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Design and Fabrication of Portable Tilling Machine

Sarthak Verma[1], Yugesh jadhav[2], Pranav Rangbhal[3]

[1,2,3]Department of Mechanical Engineering, Bharati Vidyapeeth (Deemed to be University) College of Engineering, Pune, India.

[1]*sarthakvrm83@gmail.com*, [2]*yugeshjadhav108@gmail.com*, [3]*pranavrangbhal263@gmail.com*

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Abstract

Agriculture remains a crucial sector in developing economies, where efficient soil preparation significantly affects crop yield and farmer productivity. Traditional manual tillage is labor-intensive, while conventional engine-powered tillers are costly and unsuitable for small farms. This project presents the design and fabrication of a portable, battery-powered electric tilling machine aimed at providing an affordable, lightweight, and eco-friendly alternative. The system replaces internal combustion engines with a rechargeable DC motor and battery setup, offering reduced noise, zero emissions, and lower operating costs. The compact design allows easy maneuverability in small fields, gardens, and hilly terrains. Performance calculations, cost analysis, and working principles are presented to validate the feasibility of the machine. The proposed system improves tillage efficiency while reducing human drudgery and operational expenses.

Keywords: Portable Tiller; Electric Tilling Machine; Agricultural Mechanization; Battery-Operated Farm Equipment; Sustainable Agriculture; Electric Farm Machinery.

How to Cite This Article

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Introduction

Agriculture is the backbone of the economy in many developing nations, and the efficiency of field operations directly impacts overall crop yield and farmer prosperity. Among the most critical and strenuous farm operations is tillage, the mechanical manipulation of soil to prepare the seedbed. Traditionally, this has been performed manually using simple hand tools, which is time-consuming, labor-intensive, and physically demanding.

While large-scale tractors and power tillers exist, their high capital cost, significant weight, and reliance on fossil fuels make them unsuitable for small-scale farms and home gardens. This project, titled *Design and Fabrication of Portable Tilling Machine*, aims to develop a lightweight, electric-powered tiller that is affordable, efficient, and user-friendly. By using a rechargeable battery and DC motor system, the machine offers a cleaner and quieter alternative to conventional fuel-based tillers.

Literature Review

Several researchers have contributed to the development of portable and electric tilling systems. Studies from 2020–2025 highlight advancements in battery-operated cultivators, solar-powered tillers, and smart precision tillage systems. Research shows improvements in ergonomics, soil penetration efficiency, cost reduction, and environmental sustainability.

Recent developments include hybrid solar-electric tillers, IoT-enabled smart tillers with depth control, and lightweight composite material designs to reduce operator fatigue. These studies collectively emphasize the shift from fuel-based to electric and renewable-powered agricultural equipment for smallholder farming.

Research Gap

The primary research gap lies in achieving an optimal balance between portability, low cost, durability, and effective performance across varying soil types. Many designs focus either on affordability or performance, but not both simultaneously. Additionally, limited field testing under diverse soil conditions restricts the practical applicability of many prototypes.

Problem Statement

To design and fabricate a portable, battery-operated tilling machine that reduces manual labor, operates efficiently on small farms, and offers a cost-effective and eco-friendly alternative to conventional tillers.

Objectives

- To design the basic layout of the portable tilling machine
- To create a 3D model using design software (Fusion 360)
- To calculate torque, power efficiency, and tilling time
- To fabricate the designed prototype
- To test the machine under real field conditions

Design

The portable tilling machine was designed using Fusion 360 CAD software. The design process included structural layout development, motor placement, transmission alignment, and final assembly modeling. The following figures show the design evolution from technical views to realistic field rendering.

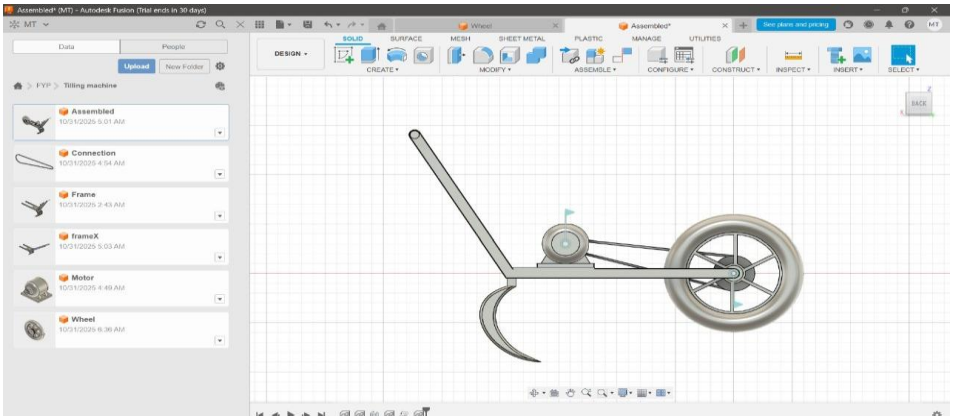

Fig. 1. *Side view of the portable tilling machine showing frame structure, motor position, wheel alignment, and tilling blade placement.*

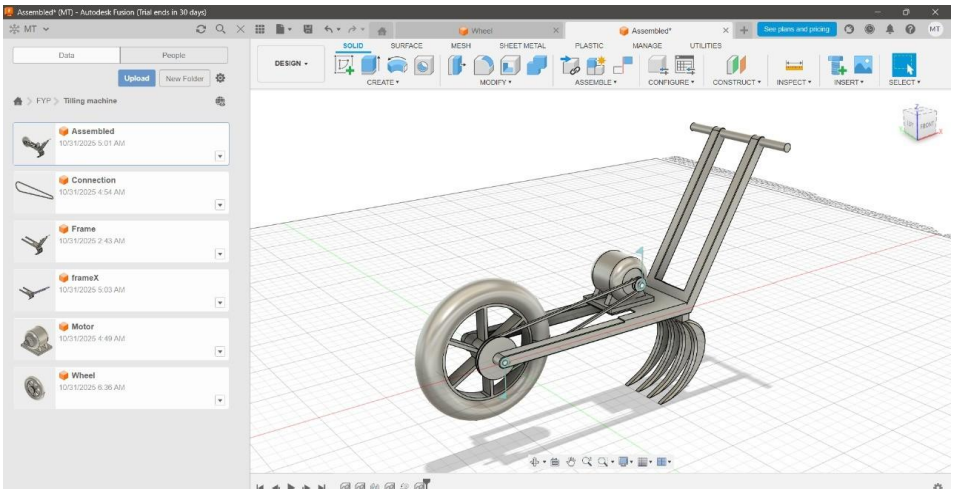

Fig. 2. *Isometric CAD model showing the complete assembly of the portable tilling machine.*

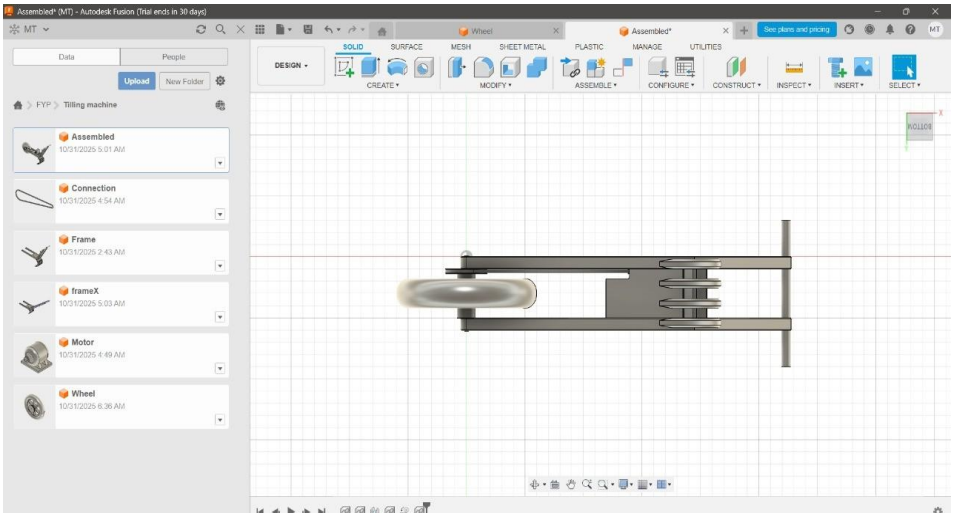

Fig. 3. *Top view of the machine illustrating component alignment and blade spacing.*

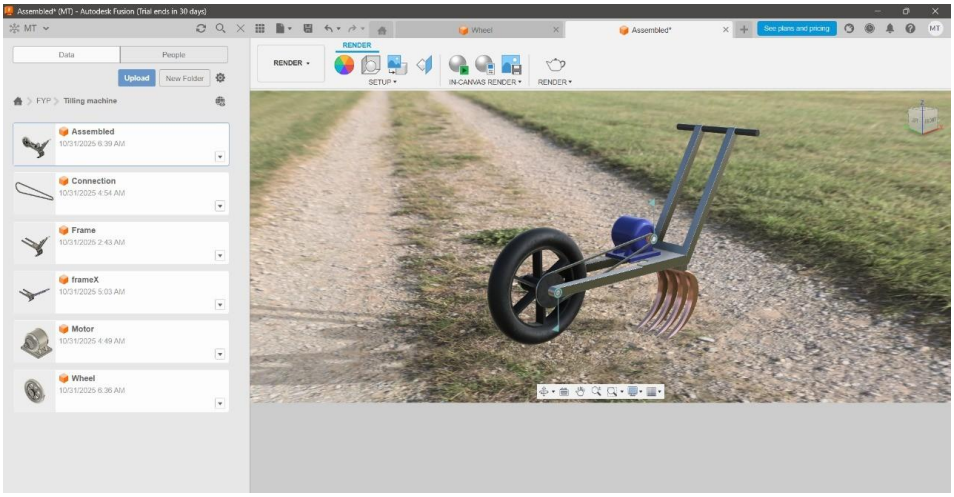

Fig. 4. *Rendered model of the portable tilling machine in a field environment showing practical deployment.*

Working Principle

The portable tilling machine works by converting electrical energy from the battery into mechanical energy through a DC motor.

- Power System: A rechargeable battery supplies DC power to the motor, enabling quiet and emission-free operation.
- Transmission System: A chain and sprocket mechanism reduces speed and increases torque to drive the rotor effectively.
- Tillage System: Rotating cultivator blades penetrate and loosen the soil, while the traction wheel helps move the machine forward.

Calculations

Draft Force

$$F_d = S_d \times W = 4000 \times 0.30 = 1200 \text{ N}$$

Power Required

$$P_s = F_d \times V = 1200 \times 0.30 = 360 \text{ W}$$

Including design factor:

$$P_{req} = \frac{360}{0.60} = 600 \text{ W}$$

Motor Torque

$$\omega = \frac{2\pi N_m}{60} = 376.99 \text{ rad/s}$$

$$T_m = \frac{746}{376.99} = 1.98 \text{ N} \cdot \text{m}$$

Gear Reduction Ratio

$$i = \frac{3600}{200} = 18{:}1$$

Rotor Torque

$$T_r = 1.98 \times 18 \times 0.8 = 28.5 \text{ N} \cdot \text{m}$$

Battery Requirement

Two 12V, 12Ah batteries connected in series provide 24V supply.
Total energy:

$$E = 24 \times 12 = 288 \text{ Wh}$$

Runtime at 877 W load:

$$\text{Runtime} = \frac{288}{877} \approx 0.43 \text{ hours}$$

Charging cost at Rs. 4/kWh:

$$0.36 \times 4 = 1.44 \text{ Rs}$$

Cost Estimation

- Power System: Rs. 3,200 – 4,400
- Motor Drive: Rs. 4,600 – 6,900
- Tillage Unit: Rs. 1,100 – 2,000
- Structure: Rs. 1,400 – 2,600
- Miscellaneous: Rs. 600 – 1,100

Total Estimated Cost: Rs. 10,000 – 13,000

Conclusion

The portable electric tiller is well suited for small farms, gardens, and hilly terrains. It reduces labor, lowers operational cost, and eliminates fuel dependency. The lightweight structure allows use in both wet and dry soil conditions. With proper attachments, it can perform multiple agricultural operations.

Future Scope

Future improvements include:

- Solar or hybrid power integration

- IoT-based monitoring
- Adjustable working width
- Interchangeable attachments
- AI-based soil sensing and automatic depth control

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