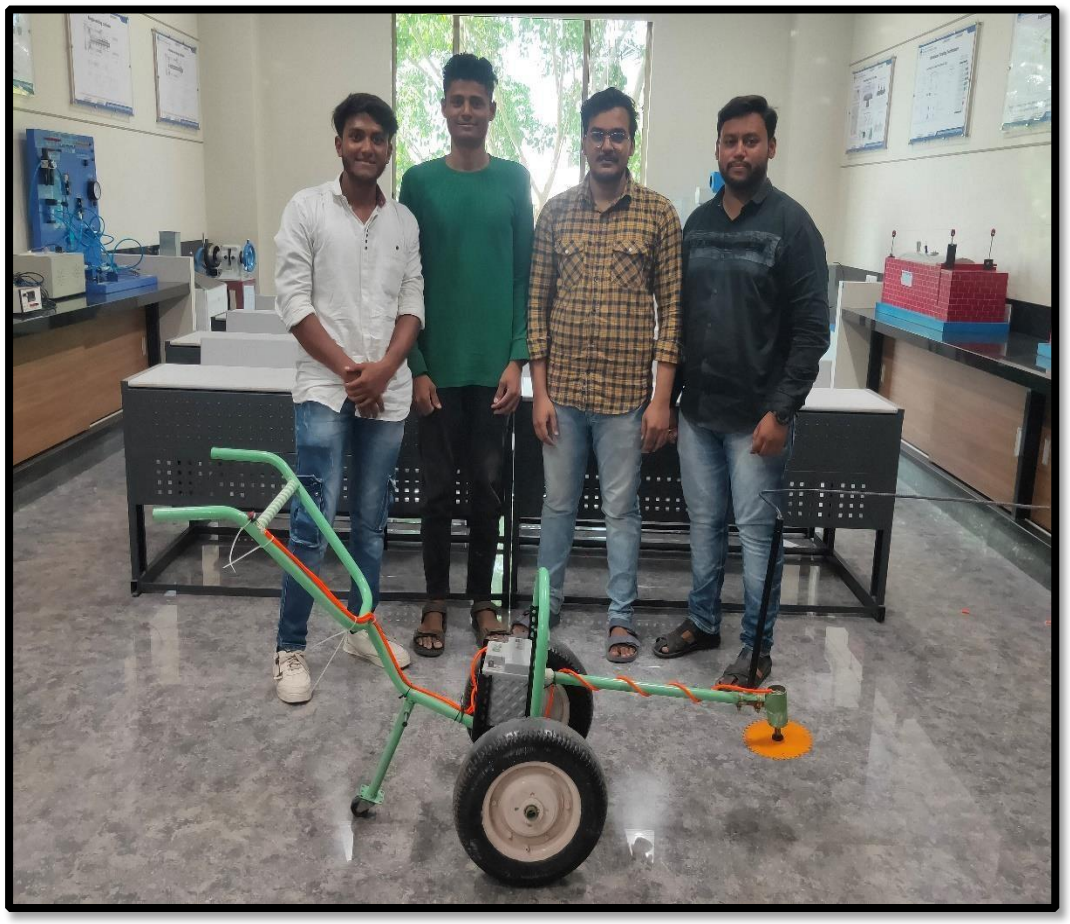

Fig 6.2: Group Picture with Project Assembly

7 Results and Discussions

- Depending on the type of crop, we discovered that the distance between the two is typically between 1.0 and 1.5 feet. However, because the majority of our project is concerned with harvesting corn and wheat, we use 1.5 feet so we consider 7 inches of Blade.

- At first, we considered using sliding blades, but given the cost and manufacturing complexity, we decided against it. Instead, we will use a rotary wood cutter blade because they are available in a variety of ranges. Since the type of blades varies depending on the crops, we can switch them out.

- It takes around 14 hours to fully discharge the battery, which indicates that under no-load conditions. Under conditions of full load, the battery discharges in 8 hours or less. Using a motor, we drive the cutters at 7000 RPM, which is enough to cut the crop.

- The manual method of reaping takes one to two days to complete, but using mechanised equipment speeds up the process to one day, saving both time and labour costs.

- Because we use battery to power our cutters with an unconventional source of energy electricity. Conventional methods typically require an hour to charge the batteries.

- Total time by blade to cut 43000 stems is 47.3 Mins, time to cover 1 acre is 70 mins, and finishing time with tolerance is 80 mins. As a result, the Reaper Machine needs roughly
3.2 hours or 197 minutes to harvest a single acre of crops.

- Even though we can also install solar cells powered charging point to charge the battery, the battery will charge in 8 hours of bright sunlight depending upon Solar Panels.

Fig 7.1: Project Model

Fig 7.2: Total Area Covered While Reaping

Chapter 8

Summary and Conclusion

Manually a battery-operated reaper is designed and made semi-automated, operative with the use of motors to assist humans to perform operations. The present work reduces the efforts to be made by farmers in the field, and it also reduces about half of the time required for manual operation. The manual battery assisted reaper is a high labor-cost-saving equipment requiring only 2 man/Acre. The cost of a reaper is low, so it is affordable for small land holders. Machines available for reaping purposes have costs above 1 lakh rupees but the manually/battery operated reaper facilitates reaping operation only at cost 11,150 i.e., almost 89.15% reduction in cost.

In Future a high-capacity battery may be provided. At present. There is only 12V 26Ah provided. So, it is a proposed future scope to provide more battery capacity so that the time of working on the reaper will increase.

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Appendices

Appendix I

When harvesting a crop, the plants are either removed after being torn out or they are cut very close to the ground. Cutting coral crop stems closely to the ground is required for crops like tuar, Jawar, Bajra, and maize. In our country, cutting things with a sharp sickle is customary. Smallscale rice farmers primarily practise traditional or conventional farming techniques. The harvesting of the rice crop is a very labour-intensive and time-consuming process.

In comparison to other crops, farming also requires more labour. As a result, mechanically operated reapers are now being developed, but they are expensive for farmers to use on their small farms. They are unable to afford expensive machinery like harvesters. Therefore, we have created a small, inexpensive rice reaper that uses solar power and batteries to power itself.

Earlier corn reaping machines had engines. That again indicates that the cost, growth, and use of fuel are not very cost-effective. The weight of the rice reaper also decreases in comparison to other rice reaper machines because we are using electric energy, which is also one of the most affordable forms of energy available. The productivity of the farm will rise, and the small-scale farmers' profits will rise as well, if we start using inexpensive and efficient machines there.

In India, the economy of our country is based on agriculture, which supports about most of the population. Therefore, as these fields advance, so does the economy of our country. Therefore, there are opportunities for the development of more practical and affordable farm equipment in these areas, which will benefit small-scale farmers.

The Farmers are unable to afford expensive machinery like harvesters. Therefore, we have created a small, inexpensive rice reaper that uses solar power and batteries to power itself. As a result, developing new equipment necessitates providing our farmers with more sophisticated and modern tools, which would shorten the total amount of time required to complete the task and make it more convenient.

We draw the conclusion that farming equipment is very expensive for small-scale farmers based on the research papers mentioned above. Farmers must spend a lot of time and energy manually harvesting their crops. Therefore, a low-cost, simple-to-use, and time-saving rice reaping machine is useful for small-scale farmers.

As a result, we have made the Reaper Machine which needs roughly 3.2 hours or 197 minutes to harvest a single acre of crops and cost efficient for the Farmers.