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A Review on Portable Electric Power Tiller Machine

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Abstract: *The Portable Electric Power Tiller Machine is designed to assist small-scale farmers with soil preparation, providing an eco-friendly and efficient alternative to conventional fuel-powered tillers. This research explores the design, development, and performance evaluation of the machine, focusing on its lightweight construction, electric motor efficiency, and ease of operation. The machine is powered by a high-torque electric motor, optimized through gear ratio adjustments to enhance power transmission and reduce energy consumption. The tiller's blade configuration is carefully designed to maximize soil penetration and minimize resistance, improving overall tilling efficiency. Motor selection and gear optimization addressed. Key challenges such as torque limitations and battery runtime. Performance tests demonstrate that the machine achieves consistent tilling depth and coverage, with reduced operational noise and maintenance requirements. Future improvements include the integration of solar charging and automation features to enhance efficiency and sustainability further. This research highlights the potential of electric-powered agricultural machinery in promoting sustainable farming practices.*

Keywords: Eco-friendly, Lightweight Construction Electric Tiller machine, motor, portable

I. INTRODUCTION

Agriculture continues to serve as a crucial pillar of the global economy, especially in developing regions where small-scale farming is widespread. Conventional tillage practices, which often depend on manual tools or fuel-driven equipment, tend to be labor-intensive, expensive, and environmentally harmful. To overcome these limitations, the **Portable Electric Power Tiller Machine** has been developed as a compact, energy-efficient, and economical alternative for soil preparation. Operated by an electric motor, this tiller eliminates reliance on fossil fuels and helps reduce greenhouse gas emissions. Its lightweight and portable design improves handling and maneuverability, making it ideal for small or irregular plots of land. The machine incorporates a high-torque motor combined with a carefully selected gear ratio to ensure efficient power transmission and optimal soil penetration. The blade system is engineered to lower resistance and enhance tilling efficiency, reducing the physical effort required from the user. Compared to traditional tillers, this electric version offers numerous benefits such as reduced operational expenses, quieter functioning, and lower maintenance needs. Additionally, its battery-powered nature opens up possibilities for integration with renewable energy sources like solar panels, thereby promoting eco-friendly farming. This study focuses on the design, fabrication, and performance analysis of the machine, emphasizing its potential to boost agricultural productivity while supporting sustainable practices.

II. LITERATURE SURVEY

Auti Omkar, Thorve Snehal, and Unde Akshay (2021) conducted a study titled *"Design and Fabrication of Power Operated Tiller Machine"*. In their research, they identified weed control as one of the major challenges faced in agricultural fields. The team explored various weed control methods and assessed their impacts on soil health and crop productivity.

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In a related study, **Zakariya et al.** (June 2021), published in the *Journal of Engineering Research and Reports*, worked on enhancing a **portable power tiller** for small-scale weeding applications. Following initial investigations, they determined that the power tiller could be adapted for effective weed management. To boost performance, they made modifications to key components, including weeding and depth control blades. They fabricated three sets of blade gangs, consisting of four, six, and eight blades each, using 3 mm thick mild steel sheets. The fabrication process was carried out at the Department of Agricultural and Bio-Resources Engineering, **Ahmadu Bello University**, Zaria. The improved tiller was tested in a maize field at the Institute for Agricultural Research (IAR), during the 2017/2018 irrigation season. The trials focused on evaluating weeding efficiency, field capacity, crop damage, and fuel usage. The experiment included four types of blades (labeled 'B') and three weeding depth levels (labeled 'D'), and was conducted using a randomized complete block design at a two-week interval.

III. DESIGN AND DEVELOPMENTS

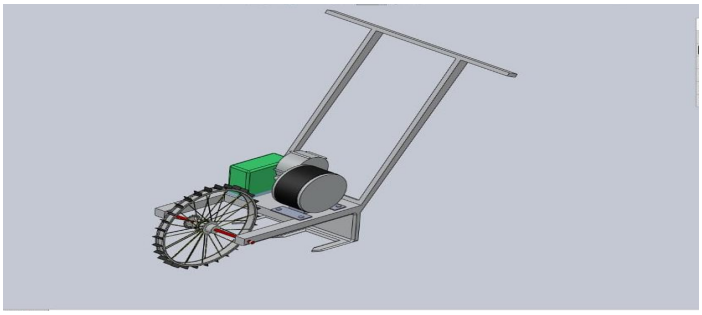

Fig3.1 3D Design

Design Considerations The tiller is designed for small-scale farming and home gardening. The key objectives include:

- Reducing dependence on fossil fuels
- Enhancing ease of operation
- Improving energy efficiency

3D Modeling in Creo Software The entire tiller was modeled using Creo Parametric to visualize and optimize the design. Key components include: The Frame is a lightweight but durable structure to support the motor and tiller blades. An electric motor is a high-efficiency BLDC motor selected for better torque and lower power consumption. Tiller Blades are optimized for soil penetration and efficient tilling. Battery Pack is Rechargeable lithium-ion batteries for extended operation. Transmission System is gear and belt mechanism designed for effective power transfer.

Development and Fabrication

The tiller was fabricated with mild steel and aluminum materials for strength and weight optimization. The gear ratio and blade geometry were fine-tuned to balance power consumption and soil penetration..

• Software Used: Creo Parametric • Model Components: Frame, electric motor, tiller blades, battery pack, transmission system

IV. CONSTRUCTION AND WORKING

CONSTRUCTION

The frame and Chassis is made of mild steel or aluminum for strength and lightweight. The Electric Motor is mounted securely to drive the tiller blades efficiently. The Transmission System is a Gear and belt drive setup to transfer power. Tiller Blades are C-shaped blades attached to a rotating shaft. The lithium-ion battery is used for the power supply. Control System is Speed controller, throttle mechanism, and emergency stop switch 5.2 Working Mechanism This portable electric power tiller machine is operated on battery power. The tiller machine runs on an electric motor using a chain and sprocket mechanism arrangement to drive the bike wheel rim. A lithium-ion battery is used to power the hub motor with a tiller blade through the soil. The tiller blade allows for easy and narrow tilling accurately as needed for farming, and on the left side of the machine is a cutter attachment for crop or grass cutting. While cutting operation, we

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remove the tiller blade and attach the wheel attachment for easy work. The machine is portable due to its simplicity in construction of machine the maintenance is very

Working Mechanism

The **portable electric power tiller machine** is a battery-operated device developed for efficient and eco-friendly soil tilling. It features an electric motor that transmits motion to a modified bike wheel rim through a chain and sprocket arrangement. Power is supplied by a lithium-ion battery, which runs a hub motor that drives the tiller blades, ensuring accurate and narrow tilling ideal for farming tasks. A side-mounted cutter attachment allows for the trimming of crops or grass. For cutting operations, the tiller blade can be easily removed and replaced with a wheel attachment to enhance performance. The tiller's straightforward design improves portability and minimizes the need for complex maintenance. Compared to traditional fuel-powered tillers, it is more economical, making it a viable option for small-scale farmers. The bike wheel rim, reinforced with angle sections, provides strong traction on soil, aiding in stable operation and efficient power delivery. A control switch positioned on the right handle ensures user-friendly operation. The high-torque electric hub motor, energized by the lithium-ion battery, allows the blades to cut through soil with precision. The specially designed J-shaped blades are optimized for effective and narrow tilling. Thanks to its lightweight and compact frame, the tiller is easy to handle and can be transported manually or in a small vehicle. This machine serves as a sustainable, fuel-free solution for agricultural and gardening applications, offering a runtime of approximately 2 to 3 hours on a full battery charge.

Fig. 5.1 Actual model

Applications

- Small-scale farming and home gardening
- Greenhouse tilling and soil aeration
- Urban agriculture and rooftop farming

V. COST ESTIMATION

Sr no.	Components	Prize
1	24V DC Motor	4000
2	Battery	10,000
3	Two Wheeler Wheel Rim	1000
4	Chain, Sprocket & Bearing	200
5	Shaft,Wheel Angles	50

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6	Nut, Bolt & Screw	50
7	controller	2000
8	Iron rod	800
	TOTAL	**18,100**

VI. CALCULATIONS

MOTOR POWER CALCULATION:-

The motor power is given as 750 W, which is already specified. However, let's verify it using the formula:

Where:

P = Power (W)

T = Torque (Nm

ω= Angular velocity (rad/s)

Angular velocity: $\omega = \frac{2\pi N}{60}$

$\omega = \frac{2\pi.4\ 5\ 0}{60} = 47.12 \text{rad/s}$

Torque (T)$= \frac{P}{\omega} = \frac{75\ 0}{4\ 7\ 12} \approx 15.91 Nm$

The torque at the motor is **15.91Nm**

THE GEAR RATIO IS CALCULATED AS:

Gear Ratio$= \frac{Teeth\ on\ Wheel\ Gear}{Teeth\ on\ Motor\ Gear}$

Given:

Teeth on wheel gear = 12

Teeth on motor gear = 28

Gear Ratio$= \frac{12}{28} = 0.42$

The gear ratio is 0.643

This means the wheel will rotate at 1/0.428 of the motor speed

3. CHAIN TENSION:-

The chain tension is given by:

$$T = \frac{P}{\vartheta}$$

Where:

T = Chain tension (N) P = Power transmitted (W)

v = Linear velocity of the chain (m/s)Linear velocity:

Given:

Motor sprocket diameter D= 6mm=0.006m

Motor speed N= 450 RPM

Linear velocity $(\vartheta) = \frac{\pi DN}{60} = \frac{\pi.0.006.4\ 5\ 0}{60} \approx 0.1 m/s$

Now calculate chain tension:

T$= \frac{75\ 0}{0.14\ 1} \approx$**531.915N**

4. WHEEL TORQUE:

The wheel torque is calculated as:

Twheel=Tmotor·Gear Ratio

Tmotor=15.91Nm

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Gear ratio=0.643

Twheel=15.91 .0.643≈ $\mathbf{10.23}\boldsymbol{Nm}$

5. TILLER BLADE FORCE:

F=$\frac{P}{\vartheta}$

P= Battery Power

ϑ= Velocity

F=$\frac{75\ 0}{0.5}$=1500N

The tiller blade force is **1500N**

6. BATTERY RUNTIME:

Runtime (hours)=$\frac{Battery\ Capacity\ (Ah)}{Current\ Drawn\ (A0}$

From the given data:

Voltage = 48 V

Current = 13.5 A

Battery power = 750 W

Battery Capacity:

Capacity (Ah)= $\frac{Power\ (W)}{Voltage(V)}$=$\frac{75\ 0}{4\ 8}$ $\approx 15.63Ah$

Runtime:

Runtime=$\frac{15.63}{13.5}$ $\approx 1.15hours \approx 69min\ utes$

The battery runtime is **69 minutes**

VII. FUTURE SCOPE

- **Solar Power Integration:** Extending operational time by incorporating renewable energy sources.
- **Automated Features:** Implementing AI-driven control systems for autonomous tilling.
- **IoT Connectivity:** Real-time performance monitoring and data collection for optimized efficiency.
- **Self-Propelled System:** Reducing the need for manual effort through automated movement.

VIII. CONCLUSION

The portable electric power tiller is highly effective for agricultural use in uneven, damp, and small land areas. It is well-suited for carrying out both initial soil breaking and subsequent soil refining operations. With suitable add-ons, the tiller can perform a wide range of farming activities, making it a flexible tool for intensive cultivation practices. Its low overall weight makes it ideal for use in both dry and wet field conditions. Furthermore, the machine's functionality can be extended by attaching different agricultural tools as per specific requirements, making it a multi-purpose solution for small-scale farmers.

IX. ACKNOWLEDGMENT

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