"INTEGRATING SOLAR POWER AND IOT: DEVELOPMENT OF A SMART TILLER FOR SUSTAINABLE POULTRY FARMING"

Savitha M[1*], Sowmya C[2], Durgesh K J[3], Gowtham S[4], Palguna U[5], Sathya Priya D[6]

[1] Professor, Department of Industrial and Production Engineering, SJCE, Mysuru, Karnataka.

[2]Assistant Professor, Department of Industrial and Production Engineering, SJCE, JSSSTU, Mysuru, Karnataka

[3, 4, 5, 6]Under Graduate, Department of Industrial and Production Engineering, SJCE, JSSSTU, Mysuru, Karnataka.

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ABSTARCT

The adaptability needed for small poultry environments is lacking in conventional tilling equipment, which is typically designed for open agricultural fields. In order to close this gap, this work describes the creation of a solar-powered, Internet of Things-integrated tiller that can effectively till soil and apply controlled pesticides in small agricultural areas. The system greatly reduces reliance on external electricity or fuel-driven mechanisms by using photovoltaic energy stored in a battery to power the tilling motor, spraying pump, and electronic subsystems. Mobility is made possible by a Wi-Fi-based control interface that allows users to operate the machine remotely in a convenient and secure manner by using a mobile application to drive it forward or backward. By warning the user of surrounding objects while maneuvering, an ultrasonic obstacle- detection module combined with an audible buzzer improves operational safety. Requirement analysis and CAD-based modeling using SolidWorks software were part of the engineering workflow. The results of the experiment showed consistent power consumption from the solar-battery system, stable tilling performance, efficient pesticide delivery, and dependable wireless control. For small poultry farms looking to automate repetitive tasks while reducing manual labour and operating costs, the suggested system provides a portable, energy-efficient, and user-friendly solution. Future improvements could include more attachments for broader farm applications, better power-management algorithms, and semi-autonomous navigation.

Keywords - IoT; Poultry tiller; Sustainable energy; Wi-Fi Control; Obstacle Detection.

* **EMAIL ID: savitham@sjce.ac.in**

INTRODUCTION

For the Indian economy, agriculture is crucial. As a developed country, India depends heavily on agriculture to meet all of its needs. The use of contemporary technology in our agricultural practices is known as farming. Arthur Clifford Howard inverted the tiller for the first time in 1919. He introduced various rotary hoe cultivator modes. The tiller was initially introduced in Germany and Switzerland in 1930. Another name for the tiller is cultivator. Digging and stirring the soil are the same functions of the tiller and cultivator. In comparison to a tiller, a cultivator is more compact, simpler to use, and capable of digging. These issues are addressed by the "Design and Fabrication of Solar Poultry Tiller – IoT Based" project, which creates an automated, intelligent, and sustainable tilling system specifically for small-scale farming and poultry operations. In this small project, a traditional tiller machine is integrated with cutting-edge parts like

Wi-Fi-controlled driven wheels, IoT-enabled sensors for obstacle detection, precision-controlled sprayers, and buzzers for alerts, all of which are managed by a specialized mobile application. Photovoltaic panels collect solar energy, which is then stored in a rechargeable battery to power the system. The motor, which in turn powers the tiller blades, is powered by this stored energy, doing away with the need for manual labour or fossil fuel-based energy sources. The main goal of this project is to cut down on manual labour, reduce operational and labour costs, and improve energy efficiency. By using Internet of Things (IoT) technology, the machine can be operated and monitored from a distance, providing more precision, safety, and convenience. The addition of sensors and buzzers allows for real-time obstacle detection, improving the device's ability to work autonomously in complex and uneven poultry areas, where movement can be limited. Moreover, by using solar energy as the main power source, the project plays a key role in promoting renewable energy use in agriculture. Solar energy is clean, plentiful, and cost-effective in the long run, especially in sunny regions. This green approach helps lower the carbon footprint linked to traditional diesel or petrol-powered tillers and supports global efforts for sustainable farming practices.

LITERATURE REVIEW

The study conducted by Prof. Prashant Rahat et al. Proposed “The design of a portable electric power tiller machine”, (2021) aimed at reducing manual labour and improving tilling efficiency in small-scale farming. The system is powered by a battery- operated electric motor, which drives the tiller through a sprocket-chain mechanism. A key modification includes the use of wheels with welded angles to enhance soil grip, ensuring that the cultivator prongs engage effectively during operation. This compact and low-cost design focuses on maximizing soil engagement, minimizing human effort, and improving operational ease, making it a practical solution for modernizing traditional farming practices.[1]

The study conducted by Sandesh Sawant, et al. “Portable Electric Power Tiller”. (2022) This project introduces a budget-friendly, electric-powered portable tiller designed to simplify soil preparation for small-scale farmers. It operates using a lithium- ion battery that powers a DC motor, which in turn drives a chain and sprocket mechanism to rotate a customized bicycle wheel with welded angles for better grip on agricultural soil. Equipped with J- shaped blades, the tiller efficiently loosens soil in narrow rows, making it ideal for moist soil conditions. The compact and lightweight design allows easy handling and manoeuvrability, reducing the need for manual labour and eliminating fuel consumption. With its simple construction, low maintenance, and effective performance, the tiller serves as an eco-friendly and practical alternative to traditional methods, helping farmers increase productivity while saving time and effort.[2]

The study conducted by Anilkumar P R, et al. “Design and Fabrication of Electric Portable Tiller for Agricultural Purpose”. (2023) presents a low- cost, battery-operated tiller developed as an efficient alternative to traditional and fuel-powered tilling methods, particularly suited for small and medium- sized farms. Aimed at reducing manual labour and farming costs, the project focuses on creating a compact and portable machine that enhances soil preparation through a motorized tilling mechanism. The design uses a wheel rim with welded angles for better grip, and a chain-sprocket drive powered by a lithium-ion battery and DC motor to move J-shaped blades through the soil. The final model proves effective in moist soils, enabling narrow tilling with minimal effort while addressing environmental concerns by eliminating fossil fuel dependence. This project successfully demonstrates how modern engineering can enhance traditional agriculture in a sustainable and economical manner.[3]

The study conducted by Kayode, J.F., et al. “Development of remote-controlled solar powered pesticide sprayer vehicle”. (2024) The project focuses on developing a solar powered, remote-controlled pesticide sprayer vehicle designed to enhance agricultural efficiency, particularly in underdeveloped regions. This vehicle addresses the challenges of traditional pesticide application by integrating automation and renewable energy. It features a semi-automated system using a solar-charged battery, Bluetooth controlled steering and spray mechanisms, and a high-pressure pump that delivers consistent spray at 5 L/min from a 20 L tank. The system achieves a coverage distance of 159 m in just 4 minutes, significantly reducing labour and health risks to farmers. Unlike earlier robotic sprayers that were either costly or less efficient, this model is cost-effective, sustainable, and suitable for local farming conditions, with an emphasis on targeted spraying, operator safety, and reduced environmental impact.[4]

The study conducted by Aditya et al. "Development of Multi-Purpose Mini Power tiller". (2025) This paper presents the development of a multi-purpose mini power tiller designed specifically to meet the needs of small and marginal farmers. Acknowledging the challenges posed by high-cost machinery and fragmented farmland, the project offers a compact, cost-effective alternative capable of performing multiple agricultural tasks such as ploughing, weeding, soil cultivation, and even crop protection through a rotating fan system. The tiller is designed with modular attachments like rotary blades, ploughs, and cultivators, allowing flexibility across different operations and terrains. Its lightweight and easy-to-operate nature makes it ideal for narrow fields and small plots where conventional tractors are impractical. The project envisions future integration of electric or hybrid systems, IoT-based automation, and interchangeable tools for season specific tasks, ultimately promoting rural entrepreneurship and sustainable agriculture.[5]

RESEARCH GAP

In recent years, the agriculture sector has seen a significant increase in the use of sustainable and smart farming technologies. This includes solar-powered machinery, electric tillers, and IoT-based systems. Several research projects have looked into different aspects, such as solar-operated tillers for land preparation, portable pesticide sprayers, and IoT-enabled monitoring systems for poultry environments. Most current tiller machines are made for large field operations or general soil tilling. Therefore, there is a need to develop a new model, a Solar Powered Poultry Tiller Integrated with IoT (WIFI Controller). This model can perform tilling, spraying, and movement on its own or remotely while ensuring safety with an obstacle buzzer system. This proposed system not only decreases the physical effort required by the farmer but also improves productivity, promotes clean energy use, and introduces affordable automation into modern poultry farming practices. Closing this gap can equip small-scale farmers with smart tools that are efficient, cost-effective, and environmentally friendly, marking a step forward toward the future of integrated smart agriculture.

PROBLEM STATEMENT

The main issue was clear: there was no affordable, automated, and eco-friendly tiller designed for small-scale poultry farming. This statement guided the design and development stages that came next. Tilling land by hand for poultry litter management and growing crops takes a lot of work and time. Traditional tilling equipment is often too large or expensive for small farms, which makes it hard for many farmers to obtain. Small- scale poultry farmers frequently deal with significant challenges in keeping their farms clean and getting ready for both bedding and vegetable crop cultivation.

OBJECTIVE

The objectives of this study are as follows:

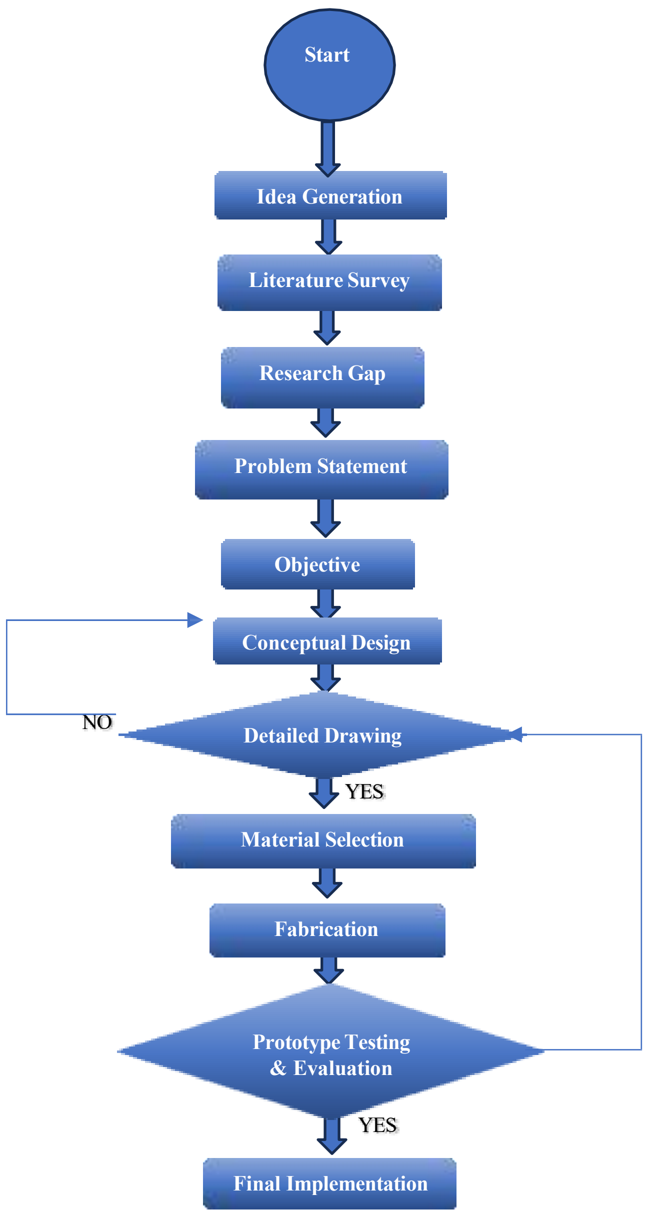
1) To design and develop a solar poultry tiller that promotes sustainable and eco-friendly poultry practices by using renewable energy.

2) To integrate IoT features such as sensors, sprayers, buzzers, and Wi-Fi for smart and remote control of the solar poultry tiller.

3) To improve productivity by increasing energy efficiency with a reliable energy solution for small-scale poultry farming.

METHODOLGY:

Start: The project starts with a clear goal to create a smart and sustainable solution for poultry farming. This



initial step marks the move from idea to action, laying the foundation for the whole development process.

Idea Generation: During this phase, we brainstormed new ideas to tackle the challenges in poultry farming operations. The main aim was to design a machine that combines IoT features with solar energy, while lowering manual labour and costs.

Problem statement: The main focus of the problem definition is a clear description of the main problem identified. That is, the lack of an automated, environmentally friendly, and affordable tiller specifically designed for small-scale poultry farmers. This definition lays out the guidelines for both design and development.

Objective: The project's key objectives were identified as reducing the amount of work performed by humans, reducing the costs associated with operation, and increasing the overall energy efficiency through the use of renewable solar energy. These three objectives formed the basis of all technical and design choices made throughout this project.

Conceptual Processing (2D): In this phase, rough sketches of the tiller and accompanying parts began to take shape through 2D sketches. They aided in obtaining a graphical outline of how the tiller would be structured, how IoT product placement would be carried out, and an estimate of the various proportions and sizes.

Design Development (3D CAD Model): The initial sketches for the tiller were transformed into CAD Designs(3D) by means of CAD software application programs. Additionally, this stage calculated how parts would mate together, also provides tolerances during construction along with simulated analysis capabilities.

Material selection: After designing the 3D model and determining how it will be used, the next step was to find the best materials for each of the parts. This process involved comparing all of the different materials available using several established criteria (i.e., strength/weight/cost/weather resistance/compatibility) to make sure that the solar IOT modules were properly integrated into the system.

2D & 3D DIAGRAM

Fabrication: The next step was to manufacture the prototype based on the selected materials. This process involved machining the various parts of the prototype, combining all of the electronic components, wiring together the IOT sensors, attaching the solar panel(s), and getting the frame ready to operate.

Prototype Testing & Evaluation: The next step after constructing the prototype involved performing a series of tests to see how the tiller would perform under conditions found on a typical poultry farm.

Performance Validation (Yes/No Decision): If the prototype did not meet performance requirements, the prototype was sent back to the 3D Drawing or Materials Selection phase to make the necessary adjustments/changes.

Final Implementation: The Prototype passed all the Evaluation stages and was documented for delivery. The final delivery consists of design files, schematics, test results, and operators guide, which indicates that the prototype has completed development and is ready for final presentation.

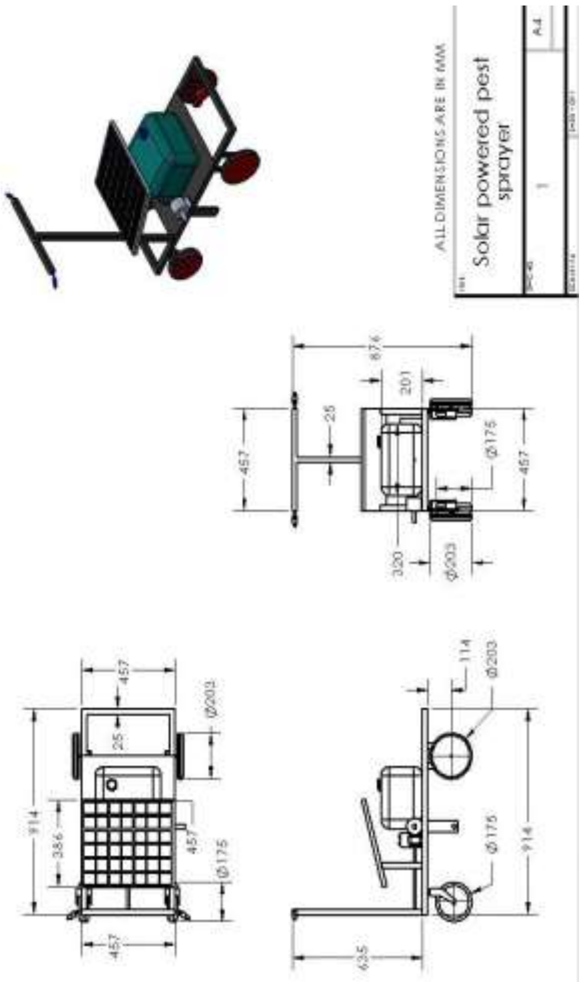
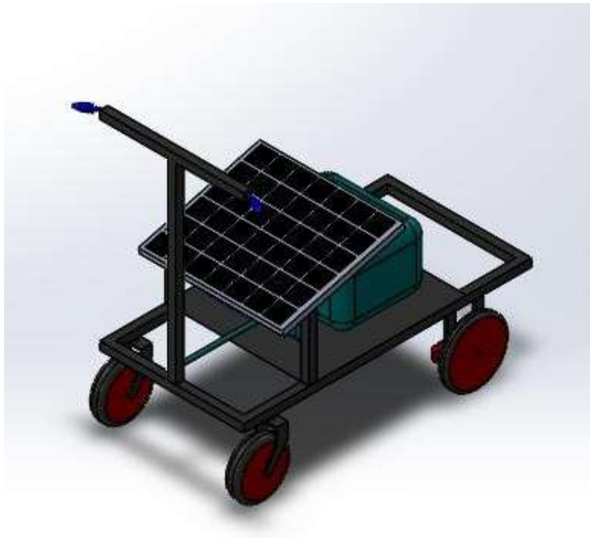


Figure 1 - 2D DRAFT

3D MODEL



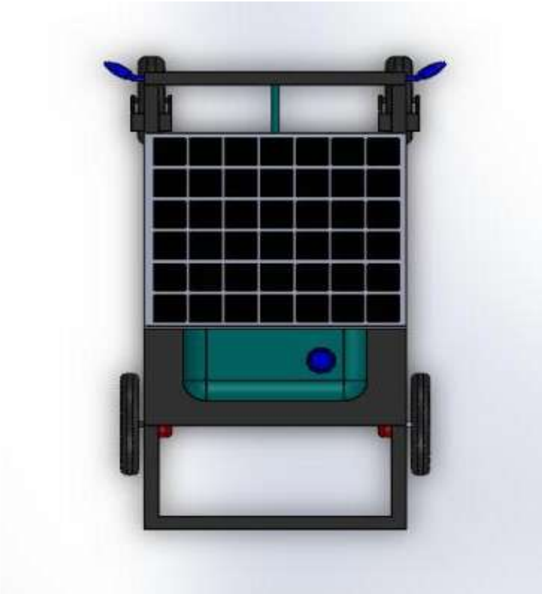


Figure 3 - Top view

Figure 4 - Side view

Figure 5 - Front view

DESIGN CALCULATION

1. Bending Moment on the Chassis

The central components (battery, pump, and 2 L tank) together exert an approximate load:

$$P = (10\text{ kg})\,g = 98.1\text{ N}$$

With a support span of $L = 0.914$ m, the maximum bending moment for a centrally applied load is:

$$M_{\text{max}} = \frac{PL}{4}$$
$$M_{\text{max}} = \frac{98.1 \times 0.914}{4} = 22.4\ N.m$$

2. Bending Stress in the Frame Member

The chassis rail is modelled as a hollow steel tube (25 × 25 × 2 mm).
Its second moment of area:

I = 1.6345×10^{-8} m4, c=0.0125 m

Bending stress:

$$\sigma = \frac{M_{\text{max}} c}{I}$$
$$\sigma = \frac{22.4 \times 0.0125}{1.6345 \times 10^{-8}} = 1.715 \times 10^{7}\text{ Pa}$$
$$\sigma \approx 17.1\text{ MPa}$$

3. Moment Load on the Axle

Each wheel supports roughly one-quarter of the total system weight:

$$R_{wheel} = \frac{W}{4} = \frac{235.44}{4} = 58.86\text{ N}$$

Taking the wheel radius as approximately 0.10 m:

$$M_{axle} = R_{wheel} \times r = 58.86 \times 0.10$$
$$M_{axle} = 5.89\text{ N.m}$$

This is the bending moment used for shaft sizing.

4. Motor Power and Speed Requirement

The spraying mechanism requires about **50 W** of electrical power once losses in the pump and motor are accounted for.

A practical motor selection is **60 W** at 12 V.

If the motor nominal speed is taken as **3000 rpm**, the output torque is:

$$T = \frac{P \times 60}{2\pi N}$$

$$T = \frac{60 \times 60}{2\pi \times 3000}$$

T=0.19 N.m

Hence a small 12 V DC motor rated around 0.18–0.20 N·m torque is sufficient.

5. Battery Capacity

For an intended operating period of **2 hours**, the total energy requirement is:

$$E_{tot} = 50 \text{ W} \times 2 = 100 \text{ Wh}$$

Adding control system and conversion losses:

$$E_{req} \approx 140 \text{ Wh}$$

Corresponding battery capacity:

$$C = \frac{140}{12} = 11.7 \text{ Ah}$$

6. Solar Panel Rating

Daily energy needed to recharge:

$$E_{pv} = \frac{E_{req}}{0.8} = 175 \text{ Wh}$$

Using about **5 peak sun hours**:

$$P_{pv} = \frac{175}{5} = 35 \text{ W}$$

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Allowing for dust, angle losses, and temperature effects, a: 50 W solar panel provides reliable recharging.

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