

Design and Fabrication of Tractor Mounted Grass Cutting Flail Mower

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Abstract—Agriculture and horticulture are the backbone of Maharashtra, supporting millions of farmers across vast stretches of farmland. Yet these farmers face the challenge of weed infestation — especially during monsoon. Existing solutions either come at a heavy price tag or simply are not built for vast lands. This paper presents the design and fabrication of a tractor mounted grass cutting flail mower to overcome this problem. Rather than building a flail mower from scratch, our approach is to modify an existing unused rotavator by integrating a vertically mounted gearbox that allows the power from the tractor's power take-off (PTO) shaft to reach the cutting assembly, eliminating the chain-driven mechanism and other excessive parts, resulting in a simpler and more efficient design. This demonstrates that a cost-effective, high-performance flail mower can be achieved through modification of an unused, readily available rotavator — offering farmers a better and practical solution without the burden of industrial pricing.

Keywords—Rotavator; flail mower; direct power transmission; power take-off shaft

I. INTRODUCTION

According to the Directorate of Economics and Statistics, horticulture and agriculture are absolutely vital to India today, acting as the foundation of the rural economy. Maharashtra is the second largest fruit-producing state in India and one of the top states in crop cultivation, with 50% of its population dependent on agriculture and horticulture. To cultivate agricultural products, it is essential to maintain the soil and land. Cutting overgrown grass is critical because it significantly reduces productivity and affects product quality and soil fertility. During monsoon, weed infestation — unwanted grass, plants, and shrubs — is a common problem for vast lands and farms, requiring a great deal of time and labor to control. For vast lands of about 50 to 100 acres where farmers grow a variety of agricultural products, traditional grass cutting machines are impractical due to their excessive consumption of time, labor, and money [1][2].

II. LITERATURE REVIEW

A. Sridhar, N. and Surendra Kumar, A. et al.

Their study aimed to determine how forward speed and blade type affect shredding efficiency and field efficiency for better crop residue management. They conducted field experiments using different shredders, testing straight and flail blades at speeds of 2, 3, and 5 km/h to evaluate performance and operational cost. A large portion of crop residues are burnt in farming fields due to non-availability of labor and the high cost of residue removal. Their findings helped identify the best solution through field tests on a flail mower with both straight blades and flail blades [3].

B. Aditya S. Rajamani et al.

In this paper the authors prepared a solar powered grass cutter to reduce fuel cost and emissions by utilizing solar energy as an alternative power source for mowing. They designed and developed a solar-powered lawn mower using a DC motor, battery, solar panel, and stainless-steel blade to perform grass cutting. The hybrid operational grass cutter was developed for use in residences and establishments with lawns where tractor-

driven mowers could not be used. The device combines the mower and trimmer in a single setup to reduce operational costs and effort [4].

C. Ashwini Kumar, Assistant Professor et al.

This research paper provides a full overview of approaches, components, design, and modifications in grass cutting machines. The study concluded that modern machines are more efficient than older machines due to the use of solar panels and better blade materials, and they also require less manpower. The importance of automation has risen dramatically in recent years, and numerous machines are employed in the agricultural sector for various functions [5].

III. RESEARCH GAP

Researchers have attempted to create a solar powered grass cutting machine with two horizontal rotating blades, successfully achieving their goal of a solar powered grass cutter. However, this machine is slow and functions as a lawn mower, which is unsuitable for vast lands such as farms.

Another researcher addressed this limitation by comparing an industrially manufactured grass cutting flail mower against a modified flail mower with a vertical rotating axis and four straight blades. This research demonstrated that a flail mower with a vertical rotary axis achieves comparable performance at a significantly lower cost than industrially manufactured units. These findings directly informed the present work.

IV. SCOPE OF RESEARCH

This research is mainly focused on structural design, cutting mechanism, and fabrication of a tractor mounted grass cutting flail mower system using a rotavator. It employs a vertically mounted multi-speed gearbox for direct power transmission from tractor to cutting assembly using the in-built components of the rotavator. The research investigates the practical implications of this modified flail mower in real-world use, and further examines overall system stability, load and stress analysis on the system and cutting blades, in-field testing of the prototype, and cutting efficiency of the system. The study also

analyses usable in-built parts of the flail mower and eliminates the belt and chain drive mechanism.

V. PROBLEM STATEMENT

In India, agriculture and horticulture are heavily impacted by seasonal weed infestation, particularly during the monsoon period, which significantly reduces soil fertility and crop quality. Existing solutions such as handheld grass cutters are time-consuming, fuel-intensive, and labor-intensive — especially for vast lands ranging from 50 to 100 acres — while industrially manufactured grass cutters are too expensive for small and medium farmers.

This study addresses the problem by designing and fabricating a tractor mounted flail mower by modifying a rotavator and integrating a vertically mounted gear transmission for direct power transmission. The resulting machine aims to achieve fuel efficiency, adaptive terrain optimization, and reduced cutting time, at a significantly lower price compared to industrially manufactured grass cutters.

VI. OBJECTIVES

A. Adaptive Terrain-Based Cutting Optimization

To create a machine capable of adjusting cutting speed and depth based on terrain conditions and soil composition, enabling optimal performance across uneven terrain.

B. High-Efficiency Time Reduction in Grass Cutting

To reduce grass cutting time by 40–50% compared to traditional grass cutting machines, while maintaining consistent performance, increasing productivity, and creating an affordable solution for farmers.

VII. WORKING PRINCIPLE

The proposed flail mower eliminates the conventional belt and chain drive system and operates on a direct power transmission mechanism. This mechanism transmits the tractor's mechanical energy through the power take-off (PTO) shaft directly to the cutting assembly, significantly increasing system efficiency, reducing mechanical power losses, and minimizing vibration and structural complexity.

The rotational motion is redirected to a vertical axis perpendicular to the PTO shaft and transmitted downward directly to the cutting assembly at the bottom of the mower structure. Three metal blades are mounted symmetrically to the cutting assembly, attached 120° apart from each other to avoid vibrations and maintain dynamic balance. The rigid frame supports the gearbox, and two angle rods are attached to the main shaft casing to avoid wobbling of the cutting assembly. As the cutting assembly rotates, centrifugal force causes the blades to extend outward, enabling them to cut through grass and vegetation through high-speed impact and shearing action.



Fig. 1. Diagram of grass cutting flail mower (left) and block diagram of the proposed model (right).

A. Power Take-Off (PTO) Shaft

The main role of the PTO shaft is to transfer rotational motion from the tractor to the gear transmission of the grass cutter. The PTO shaft has internal splined sleeves connected to a U-joint on both ends, which mesh with the shaft from the tractor and the flail mower. The middle part of the shaft is divided into two parts — one with internal splined sleeves and one with external splined sleeves — which interconnect to prevent internal rotation of the shaft.

B. Wet-Sump Single-Speed Gearbox

The gear transmission redirects horizontal rotational motion from the PTO shaft to vertical rotational motion at the cutting assembly. It consists of two speed-reduction straight bevel gears forming a simple gear train inside the casing, converting speed into torque. It includes a gearbox housing that also acts as an oil reservoir, straight bevel gears, an input shaft, an output shaft, bearings, and oil seals.

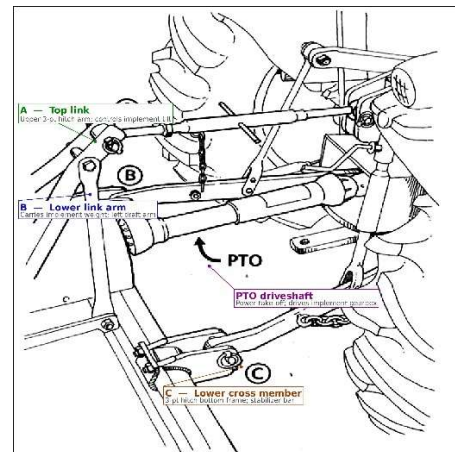


Fig. 2. Rotavator body with three-point linkage attachment.

C. Rotavator Body and Attachment

The rotavator body serves as the base for the flail mower, supporting the structure. The three-point linkage attachment connects using a (A) top-link assembly to support hydraulic lifting. It also has (C) two brackets at the front to attach the adjustable hydraulic arms. All components are mounted on the body of the rotavator. The top link is supported by (B) lower link arms for additional support.

D. Cutting Assembly and Blades

The cutting assembly consists of a main shaft, three mild steel blades, and a blade hub. The blades are attached 120° apart. The assembly is the primary cutting mechanism driven directly by the gearbox output shaft. Three mild steel blades are tempered and mounted at equal angular intervals to ensure dynamic balance during high-speed rotation.

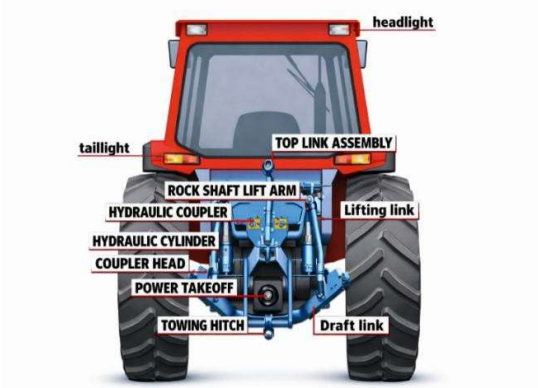


Fig. 3. Four essential components of the grass cutting flail mower.



Fig. 4. Fabricated prototype of the tractor mounted flail mower.

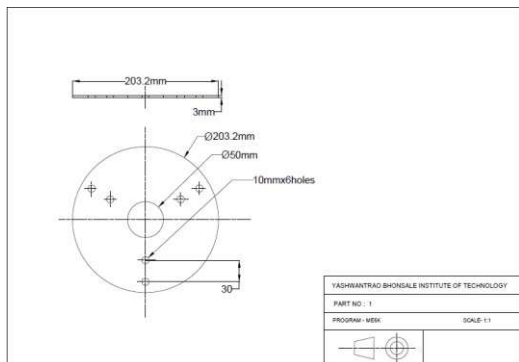


Fig. 5. Cutting assembly with blades mounted at 120° intervals.

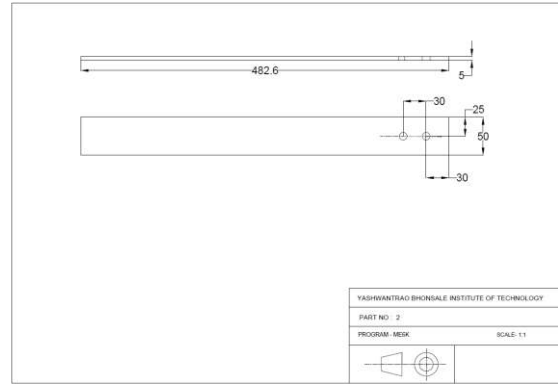


Fig. 6. Labeled engineering diagram of the complete assembly.



Fig. 7. Gearbox assembly detail.

VIII. DESIGN CALCULATIONS

A. RPM of Gear [6]

The gear speed ratio formula is:

$$N_1 / N_2 = T_2 / T_1 \quad (1)$$

where $N_1 = 1000$ rpm (PTO input speed), $T_1 = 14$ (driver gear teeth), $T_2 = 22$ (driven gear teeth). Substituting:

$$N_2 = (1000 \times 14) / 22 = 636.36 \text{ rpm} \quad (2)$$

The RPM of Gear 2 equals the RPM of the blades. For comparison, using the same formula with the chain-driven system ($T_3 = 11$):

$$N_3 = (636.36 \times 11) / 14 \approx 500 \text{ rpm} \quad (3)$$

B. Angular Velocity [6]

The angular velocity of the cutting assembly is given by:

$$\omega = (2\pi N) / 60 \quad (4)$$

Substituting $N = 636.36$ rpm:

$$\omega = (2 \times \pi \times 636.36) / 60 = 66.63 \text{ rad/sec} \quad (5)$$

C. Torque [7]

Available power at the PTO shaft $P = 16.4$ kW = 16400 W. Torque is given by:

$$\tau = P / \omega \quad (6)$$

$$\tau = 16400 / 66.63 = 246.13 \text{ N}\cdot\text{m} \quad (7)$$

D. Bending Moment of Blade [8]

The length of blade is 482.60 mm. Considering a resistance force applied by the grass $F = 80\text{--}100 \text{ N}$ [12], the bending moment is:

$$M = F \times L = 100 \times 482.60 = 48260 \text{ N}\cdot\text{mm} \quad (8)$$

E. Bending Stress of Blade [8]

Blade dimensions: width $b = 50 \text{ mm}$, thickness $t = 5 \text{ mm}$. The section modulus Z is:

$$Z = (b \times d^2) / 6 = (50 \times 5^2) / 6 = 208.33 \text{ mm}^3 \quad (9)$$

Bending stress is then:

$$\sigma_b = M / Z = 48260 / 208.33 = 231.65 \text{ N/mm}^2 \quad (10)$$

F. Factor of Safety [8]

Considering yield strength of mild steel with high-temperature tempering = 300 N/mm^2 [9]:

$$F.O.S = \text{Yield Strength} / \sigma_b = 300 / 231.65 = 1.29 \quad (11)$$

G. Blade Cutting Speed

Time recorded during testing within a distance of 1 m: $T_1 = 2.66 \text{ sec}$, $T_2 = 2.94 \text{ sec}$, $T_3 = 2.74 \text{ sec}$. Using the formula $V = \text{distance} / \text{time}$:

$$V_1 = 1 / 2.66 = 0.375 \text{ m/sec} \quad (12)$$

$$V_2 = 1 / 2.94 = 0.339 \text{ m/sec} \quad (13)$$

$$V_3 = 1 / 2.74 = 0.364 \text{ m/sec} \quad (14)$$

H. Cutting Area Analysis

Cutting radius $r = 21 \text{ inches} = 53.3 \text{ cm}$. Cutting diameter $D = 106.6 \text{ cm}$.

$$\text{Cutting Area (a)} = \pi r^2 = \pi \times (53.3)^2 = 8924.91 \text{ cm}^2 \approx 0.8925 \text{ m}^2 \quad (15)$$

I. Time to Clean 1 m² by Flail Mower [10]

The machine tilts approximately $10^\circ\text{--}5^\circ$ when lifted by the tractor hydraulic system. Average velocity:

$$V_{\text{avg}} = (V_1 + V_2 + V_3) / 3 = (0.375 + 0.339 + 0.364) / 3 = 0.359 \text{ m/sec} \quad (16)$$

Width of blade = $5 \text{ cm} = 0.05 \text{ m}$. Number of passes required:

$$N_p = 1 / 0.05 = 20 \text{ passes} \quad (17)$$

Time required per pass:

$$T_p = 1 / 0.359 = 2.78 \text{ sec} \quad (18)$$

Total time for 20 passes = $20 \times 2.78 = 55.6 \text{ sec} = 0.9266 \text{ min}$.

J. Efficiency Ratio [10]

A traditional handheld grass cutting machine takes 20 minutes to clean 1 m^2 [11]. The efficiency ratio is:

$$Er = 20 / 0.9266 = 21.58 \approx 22 \quad (19)$$

The flail mower is therefore 22 times faster than the handheld machine.

IX. RESULTS

The tractor mounted flail mower was successfully designed and fabricated by modifying a rotavator, ensuring safety with a factor of safety of 1.29 for the blades, and carefully constructing the machine to operate and handle rough terrains and thick bushes. The elimination of the belt and chain driven system increased the system RPM by 20%, achieving a cutting area of 0.8925 m^2 . The flail mower requires 20 passes to cover 1 m^2 of land in 0.9266 minutes — which is 22 times faster than the handheld machine.

TABLE I. Summary of Design Calculations

Sr.No.	Parameters	Values	Units
1	Power take-off input speed	1000	RPM
2	Gear ratio	1.5714	—
3	Cutting assembly speed	636.36	RPM
4	Angular velocity of cutting assembly	66.63	Rad/sec
5	Available power at PTO shaft	16400	W
6	Torque at cutting assembly	246.13	N-m
7	Bending moment on blade	48260	N-mm
8	Maximum bending stress on blade	231.65	N/mm ²
9	Factor of Safety	1.29	—
10	Time required by handheld grass cutter	20	min
11	Time required by flail mower	0.9266	min

TABLE II. Field Testing Observation

Sample Plot	Time (sec)	Distance (m)	Cutting Speed (m/sec)	Grass Height After Mowing (mm)
1	2.66	1	0.375	72
2	2.94	1	0.339	67
3	2.74	1	0.364	81
Avg.	2.78	—	0.359	—

Observation during field testing: While testing the flail mower it was observed that rough and uneven terrains affect the cutting of grass, resulting in uneven cuts. Also, when the flail mower is lifted using the hydraulic system there is an inclination of approximately 30° , increasing the depth of cut.

X. CONCLUSION

The research successfully demonstrates the design and fabrication of a cost-effective and fuel-efficient tractor mounted grass cutting flail mower by modifying an existing rotavator. The proposed model eliminates the chain mechanism, resulting in a simpler, more efficient, and more maintainable system while increasing the RPM by 22%. By calculating and comparing the time required to cut an area of 1 m² by both machines, it is clearly indicated that the mower is 22 times faster than handheld grass cutting machines. Hence, the machine can save a significant amount of time, fuel, and labour. Overall, this work validates the concept of an affordable, high-performance grass cutting flail mower achieved through modification of an existing rotavator — rather than relying on industrial machinery or handheld grass cutters.

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REFERENCES

- [1] Economic Survey of Maharashtra 2025-26, Available: <https://treelife.in/wp-content/uploads/2025/03/Maharashtra-Economic-Survey-2024-25-Key-Highlights.pdf>
- [2] Maharashtra Economic Survey 2024-25, Available: https://agriwelfare.gov.in/Documents/AR_Eng_2024_25.pdf
- [3] N. Sridhar and A. Surendra Kumar, "Performance evaluation of rotary and flail shredders," *Internet J. Agric. Engg.*, vol. 11, no. 1, pp. 23-29, 2018. DOI: 10.15740/HAS/IJAE/11.1/23-29.
- [4] A. S. Rajmani, A. N. Gaonkar, A. Darak, A. Joshi, and V. M. Murgod, "Design and Fabrication of Hybrid Operating Grass Cutter," *International Journal of Engineering Research and Technology (IJERT)*.
- [5] P. K. Dhadve, "Design and Development of Cutting Mechanism of Flail Mower," B.Tech. (Agril.Engg.), Available: <https://krishikosh.egranth.ac.in>
- [6] A. Kumar, "A Review on Grass Cutter," *JETIR*, vol. 5, no. 7, Jul. 2018. (ISSN-2349-5162)
- [7] Theory of Machines, K Scheme (313313), MSBTE e-Content, Available: <https://econtent.msbt.edu.in>
- [8] Applied Mathematics, K Scheme, MSBTE e-Content, Available: <https://econtent.msbt.edu.in>
- [9] Strength of Materials, K Scheme (313308), MSBTE e-Content, Available: <https://econtent.msbt.edu.in>
- [10] Understanding IS 2062:2011 E350A — Hot Rolled Structural Steel, JSW One MSME, Available: <https://www.jswonemsme.com>
- [11] A. K. Srivastava et al., "Engineering Principles of Agricultural Machines," 2nd ed., ASABE Publications, St. Joseph, Michigan, 2006.
- [12] G. A. Ibe, "Design of a Hand-held Grass Mower," *International Journal of Engineering Research*, vol. 6, no. 3, pp. 116-119, Mar. 2017.
- [13] X. Zi, "Dynamics of shearing force and its correlations with chemical compositions and in vitro dry matter digestibility of stylo stem," *Asian-Australas. J. Anim. Sci.*, vol. 30, no. 12, pp. 1718-1723, Jun. 2017. DOI: 10.5713/ajas.17.0077.