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Semi-Automated Motorised Cultivator for Agriculture

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Abstract: Agriculture process includes Ploughing, Planting, Watering, Weeding, Harvesting and Delivery. Among different methods of weed controls in agricultural crops, mechanical control has a special place from the viewpoint of its effectiveness, feasibility and flexibility. The development of appropriate mechanized weeding control is a need for increasing productivity and reducing the production cost. The primary purpose of ploughing is to turn over the upper layer of the soil, bringing fresh nutrients to the surface, while burying weeds and the remains of previous crops and allowing them to break down. Ploughs were initially human-powered, but the process became considerably more efficient once animals were pressed into service. The first animal-powered ploughs were undoubtedly pulled by oxen, and later in many areas by horses In industrialised countries, the first mechanical means of pulling a plough were steam-powered but these were gradually superseded by internal-combustion-powered tractors. In this paper Ergonomic Semi-Automated motorised cultivator for agriculture purpose is designed which is be able to plough in 15 inches gap distance in irrigation fields where cattle's find difficult to pass through. In addition, fertilizer sprayer and pesticide spreader is provided as add on features. The cultivator is designed as per farmers feedback and requirement.

Index Terms **– Agriculture, Cultivator, Motorised, Sprinkler**

I. INTRODUCTION

Karnataka is one of the agricultural based land and some of the predominantly important crops grown here are Jowar, Raagi, cotton and sugarcane etc. Agriculture process includes Ploughing, Planting, Watering, Weeding, Harvesting and Delivery. The primary purpose of ploughing is to turn over the upper layer of the soil, bringing fresh nutrients to the surface, while burying weeds and the remains of previous crops and allowing them to break down. As the plough is drawn through the soil it creates long trenches of fertile soil called furrows. In modern use, a ploughed field is typically left to dry out, and is then harrowed before planting. Ploughing and cultivating a soil homogenies and modifies the upper 12 to 25 cm of the soil to form a plough layer. In many soils, the majority of fine plant feeder roots can be found in the topsoil or plough layer **[1].** A cultivator is generally more hand driven. Usually cultivators have no wheels and are driven along the blades of the machine, although this is not always the case. Because cultivators tend to be smaller and lighter, they are usually cheaper and more financially attractive to a small plot holder or for only occasional use. Like rotavators, cultivators can be powered by petrol or by electric. The latter is usually cheaper and quieter, but not as powerful, and the blades tend to be lighter than those of a rotavator. Since cultivators turn the ground over at less of a depth than a rotavator, they are better for removing weeds. Management of weeds is really one of the problems Farmer's encounters on their farming. Without submerging the rice plants, weeds around the plants increase. Rather than using synthetic chemicals to eliminate them, the rotary weeder uproots and leaves them on the field. The uprooted weeds become nutrients in the soil. The weeder also aerates the soil, allowing oxygen needed in the growth of the plants to flow through. In the current agriculture scenario many of the traditional crops cultivated have the gaps spacing invariably small which makes the movement of cattle's difficult and the effectively of ploughing drops. At the same time chances of crops getting uprooted or damaged [4]

II. LITERATURE SURVEY

[1] Presents Rotary cultivator as one of key equipment's in modem agricultural machinery. It is a kind of great practicability and versatility tillage and soil preparation machinery with good performance in cutting soil, broken soil ability, etc. Blade shaft assembly is the key components in rotary cultivator, and it is composed of a shaft weldment and a series of blades fixed in a blade holder respectively. It consists of a blade holder library with chain conveyer, a vertical linear guide, a pneumatic finger and a feeding device frame fixed on horizontal linear guide sliding along bed guide. [3] presents the major draft power sources used in Indian agriculture are bullocks although some other animals like buffaloes and camels are also used. On the basis of 1991 estimates, the availability of power on Indian farms is about 0.55 hp/ha of cultivated area. The contribution of draft animal is about 52 percent and the rest comes from tractors and power tillers. Some of the Comparison of Various Portable Weeder's on the Basis of Power Details such as Power Source, Power Generated & Transmission used is shown in Table 1.1 and the Comparison of Various Portable Weeder's on the Basis of Operating Details in Table 1.2 [2,3]

Table 2.1: Comparison of Various Portable Weeders on the Basis of Machine Details such as Weight of Machine, Type Cutting Blades, Area of Application, etc.

SL. No.	Company Name	Product Name	Weight of Machine	Cutter	Application	Forward Motion
1	Rekha Agriplus Pvt Ltd.	CL262 Power Weeder	10.4 kg	Carbon steel blades	Vegetables Fields, Fruit orchards, cotton, wheat, rice, etc.	Manual
2	Maxx Engg. Pvt Ltd.	Power WeederPW210	15-20 kg	Carbon steel blades	Paddy, corn, wheat, maize, groundnuts, sunflower, and vegetables	Manual
3	Premier Pvt. Ltd.	Portable Weeding machine KW 825	12 kg	High carbon steel blades	Vegetables, Grapes, Sugarcane, Mulberry, etc.	Manual
4	Premier Pvt. Ltd.	Cultivation machine	15 kg	High carbon steel blades	Vegetables, Grapes, Sugarcane, Mulberry, etc.	Manual

Table 2.2: Comparison of Various Portable Weeder's on the Basis of Operating Details such as tilling or Weeding Width, Weed Removal Rate & Costs.

SL. No	Company Name	Product Name	Tilling Width	Operating Cost	Initial Cost	Weed Removal Rate
1	Rekha Agriplus Pvt Ltd.	CL262 Power Weeder	40-60 cm	Medium	Medium	Slow
2	Maxx Engg. Pvt Ltd.	Power WeederPW210	25 cm	Medium	Medium	Slow
3	Premier Pvt. Ltd.	Portable Weeding machine KW 825	70-90 cm	Medium	Medium	Slow
4	Premier Pvt. Ltd.	Cultivation machine	90 cm	Medium	Medium	Slow
5	KSNM Agricultural Pvt. Ltd	Cono Weeder	35 cm	Low	Low	Slow

Based on the literature survey, we decided to design a Semi-Automated Ergonomic Cultivator in Agriculture which is achieved by the designing of model that performs Ploughing of land and removing weeds within a gap distance of 15-inches, automatic Pesticide sprayer to help farmer to spray the pesticide over the plantation, provide the fertilizer spreader to spread the fertilizer like urea at the roots of the plants

III. HARDWARE DESCRIPTION

The following calculations were done in order to decide upon the selection of the Motor and other parameters as described below.

a. Load Calculation

The maximum load weight was taken to be as 35kg and the overall weight was taken to be as 65 kg. A spring balance test was carried out which involved moving a single wheel cultivator by using a spring a balance for both Dry and Wet land as shown in Figure 3.1(a) and (b). Therefore, the spring balance reading by carrying out the above test = 25kgs (For Wet Land)

Fig 3.1(a): Spring Balance reading = 30Kgs (For Dry Land)

Fig 3.1(b): Spring Balance reading = 25Kgs (For Wet Land)

b. Force Required

The force is given by Eqn. 3.1

$$F = Mxa \qquad (3.1)$$

Where, F = force required;M = mass obtained from spring balance reading; a = acceleration due to gravitation in m/s2 = 9.81 m/s2. Substituting the value of M from load calculation and a we get the force as,

=245.25 N

c. Torque Required

The torque required is given by Eqn. 3.2,

$$T = Fxr \qquad (3.2)$$

Where,

T = torque required; r = radius of the wheel. The force calculated as per Eqn.3.1 is 245.25 N and r= 0.2032 m

Therefore, the torque is calculated as,

=49.84 Nm

d. Motor Power Rating

Consider the walking speed of a human being to be 4 km/hr. Now converting it into m/s,

=1.11m/s

$$Power\ needed\ to\ move\ the\ load = \frac{Forcexdi\tan ce}{time} \qquad (3.3)$$

= 272.23W

Assuming 20% rotational losses and we get the power as,

Power = 326.68W

e. Current Rating

The current rating of the motor is determined with the help of Eqn. 3.4,

$$Current = \frac{Powerratingofthemotor}{Voltageacrossmotorter\min als} \qquad (3.4)$$

= 14 Amps

f. Peripheral Velocity

The formula for Peripheral velocity is given by Eqn. 3.5,

$$Ve = \frac{\Pi Dn}{60} \qquad (3.5)$$

Where = Diameter of the wheel; N = Speed of the wheel to be found in RPM; Ve = Peripheral Velocity = 1.11 m/s

$$N = \frac{1.11X\,60}{\Pi X\,0.4064} \qquad (3.6)$$

= 51.69RPM

g. Battery Consumption

Considering 1 acre of land for ploughing, on an average it is divided 50 columns. Based on the test, Each row requires 3-4 minutes for complete ploughing. Current drawn by cultivator for wet land is 10-12A and Current drawn by cultivator for dry land is 12-14A

Total time for ploughing 1-acre land = 50 columns X 4 minutes =200 minutes (3.4 Hours).

Battery capacity required = 3.4 hours X 14Amps **= 47.6 Ah**

h. Gear Mechanism

To reduce the rated speed of the motor from 1500 RPM to around 300 RPM, this mechanism is inbuilt in the motor itself.

The formula of the gear ratio is given by Eqn.3.7,

$$\text{Gear ratio} = \frac{Speedofthedrivegear}{Speedofthedrivengear} \qquad (3.7)$$

Hence the total number of teeth of the drive gear is 9 and the total number of teeth of the driven gear is

Gear ratio = 5:1

IV. MOTOR DRIVE CIRCUIT

We decided to use Pulse Width Modulation (PWM) to control the speed of the motor. The advantage of pulse width modulation over the use of adding gears to the system is the fact that with gears, torque is gained, but distance efficiency is lost. Pulse width modulation allows the motor to operate at a variety of speeds. Motor drive circuit is used to drive the motor which are installed at the front wheel of the cultivator for moving forward direction with variable speed. Figure 4.1 shows the Motor drive circuit used.

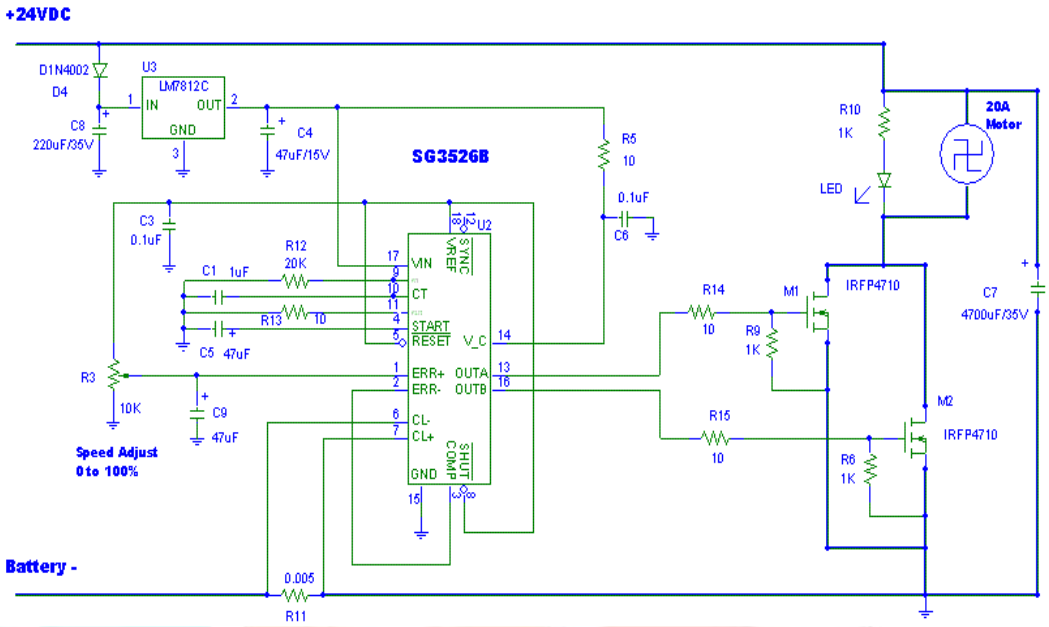

Fig 4.1: Motor Drive Circuit

The main component of the motor drive circuit used in this project is described briefly and the working of each component is explained below. The Fig 4.1 shows the motor drive circuit with 20A short circuit protection. The 24V DC voltage is applied to the voltage regulator IC LM7812C which regulates supply and gives up-to as variable 12-24V output. This voltage is now applied to the input of the SG3526. The SG3526 is a high performance pulse width modulator integrated circuit intended for fixed frequency switching regulators and other power control applications. The Throttle is used to vary the width of the PWM in order to control the speed of the motor. The output of the high performance pulse width modulator integrated circuit SG3526 is given to the driver circuit which consists of 2 MOSFETs which is used to drive the motor.

V. RESULTS AND DISCUSSION

The total weight of the Cultivator is calculated as follows:
Load weight = 25kgs, Sprinkler tank weight =10kgs, Motor and drive circuit weight = 10kgs, Battery weight = 8kgs
Hoe weight = 2.72kgsAdditional weight = 10kgs
Therefore,

Total weight = 25+10+10+8+2.72+10 = **65 kgs**

The Model was initially designed for very narrow dimension so that it cab be able to use in very small gap space, but because of this design model lost the balance and its became tough to control the direction of the movement. The cultivator hoe designed earlier became more wide because of which it was not able to use for most type of crops. Hence, two more-wheel support at the backside so that stability can be improved. In addition, two more sets of wholes to shift the teeth of the hoe, so that we can be able to make changes according to our width requirement. Battery position was changed and placed on top of the motor and wheel alignment so that heavy weight is placed on wheel which also avoids slipping of the wheel from motor. Figure 4.1 shows the final model designed.

Fig.4.2: Final Model

In the designed model, there are variations in proportional dimensional scaling. These are due to the different percentiles of Ergonomic hand driven cultivator considered in the design of individual features of cultivator. These percentiles to be considered are based on subjective perceptions arrived at by subjective analyses. The mechanism for engagement and disengagement of shaft to the gear and the wheel carrier are to be developed further. The Components Specifications, Plot area and Battery duration is shown in Table 4.1 and 4.2 respectively.

Table 4.1: Components Specifications

SL.No.	Cultivator	Motor	Gear Mechanism	Motor drive circuit	Battery
1	**Height:** Front view:1097.28mm Back view: 975.36Mm **Length:** 1066.8 mm **Width:** 457.2 mm	350W,24V,14A	5:1	14A capacity	24V,70AH

Table 4.2: Plot area and Battery duration

SL.No	Plot Area	Number of Gap Spacing	Battery Duration
1	½ Acre	25	1.3 hours
2	1 Acre	50	3 - 3.4 hours

The data recorded for dry and wet land is shown in Table 4.3

Table 4.3: Tabulation of results

Readings for Dry Land						Readings for Wet Land					
Cultivator		Sprinkler		Both		Cultivator		Sprinkler		Both	
I (amps)	V (volts)	I (amps)	V (volts)	I (amps)	V (volts)	I (amps)	V (volts)	I (amps)	V (volts)	I (amps)	V (volts)
11-13	24	6-8	24	14-16	24	8-10	24	6-8	24	10-12	24

VI. CONCLUSION

The designed model after trials and iterations came out successful and currently is utilized by a farmer. The objective proposed was achieved which mainly focused for farming and gardening applications. Based on farmer's feedback, by incorporating some changes in the design model can be brought to the market in the future. As a suggested scope of improvement, by making chassis more stable by using metal having more strength vibrations can be avoided. Casing can be provided to give more safety to the motor battery and circuit.

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