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SOLAR BASED FERTILIZER MANUFACTURING MACHINE USING KITCHEN WASTE

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Abstract: This project presents the design and development of a solar-powered fertilizer manufacturing machine that utilizes kitchen waste as a primary feedstock. The growing concern over waste management and the need for sustainable agricultural practices prompted the exploration of innovative solutions to recycle organic waste into valuable resources. The proposed machine employs a two-stage process: first, the anaerobic digestion of kitchen waste to produce biogas and digestate, followed by the solar-assisted thermal treatment of the digestate to create nutrient-rich organic fertilizer.

By harnessing solar energy, the system minimizes reliance on conventional energy sources, reducing operational costs and environmental impact. The machine is designed for ease of use in urban households, promoting local waste management and fostering community involvement in sustainable practices. Pilot studies indicate a significant reduction in kitchen waste volume and the successful production of high-quality organic fertilizer, which can enhance soil health and crop yield. This project aims to contribute to a circular economy by transforming waste into a resource while addressing the dual challenges of waste disposal and agricultural sustainability.

I. INTRODUCTION

The rapid urbanization and population growth in recent decades have led to a significant increase in food waste, particularly in households. According to the Food and Agriculture Organization (FAO), approximately one-third of food produced for human consumption is wasted each year. This not only represents a lost resource but also poses serious environmental challenges, including greenhouse gas emissions and increased landfill usage. Simultaneously, the demand for sustainable agricultural practices is rising, driven by the need to enhance soil health and reduce reliance on chemical fertilizers. In response to these pressing issues, this project proposes the development of a

solar-based fertilizer manufacturing machine that utilizes kitchen waste as a primary raw material. By converting organic waste into nutrient-rich fertilizer, the machine addresses both waste management and sustainable agriculture. The integration of solar energy into the process further enhances its sustainability by minimizing the carbon footprint associated with conventional energy sources. This innovative system employs a two-stage conversion process: anaerobic digestion to produce biogas and nutrient-rich digestate, followed by a solar-assisted thermal treatment to create organic fertilizer. The design is tailored for urban households, encouraging local participation in waste recycling and promoting environmental stewardship. This project not only aims to reduce kitchen waste but also seeks to empower communities to contribute to sustainable agricultural practices, ultimately fostering a circular economy where waste is transformed into a valuable resource.

Problem Statement

The increasing volume of kitchen waste generated in urban households poses significant environmental challenges, contributing to landfill overflow, greenhouse gas emissions, and resource wastage. Traditional waste disposal methods are often inadequate, leading to unsustainable waste management practices. Simultaneously, the agricultural sector faces growing demand for sustainable fertilizer alternatives that can enhance soil health while minimizing environmental impact.

Existing solutions, such as composting and chemical fertilizers, are either labour-intensive, time-consuming, or harmful to ecosystems. There is a critical need for innovative, efficient technologies that can convert organic waste into nutrient-rich fertilizers while leveraging renewable energy sources. This project addresses the dual challenge of organic waste disposal and sustainable agriculture by proposing a solar-based fertilizer manufacturing machine that utilizes kitchen waste,



providing a practical and eco-friendly solution for urban households.

II. LITERATURE REVIEW

The conversion of organic waste into valuable resources, particularly fertilizers, is a critical area of research in sustainability and waste management. Kitchen waste, which constitutes a significant fraction of municipal solid waste, offers a promising feedstock for nutrient recovery. Studies indicate that anaerobic digestion can effectively transform this waste into biogas and nutrient-rich digestate, reducing landfill contributions and greenhouse gas emissions (Möller & Stinner, 2016). This process not only generates renewable energy but also provides a base material that can be further processed into organic fertilizers. Solar energy has been increasingly recognized for its potential in agricultural applications. Solar-assisted technologies enable the efficient drying and processing of organic materials, reducing reliance on fossil fuels and enhancing the sustainability of fertilizer production (Moussa et al., 2020). This approach is particularly beneficial in urban areas where energy costs can be prohibitive, and access to conventional energy sources may be limited. While traditional composting and vermiculture have been widely used for waste recycling, these methods often require significant time and labour, making them less practical for urban households (Hassan et al., 2019). In contrast, the combination of anaerobic digestion and solar thermal treatment offers a streamlined and efficient alternative, yielding high-quality fertilizers in a shorter timeframe. Furthermore, literature suggests that community engagement in decentralized waste management systems can foster greater environmental responsibility (Ravindranath & Venkataraman, 2018). By empowering households with easy-to-use technology for waste conversion, this project not only addresses waste disposal challenges but also encourages local participation in sustainable practices. This review underscores the potential of integrating solar energy with waste-to-fertilizer technologies, paving the way for innovative solutions that contribute to both environmental sustainability and agricultural productivity.

III. METHODOLOGY

The development of the solar-based fertilizer manufacturing machine utilizing kitchen waste involves several key stages, including design, construction, testing, and evaluation. The following methodology outlines each step of the process:

1. Literature Review and Concept Development

- Conduct a comprehensive review of existing technologies related to organic waste conversion, anaerobic digestion, and solar energy applications.

- Identify gaps in current methodologies and propose a design that integrates solar energy with anaerobic digestion and thermal treatment.

2. System Design

- **Machine Components:** Design the machine to consist of three main components:
 - **Anaerobic Digester:** To break down kitchen waste and produce biogas and digestate.
 - **Solar Thermal Unit:** To utilize solar energy for heating and drying the digestate.
 - **Fertilizer Output Chamber:** To collect and store the final organic fertilizer.
- **Technical Specifications:** Determine the dimensions, materials, and energy requirements for each component.

3. Construction of the Prototype

- **Materials Selection:** Choose eco-friendly and durable materials for construction, ensuring that components are resistant to corrosion and wear.
- **Assembly:** Construct the prototype based on the design specifications, integrating solar panels, storage tanks, and piping systems for biogas and liquid management.

4. Testing and Optimization

- **Feedstock Preparation:** Collect a variety of kitchen waste samples for testing, including fruit and vegetable scraps, coffee grounds, and eggshells.
- **Anaerobic Digestion Trials:** Operate the anaerobic digester under controlled conditions to assess biogas production and digestate quality. Monitor parameters such as temperature, pH, and retention time.
- **Thermal Treatment Trials:** Test the solar thermal unit's effectiveness in drying and processing the digestate. Measure the nutrient content of the resulting fertilizer.

5. Data Collection and Analysis

- Collect data on biogas yield, digestate composition, and fertilizer quality throughout the testing phase.
- Analyse the data to evaluate the efficiency of the machine and its effectiveness in converting kitchen waste into fertilizer.

6. Evaluation and Community Engagement

- **Performance Assessment:** Assess the overall performance of the machine in terms of waste reduction, energy consumption, and fertilizer quality.
- **User Feedback:** Conduct surveys and interviews with potential users to gather insights on usability and practicality. Incorporate feedback to refine the design.

7. Final Reporting

- Compile findings into a comprehensive report detailing the design process, testing results, and user feedback.
- Provide recommendations for future improvements and potential scaling of the technology for broader community use.

This methodology aims to create a functional, efficient, and user-friendly solar-based fertilizer manufacturing machine that not only addresses kitchen waste management but also promotes sustainable agricultural practices in urban environments.

System design

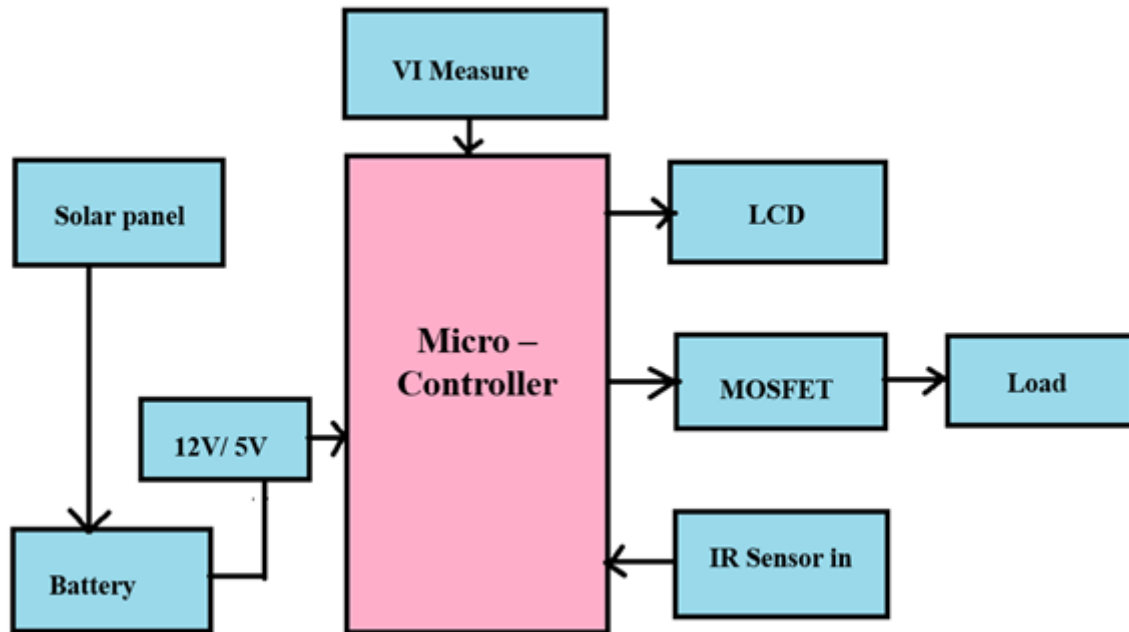


Fig1. Block diagram

Working

To reduce the complexity of the circuit, we selected the Atmega 328 P-Pu microcontroller. Charging current control is achieved using PWM. To monitor the battery's status, a voltage divider circuit checks the battery voltage, with part of this voltage applied to ADC (A3). The LCD display then shows the battery status. The microcontroller compares the battery voltage: if it is less than 12V, charging is initiated; if it exceeds 14V, charging is stopped.

For on/off charging, we use a MOSFET (IRF3205) driven by a gate driver (PC817 optocoupler). The battery is connected to the solar panel through the MOSFET. During the charging process, the microcontroller sends a signal to the optocoupler, activating the MOSFET, which connects the solar panel directly to the battery and starts the charging process.

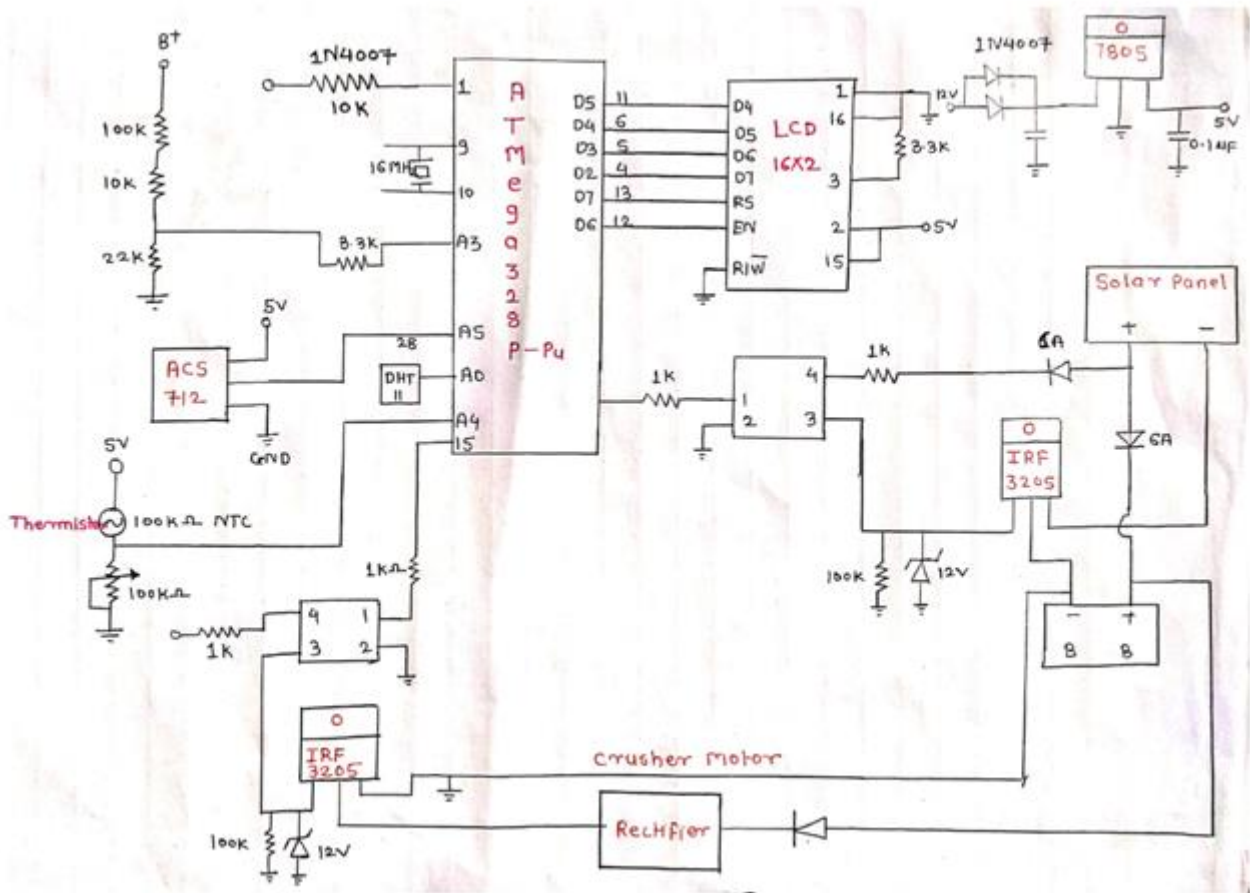
The LCD display shows voltage, current, and temperature. The microcontroller operates on a 16 MHz crystal. Two loads are controlled: one for a motor and another for a water pump. Two separate MOSFETs are utilized, with pin

number 14 designated for charging, pin number 15 for the motor, and pin number 16 for the pump. Diodes in the circuit protect against reverse current, while a Zener diode acts as a voltage stabilizer. Additionally, the ACS 712 current sensor, with a capacity of 20 Amperes, measures the current flowing through the conductor.

Circuit diagram

Required components.

- Microcontroller ATmega 328 P-Pu
- MOSFET IRF 3205
- Current sensor ACS712
- Diodes
- Optocoupler PC817
- LCD 16*2
- DHT11 sensor
- DC Motor
- Solar panel



Advantages

- **Sustainable Waste Management:** The machine effectively reduces kitchen waste by converting it into nutrient-rich fertilizer, thereby minimizing landfill contributions and promoting a circular economy.
- **Renewable Energy Utilization:** By harnessing solar energy, the system reduces reliance on fossil fuels, lowers operational costs, and decreases the carbon footprint associated with fertilizer production.
- **Improved Soil Health:** The organic fertilizer produced enhances soil quality, promoting healthier plant growth and contributing to increased agricultural productivity.
- **Cost-Effective Solution:** Utilizing kitchen waste as a raw material for fertilizer production lowers input costs for households and small-scale farmers, making it an economically viable option.
- **User-Friendly Design:** The machine is designed for ease of use, allowing urban households to participate in sustainable practices without requiring extensive technical knowledge.

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