Design of Rotary Tiller With Grass Cutter

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***Abstract*—** Tilling is the process in which one is required to remove weeds or unwanted crops from the field, so that it may not obstruct the growth of the crop which is being intended to grow on the field. As there are weeds and unwanted crops on the field then it may consume the nutritious elements which are intended for the crop that is to be grown. So, here we have designed a machine which would uproot the weeds and unwanted crops from the field completely. Similarly, grass cutter can also be utilized for cutting off the crops as it has nylon rope tightened at the end of it which expands outwards and rotate at a high speed as the power is given. Basically, we have merged two different machines one is a rotary tiller and the other one is grass cutter. Merging two machines to work together as a single unit gives out the output as we have expected. According to our survey, to nearby fields we came to conclusion that the tilling process which is traditionally done by use of animals or employing labor according the size of the field is very time consuming and the cost of tilling the field traditionally is quite high. So, our machine fulfills the promise of helping out our farmers with the help of technology.

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I. INTRODUCTION

What Agriculture in India has a significant history. As all know that, the nation's economy largely depends upon farming and farmers, but farming methods and techniques are not much improved. The economic contribution of agriculture to India's GDP is steadily declining with the country's broad-based economic growth. Still, agriculture is demographically the broadest economic sector and plays a significant role in the overall socio-economic fabric of India.

Soil preparation is the first and most important operation in agriculture. Destruction of weeds and to cut up crop residues is called as Secondary tillage in agriculture field. Secondary tillage is performed after some time interval of plant growing and is undertaken for

1) Weed control and uproot unwanted crops
2) Incorporation of fertilizers
3) Leveling soil surface.

The main objectives of soil preparation are, to improve the physical conditions of soil, to destroy weeds and to prepare a suitable seedbed. Rotary tiller is advantageous over the conventional implements (i.e. moldboard plow and disk plow) due to two main effects of the direct application of power to the soil engaging tool rotating around a horizontal-transverse axis. From decades, farmers use animal and human efforts for destruction of weeds and to uproot the crop residues. The basic idea of soil scratching for weed control is ancient and was done with hoes or mattocks for millennia before cultivators were developed. Cultivators were originally drawn by draft animals (such as horses, mules, or oxen) or were pushed or drawn by people. But it is very time consuming and also animals have limited range of working conditions and limited daily working hours. Also unavailability of workers and their high wages makes it more a headache.

There is a need to design machines and tools relating the operations with minimum power required and maximum efficiency possible. On design aspects there are different factors to be considered such as tool profile, tool position, and flexibility to adjust with varying characteristics of regional soil, etc. These above technical aspects are needed to be considered for the features of machine to increase efficiency and effectiveness. There is a particular need to improve the farming methods and create method more efficient by providing new technologies and fabricating new equipments.

Two benefits of the direct application are (i) rotary tiller achieves both plowing and harrowing in a pass of machine on the field and (ii) the traction demanded of driving wheel is reduced due to the rotary blade provide some forward thrust as operating. Hence, the design of Weed Uprooting Machine with Grass Cutter is done.

II. LITERATURE REVIEW

A. The Performance of Rotary Power Tiller Using Prototype Rotary Blades in Dry-Land Field. [6]

That the effect of various shape of prototype rotary blades on the performance of rotary power tiller. The test was conducted in a dry-land field. The experimental results showed that the mean soil clod diameter decreased and soil inversion increased with increasing rotational speed of the rotor. The mean soil clod diameter decreased at pass 2. Soil inversion during pass 2 was higher than pass 1. There is no significant difference on mean soil clod diameter and soil inversion. Also it results that the Japanese C-shaped blade is better than any other type. [6]

B. Rotary Tiller Design Proportional to a Power Tiller using Specific Work Method (SWM). [5]

That the total specific work is the sum of static and dynamic specific work of the tiller. For selecting work width of tiller maximum benefit power of the power tiller was considered, which it could be decreased by increasing work speed. Again it was revealed that the addition of torsional moment the flexural moment was also effective on system safety design. The investigation of conclude that the power tiller selected for supporting the rotary tiller, could only pull the rotary tiller at first heavy gear.[5]

C. Optimal design of rotary tiller's and width proportionate to tractor power using energy method [7]

That the proper selection and use of agricultural machines are important factors to achieve optimal design. Considering the widespread application of rotary tillers and wide use of modern, optimal design of these machines is mandatory. Therefore in this study they expressed the optimal working width and optimal diameter of the rotary tiller's rotor proportionate with the power of tractor or engine was delineated based on the energy method. Hence they conclude with optimal working width and optimal diameter of rotary tiller proportionate to the power of tractor or engine were determined in order to achieve to the maximum field efficiency of rotary tiller and to minimize the consumed materials in the building of this machines.[7]

D. A Width of Cut Analysis on the Performance of a Rotary Strip Tiller.[1]

That describes a soil bin study on the effect of blade width upon rotary tiller performance. Blades used were designed and tested at several forward and rotor speed combinations using a single rotor flange. Hence they conclude with for each combination of forward and rotor speed, the power requirement increased almost linearly with cutting width and reducing rotational speed at a constant forward speed, significantly reduced the power requirement for all cutting widths. [1]

E. Design and Development of Grass Cutting Machine using DFMA Methodology .[8]

That paper presented about the implementation of redesign the grass cutting machine by using the application of Design for Manufacturing and Assembly (DFMA) methodology. The improvement of redesign grass cutting machine finally will be able to meet user requirements and satisfactions. Result shown that the design efficiency for redesign grass cutting machine obtained better percentage rather than the existing design.[8]

F. Evaluation and Optimization of Handle Design Parameters of a Grass Trimming Machine .[9]

That proposes a new design of a handle of the grass trimming machine. When this new design was compared with the old one, it was found that the new handle resulted in 18% lower HAV (hand arm vibration). To find the lowest HAV, 3 critical parameters of the new handle (length, angle and material of the cap of the handle) were optimized using the Taguchi quality tool. He concluded that among the three handle design parameters considered in this research, the material of the cap of the handle emerged as the highest contributor to HAV generated in the grass trimmers, followed by the angle and length of the handle.[9]

III. DESIGN OF ROTARY TILLER WITH GRASS CUTTER

It is the structural view of project which consists of various parts. The different numbers are given to various parts, which are sown in figure 1, and detailed in table 1.

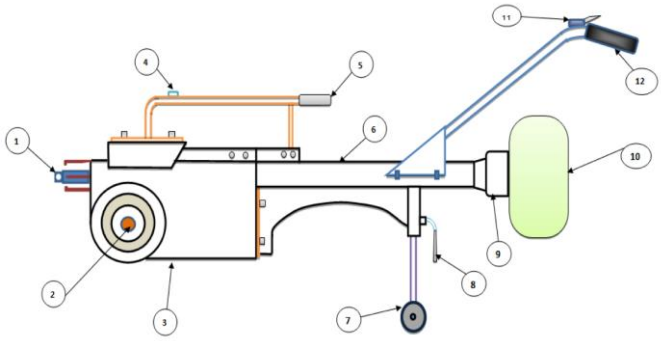

Figure 1: Structural View of Machine

Sr. No.	Part Name
1.	Driving shaft
2.	Tiller blade shaft
3.	Gear box casing (worm gear assembly)
4.	Oil fill plug
5.	Supporting handle
6.	Frame
7.	Supporting wheel
8.	Lock lever
9.	Clutch casing (centrifugal clutch)
10.	Engine
11.	Accelerator lever
12.	Handle

Table: 1 Parts of machine

Tiller Blade

The schematic diagram of tiller blade is shown by figure 2 and various parts are shown in table 2

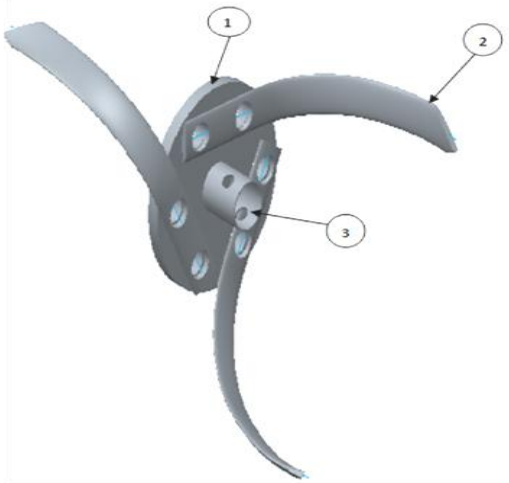

Figure 2: Tiller Blade

Sr. No.	Part Name
1.	Blade mounting disc
2.	Tiller blade
3.	Mounting shaft

Table 2: Parts of Tiller blade

Cutter Assembly

The arrangement of cutter assembly is shown by figure 3 and various parts are given in table 3

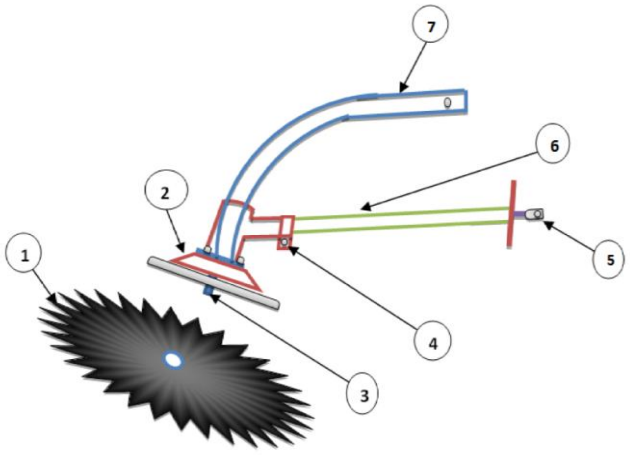

Figure 3: Cutter Assembly

Sr. No.	Part Name
1.	Cutter blade
2.	Bevel gear casing
3.	Shaft
4.	Lock screw
5.	Shaft coupling
6.	Shaft casing
7.	Frame

Table 3: Parts of Cutter Assembly

Design Parameters Of Rotary Tiller Blades

In this study to design and develop an "L" type blade, advantages of CAD methods like 3D modeling and analysis was used. Accordingly at the initial stage 3D Modeling was done on the basis of geometrical parameters normally which are similar to a commercially available blades using 3D CAD software. This model was analyzed through ANSYS for Finite Element Analysis particularly to investigate the main causes of wear. Based on the analysis results, it was noted that by altering some geometrical parameters improvement can be made and hence through the analysis a final blade has been designed. Table 4 and figure 4 show the specifications and important parameters of the blade, respectively. This blade was designed by considering: (1) cutting width which should be more than 40mm for cutting and breaking paddy residues into pieces and making a seedbed of sufficient width for direct seeding; (2) maximum radius of rotation should be more than 150mm to achieve a cutting depth of 60mm without the rotary shaft touching the surface. Fig. shows the 3D Model and original photograph of the developed blade.

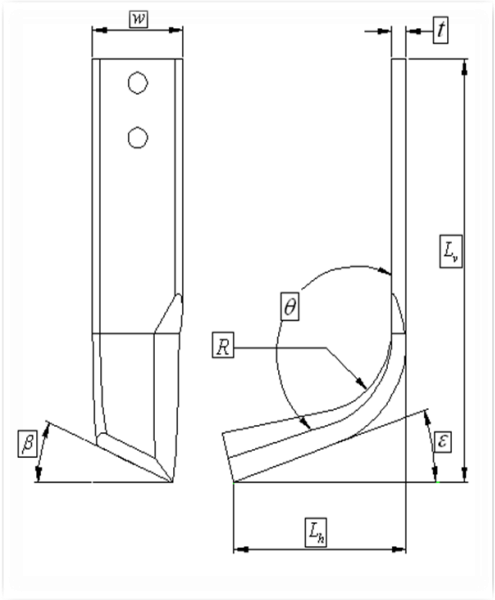

Figure 4: Blade Nomenclature

Parameters	Notations	Values
W	Blade span, mm	40
L_v	Effective vertical length, mm	212
L_h	Blade cutting width, mm	88.7
R	Curvature between L_v and L_h mm	40
θ	Blade angle, degree	108
β	Clearance angle, degree	20
T	Blade thickness, mm	8.0
$\in$	Bending angle, degree	22

Table 4: Various Parameters of the Blade Designed for the Study

Analysis work was carried out using the input data, which are given in Table 4. These data is very much similar to the actual data generally observed while carrying out a laboratory as well as field performance trials.

On the above parameters including the design parameters as detailed we get soil force acting on each of the blades (K_e), minimum of blades tangential speed (K_s)

K_s = 2083 kg and

K_e = 378 kg = 3800 N.

These values were used as input parameter along with other parameters as stated in Table 5

Table 5**:** Input Parameters of Analysis

Parameter	**Values/range**
Rotary tiller work depth	100 mm – 150 mm
Rotary tiller work width	1600 mm
Rotor rpm	200- 220
Blade peripheral velocity	5-6 m/s
Total number of blade	66
Number of blades on each side of the flanges	1
Prime mover forward speed	0.7- 1.7 m/s
η_e, number of blades which action jointly on the soil into the total number of blades n	11/66
Prime mover Power (N_c)	30-40 hp
Traction efficiency (η_c)	0.8-0.9
Coefficient of reservation of tractor power (η_z)	0.7-0.8

Technical specifications of engine and cutter used are as follows:

Engine Type	Single cylinder air cooled 2-cycle gasoline engine
Displacement	49 cubic centimeters
Engine Idle Speed	2800-3000 rpm
Volume Of Fuel Tank	2.1 litres
Fuel Ratio	25:1
Carburetor Type	float type
Maximum Engine Rotation/Power	11000 rpm/1.65kw
Starting Method	Recoil starter
Stopping Method	Sparking circuit primary short
Transmit Method	Centrifugal clutch, drive shaft

Table 6: Technical specifications of Engine

Materials	65Mn or 50# steel
Diameter	255mm
Teeth	80T
Bore	25.4mm
Thickness	1.6mm

Table 7: Specifications of Cutter

Working

The working of grass cutter is considered first. When the engine is start, it will run at idle speed. This power is transmitted with the help of a centrifugal clutch. When the accelerator lever is moved, it starts transmitting the power through transmission shaft to gear box of tiller. In tiller gear box there is worm and worm gear assembly, which is attached to the transmission shaft comes from the engine. This power is further transmitted to the bevel gear assembly on which cutter blades are attached this blades are used to cut the grass and crops. For cutting grass and crops the bevel gear ratio is 15:20. The rotational speed of cutter blade is adjusted by accelerator lever which provided on the handle of the machine. The speed of the cutter blade is maximum, up to 8000 rpm. But while working of cutter one has to attach wheels in place of tiller blades, which helps the machine to move forward. In this way cutter rotates and the working of grass cutter take place. Figure 5 shows the working of grass cutter.

For shifting the grass cutter to tiller one has to remove some parts of the machine. First remove the cutter assembly by removing only two to three nut bolts. Then remove wheels which are attached to the gear box assembly of rotary tiller by cotter pin and attach the tiller blades in place of wheels by inserting the cotter pin. Now the tiller is use for its working.

Now consider the working of tiller. As engine start, it will run at idle speed. This power is transmitted with the help of a centrifugal clutch. When the accelerator lever is moved it start transmitting the power through transmission shaft to the gear box of tiller. The power which is come from engine is transmitted to the tiller blades through worm and worm gear assembly with a gear ratio of 1:35. By reducing gear ratio the speed of engine is converted into high torque which is required for tilling. By rotation of worm gear, the shaft of worm wheel also rotates which rotates the tiller blades. The high torque helps in digging the soil to some depth with the tiller blades. Similarly the rotational speed of tiller blade is adjusted by accelerator lever which provided on the handle of the machine. The speed of tiller is maximum up to 300 rpm. This is the working of weed uprooting machine with grass cutter.

Figure 5: Working of gear assembly

IV. CONCLUSIONS

After successful trial of the machine some of the conclusions are as follows:

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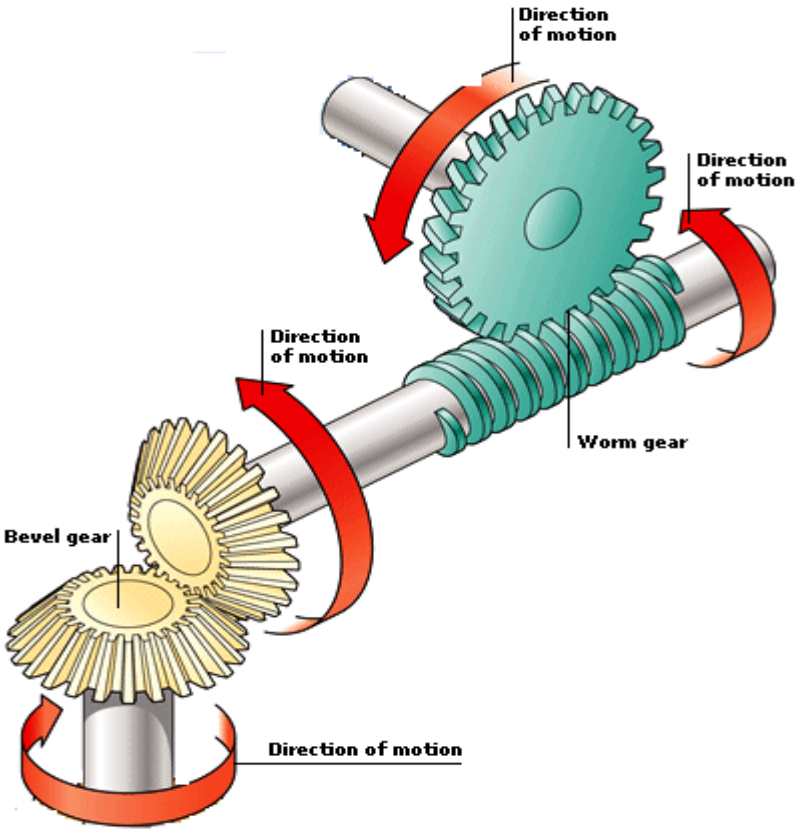

- This will help to bring down the cost of labor tremendously as while operating machine one or two workers are required whereas in traditional method quantity of workers are huge depending upon the size of the field (generally 50 workers).
- It saves time considerably as compared to when done by employing animals or labors which will take huge time and are bound to tire out after some time and need rest.
- The depth obtained in tilling is sufficient. However, more depth can be achieved by replacing tilling blades with the bigger blades and by upgrading the engine by increasing its power.
- Design parameters used are taken with respect to the normal conditions. However, Selection of the design parameters of the rotary tiller depends on many parameters such as kind of machine usage, Type of soil, Structure of soil, Quantity of weed, Cultivable or uncultivable of field, Kind of tillage, Available engine power and several other factors.

V. FUTURE SCOPE

1) By replacing the 2 stoke engine with 4 stroke engine to increase the efficiency and reduce NOx emission.
2) Alternative fuel such as LPG, CNG, Bio-Fuel can also be used as working fuel for engine.
3) Horizontal motion (left and right) can be given to the cutter by cam and follower arrangement.
4) Special arrangement can be design so that the cutter and tiller can be work at a time.

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