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Design and Fabrication of Solar Hector Wheel Hoe

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Abstract: *Agriculture in India is highly dependent on manual labour, particularly for inter-row weeding operations, which are labour-intensive, time-consuming, and physically demanding. The increasing cost of fuel and the scarcity of farm labour necessitate the development of sustainable and affordable mechanized solutions. This paper presents the design and fabrication of a solar-powered hectare wheel hoe intended to reduce human effort while improving weeding efficiency for small and marginal farmers. The system integrates a photovoltaic panel, rechargeable battery, DC motor, and a mechanical wheel hoe mechanism. Solar energy is harnessed to power the motor, which drives the weeding blade through a transmission system. Experimental trials indicate that the proposed system reduces operator fatigue, eliminates fuel dependency, and provides an eco-friendly alternative to conventional weeders. The developed solar hectare wheel hoe is cost-effective, simple to operate, and suitable for rural agricultural applications.*

Keywords: Solar Energy, Wheel Hoe, Agricultural Mechanization, Renewable Energy, Weeding Machine

I. INTRODUCTION

Agriculture remains the foundation of the Indian economy, contributing nearly 18 % of national GDP and employing over half of the workforce. Mechanization has historically improved farm productivity, yet most small and marginal farmers still depend on manual labour or diesel-powered implements. These systems are inefficient, expensive to operate, and environmentally harmful.

The global energy crisis, coupled with climate concerns, has encouraged a transition toward renewable-energy-based farm equipment. Solar-powered and electric hybrid mechanisms reduce dependence on fossil fuels, minimize carbon emissions, and simplify maintenance. Integrating these technologies into compact, efficient field implements such as a hectare wheel presents an opportunity to modernize agriculture sustainably.

The Smart Solar-Electric Hectare Wheel is designed to combine photovoltaic (PV) energy harvesting, battery storage, and high-efficiency electric drive. The system uses a 750 W, 48 V BLDC hub motor, a 48 V 32 Ah lithium-ion battery, and a 200 W monocrystalline solar panel regulated through an MPPT controller. The concept focuses on creating an autonomous, energy-efficient solution for small-scale farm operations such as weeding, soil aeration, and transport.

II. PROBLEM STATEMENT

Weed growth in agricultural fields significantly affects crop productivity by competing for nutrients, water, and sunlight. Traditional weeding practices in India largely depend on manual labor, which is time-consuming, physically demanding, and increasingly expensive due to labor shortages. Small and marginal farmers often cannot afford fuel-powered weeding machines because of high initial cost, fuel expenses, maintenance issues, and environmental pollution.

Conventional mechanical weeders also rely on fossil fuels, contributing to greenhouse gas emissions and operational inefficiencies. Although solar-powered agricultural implements exist, many designs are complex, costly, or unsuitable for small land holdings. Hence, there is a need for a simple, low-cost, eco-friendly, and efficient weeding solution that reduces human effort, eliminates fuel dependency, and is suitable for small-scale farming.

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Therefore, this project addresses the problem by designing and fabricating a solar-powered hectare wheel hoe that utilizes renewable energy to improve weeding efficiency, reduce labor fatigue, and promote sustainable agricultural practices

III. METHODOLOGY

1. Problem Identification and Requirement Analysis
2. Conceptual Design
3. Component Selection
4. Mechanical Design and Fabrication
5. Solar Power Integration
6. Assembly of Prototype
7. Testing and Field Trials
8. Performance Evaluation and Improvement
9. Documentation and Finalization

- Conduct literature survey on solar-electric agricultural tools and hub-motor technologies.
- Perform conceptual design and CAD & solid edge modeling of the hectare wheel structure.
- Select major components: 750 W hub motor, 48 V 32 Ah battery, 50 W solar panel, controller, and frame.
- Fabricate the prototype using cutting, welding, machining and mounting processes.
- Integrate electrical systems: motor driver, wiring, controller, and display.
- Conduct performance testing: torque measurement, runtime test, solar charging efficiency, field trial.
- Analyze results and compare with design expectations requests.

IV. FABRICATION PROCESS AND DESIGN

Fig 1: Frame

Fig2: Motor placing in frame

Fig3: Battery and controller

Fig4: Final assembly image

Fig1: MS tubes were cut to size (25 × 25 × 3 mm) and joined via arc welding to form a rectangular base frame.
Fig2: The 750 W BLDC hub motor was fixed on the rear wheel hub with a key-and- bolt arrangement.
Fig3: The Li-ion battery pack and MPPT charge controller were enclosed in metal housings bolted to the frame.
Fig3: The entire system was visually inspected and tested under no-load conditions before field evaluation.

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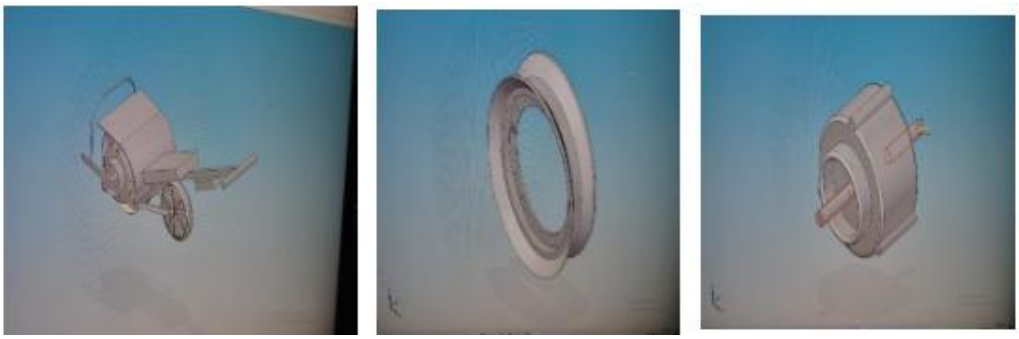
CAD Designs



V. RESULTS AND DISCUSSION

Field tests were conducted on agricultural land with typical weed density. The solar hectare wheel hoe demonstrated effective weed removal with minimal operator effort. The system operated smoothly under solar power, and battery backup ensured continuous operation during low sunlight conditions. Compared to manual weeding, the developed system significantly reduced time and physical strain. The operational cost was negligible, as solar energy eliminated fuel expenses. The results confirm the feasibility and effectiveness of the proposed design.

VI. CONCLUSION

The design and fabrication of a solar-powered hectare wheel hoe have been successfully completed. The developed system offers an eco-friendly, cost-effective, and efficient solution for weed management in agriculture. It reduces labor dependency, operating costs, and environmental pollution. The machine is particularly beneficial for small and marginal farmers. Future improvements may include the use of higher efficiency solar panels, adjustable blade mechanisms, and automation features to enhance performance further.

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