DESIGN OF POWER WEEDER FOR LOW LAND PADDY CULTIVATION

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***ABSTRACT* —** Lack of man power has been identified as one of the major problems for the sustainability of the Sri Lankan paddy industry. Hence transplanters and seeders were well developed as a step for mechanization. However, weeding method is still not well developed up to mechanization. Therefore, our main objective is to design and fabrication of a power weeder. Weeding ability will be optimized by weeding three rows simultaneously. The machine is designed to use in the fields, cultivated by using mechanized seeder or mechanized transplanter introduced by Farm Machinery Research Centre (FMRC), Sri Lanka.
The double-action weeding drums will be driven by a small 1.3 kW gasoline engine, that can enable removal of weeds, while facilitating the forward motion of the machine. In addition, the conical shaped weeding drums will be designed to loose-up soil without harming the paddy. Totally six drums will be used, in such a way that rear three drums have high angular velocity with respect to the front drums.
A novel maneuvering method for row changing when the machine is in paddy fields also introduced in the design. More than 5-fold improvement of weeding efficiency in terms of weeding time is expected in this design. Further, a significant improvement of weeding quality is also expected in this design.

Keywords – *Weeds, Paddy cultivation, Manual weeders, Mechanized weeders, Double action-weeding drums*

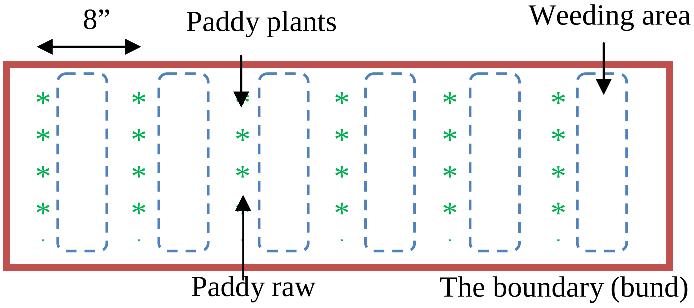
ABBREVIATIONS

Fos – Factor of safety

1. INTRODUCTION

Weeds are a major problem in paddy cultivation. Herbicides are usually used for weed controlling despite the fact that herbicides have many negative effects due to environmental contamination.
It has been understood that mechanized weeding significantly improves weeding efficiency as well as the quality of weeding. However, it may consume non-renewable petroleum for operations.
Cono-weeder, which is mechanized weeding (manual) method, capable of weeding about 0.18 ha/day. However, operational difficulties and slow weeding rate have been identified as major drawbacks of this weeder, particularly in large-scale cultivation.
The specifications of a paddy field, which is cultivated by using a mechanized seeder, are as follows.(ground requirement for power weeder)

- The space between each row of paddy is about 8 inches.
- The spaces between two paddy plants are 2-3 inches.



The machine is to be designed to remove weeds while travelling along the weeding area of the field as shown in Figure 1. Simultaneous removal of weeds in several weeding areas is a key requirement for efficient operation. Further, a mechanism is needed to move the machine between weeding areas without damaging paddy plants. The major mechanical engineering considerations in the design are: Driving mechanism, Weeding mechanism, Turning and row changing mechanism, Power transmission, Floating mechanism.

2. OBJECTIVES AND METHADOLOGY

The main objective is to design and fabrication of a power weeder, while minimum damages done to paddy plants, cost effectiveness, easy manuvelling, low weight, fabricationby using freely available components and easy maintenance are main features of this design. The following methodology was used:

- Development of the concept
  - No or minimum damage to the paddy
  - Easy maneuvering on wet fields
- Dynamic analysis and mechanical design
  - Kinematic analysis
  - Power transmission and drive systems design
  - Design of mechanical components
  - Assembly of components
- Fabrication of components
- Field testing and improvements
- The cost analysis

3. DEVELOPMENT OF THE CONCEPT

3.1. CHAIN DRIVEN SYSTEM

The weeding drums are driven by a chain drive arrangement as shown in Figure 2. Accordingly specially designed double-acting weeding drums are proposed in the design to remove weeds while providing the necessary traction to move the machine forward. Rear group of weeding drums rotate faster than the front weeding drums to provide better shearing.

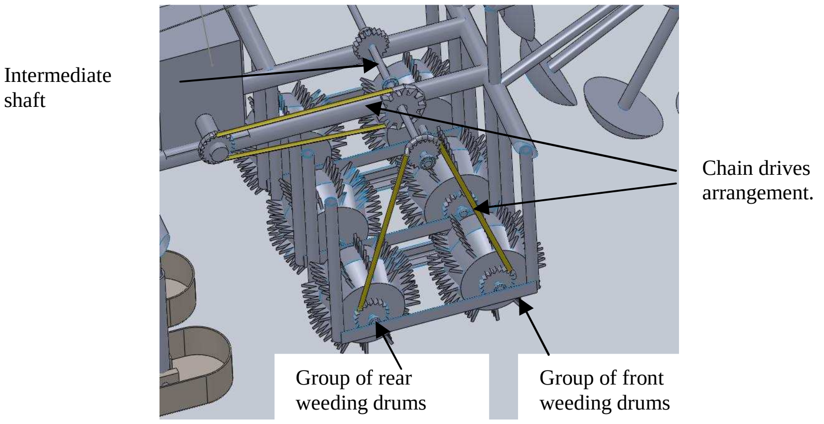


Figure 2: *Arrangement of the weeding drums*

3.2. DEFERENTIAL SPEED OF WEEDING DRUMS

Two weeding drums which rotate at a deferential speed are suggested for each row. As shown in Figure 2, the drums at the rear are set to rotate faster than the drums at the front by using different sprockets. This design would enhance the shearing process due to the miss-match of linear speed of the two drums at the ground level. Further, it helps to push the weeds already removed under the mud to avoid any possible re-growth.

3.3. SHAPE OF THE WEEDING DRUMS

The weeding drums are expected to perform two activities simultaneously: driving the machine forward and weeding. As shown in Figure 3, helical shaped teeth made on conical shaped drums are proposed for the weeding wheel. The conical shape helps to push mud to the roots of the paddy plants as it rotates which enhances the growth of the paddy plants. On the other hand, helical shaped teeth help to provide the shearing effect required for weeding and traction force required for the forward motion.

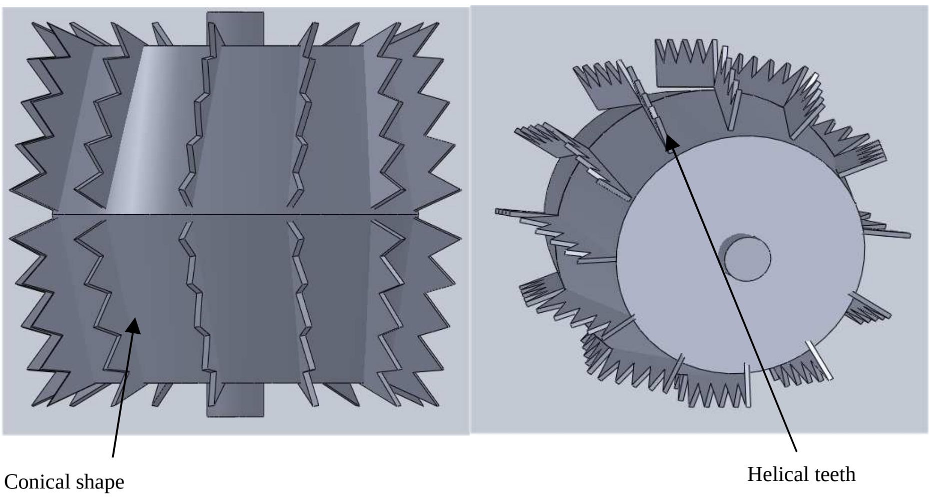


Figure 3: *The weeding draum*

3.4. NUMBER OF ROWS TO BE WEEDED SIMULTANEOUSLY

It has been observed that if an odd number of rows are to be weeded simultaneously the maneuvering is easy as the operator cas easly walk in the middle raw. Therefore, it is decided to design the machine to weed three paddy rows simultaneously at a single operation. This is schematically shown in Figure 4.

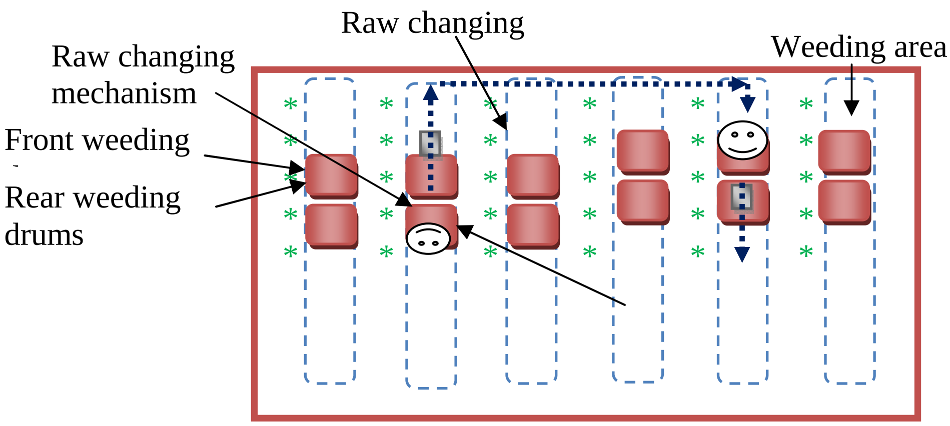


Figure 4. *Top view of the Operational behavior in the field.*

3.5. TURNING AND ROW CHANGING MECHANISM OF THE MACHINE

In order to ensure continuous weeding, it is necessary to change the machine from one set of rows to another set without damaging the paddy plants. Thus an effective mechanism inspired by the human leg movement is invented. The initial configuration is shown in Figure 5.

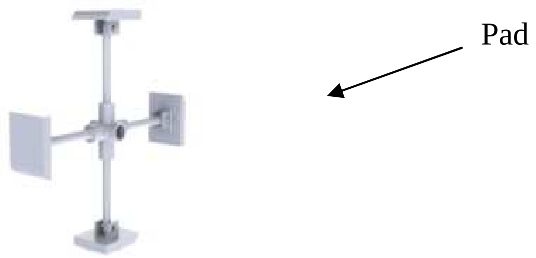


Figure 5: *Initial turning and raw changing mechanism*

Figure 6: *Developed mechanism*

The initial design consists of four floater pads as shown in Figure 5. Each pad is pin jointed to a steel rod which is connected to the central hub using a bearing so that the rod is free to turn about its own axis. As a result each pad is free to rotate about two mutually perpendicular directions. This turning mechanism is fixed at the front of the machine.

The mechanism is fabricated and tested in paddy fields under different ground conditions. An acceptable operating characteristics were observed. However, several issues with regards to the durability and maintenance have been recognized as bearings and pin joints can easily get damaged in muddy conditions. Therefore, as shown in Figure 6, hemispherical floating pads rigidly connected to the central hub using steel rods are proposed in the final design.

3.6. FLOATING MECHANISM

The floating mechanism is another important part of the machine, as it helps the machine to float in muddy conditions without sinking. The floaters reduce the ground reaction due to buoyancy effect. In the present study three adjustable mechanical floaters are considered to control the depth of shearing as required in different ground conditions.

The height adjustment has been achieved by using a simple arrangement with the aid of a screw as shown in Figure 7.

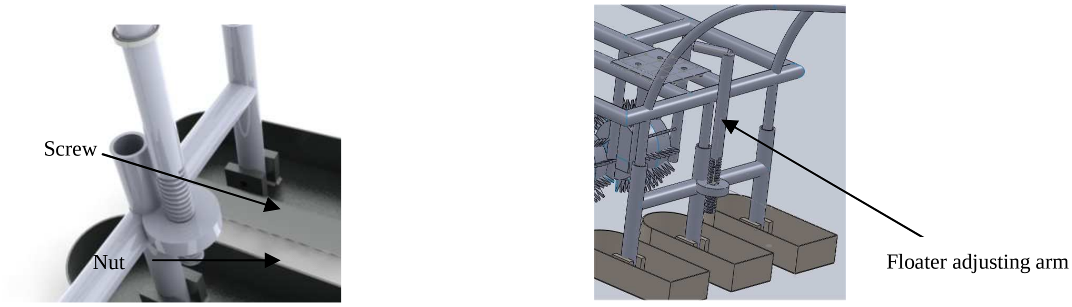


Figure 7: *The floating mechanism*

4. THEORY AND CALCULATIONS

4.1. POWER REQUIREMENT OF THE ENGINE.[3]

Maximum Shearing area for one blade = $4x10^{-3}$ m^2

(Assuming three blades are shear the soil at same time)

Effective shearing area for one weeding drum = $12*10^{-3}$ m^2

(Assume only three blades are done the effective shearing)

Shear stress of the soil (APPENDIX 2) = $5*10^3$ Nm^{-2}

Effective force on the weeding drum (area*shear stress) = 120 N. (FOS = 2)

The average speed of the drum (design value) =1.3 ms^{-1}(14.1rad /s)

Average radius of the weeding drum =$8*10^{-2}$ m

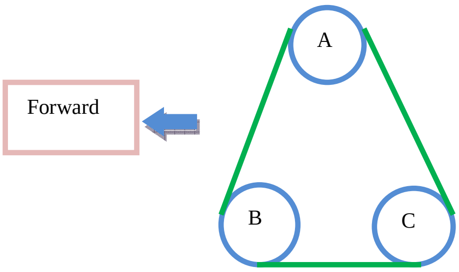
Average power requirement for one weeding drum (torque *speed) =$120*8*10^{-2}*14.1$

=135 W

Total power requirement for all weeding drums =810 W(135*6)

4.1.1. SPEED REDUCTION

The comfortable working speed in the paddy fields = 2.5 km/h(0.7 ms^{-1}) .[4]
The detailed schematic diagram is shown in Figure 4.



A– Driving wheel which connect to the intermediate shaft
B & C–Driven wheels which connect to the weeding drums

The speed of engine shaft / speed of intermediate shaft = 270 / 135
= 2 / 1

5. RESULTS.

Table 2: *The engine selection*

Total power requirement/kW	safety factor	The estimated power/kW
0.81	1.5	1.2

Table 3: *Design of chain drives*

Rated power/kW	safety factor	Design power/kW
1.3	1.5	1.95

Table 4: *Speeds of each drum*

Speed of intermediate drum,N_A / rev/min	Speed of front drum,N_b/ rev/min	Speed of rear drum,N_c/ rev/min
135	121rev/min	148 rev/min

Note : $N_b < N_c$

APPENDIX 1

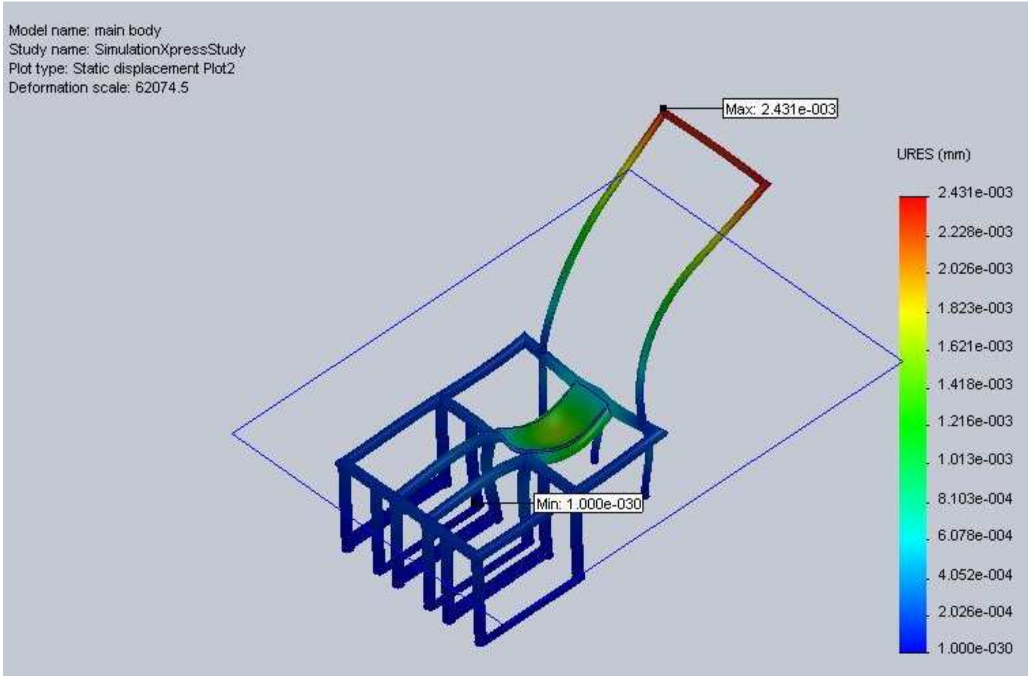


Figure 8: *Static deflection of the main body frame*

Hence main body frame was not statically deflected as the test shown in above figure 8. The test was done by using solid works.

Figure 9: *Static nodal stress of the main body frame*

Hence there was no excessive static nodal stresses developed in the main body as the test shown in above figure 9. The test was done by using solidworks

APPENDIX 2

VANE SHEAR TESTER

Vane shear test was done to investigate the shear stresses of the soil of paddy fields.

Figure 10: *Vane shear testing*

RESULTS

Shear stress near bund	= 15 MPa
Shear in the middle of the paddy field	= 5 MPa
Average shear stress	= 10 MPa

DISCUSSIONS

- The novel raw changing mechanism would be helpful for operating the machine by single person without destroying paddies.
- According to Figure 8 and 9 the structure would safe for static loads.

5. CONCLUSION

- Cost effective method for weed controlling
- Attracting the young generation for paddy industry because of mechanization.
- Well improved, unique raw changing mechanism would increase the effectiveness of the power weeder.
- A novel double action weeding drum is introduced in this design to facilitate the effective weeding while providing the necessary traction for the forward motion of the machine.
- Helical shaped teeth is formed in the weeding drums to enhance the shearing effect for weeding while loosing up the soil.
- The weeding drum is formed into conical shape to push the mud towards the paddy plants to ensure the proper growth.
- Two drums operate at differential speed is used to further improve the shearing process.
- Three sets of such drums were fixed in parallel to remove weeds in three paddy rows simultaneously

REFERENCES

1. A Tajudding/ R Karunanithi/ K R Swaminathan./ Design, development and testing of and engine operated blade harrow for weeding/ Indian journal of agricultural engineering, vol 1, no 2, 1991
2. A Tajuddin./ Mechanising Indian Agriculture. /Kisan World, vol 31, no 6, 2004
3. R.S. khurmi/ J.K. gupta/ A Textbook of Machine Design/ Multicolor Edition
4. www.sri agricultural machineries.com

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