ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25may2120

Creation and Design of an Automated Kitchen Waste Composting System for Homes

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Publication Date: 2025/06/06

Abstract: Vegetable peelings possess unique attributes as a type of kitchen waste, characterized by a high moisture content, significant organic matter, and excellent biodegradability. This waste can be effectively recycled, minimized, and rendered safe through the process of biological composting. Following an analysis of experimental findings regarding the fermentation and composting of vegetable peels and leaves, a household automatic composting device was developed and studied. This apparatus incorporates elements such as a wringer blade and a cross blade broken baffle to facilitate functions including material transfer, pre-treatment crushing, fermentation, and separation. The issue of odor during fermentation was addressed through activated carbon adsorption. Ultimately, the process yielded a fermentation broth with decontamination properties and high-quality fertilizer. Composting food waste is a multifaceted process that necessitates specialized equipment and facilities capable of gradually converting waste into nutrient-rich fertilizer. Furthermore, it requires ongoing expert supervision to ensure a high-quality outcome. Consequently, the evolution of automated composting machinery represents a significant advancement, as modern technology enhances efficiency. The objective is to create a fully automated composting machine that employs a more effective and eco-friendly approach to successfully reduce food waste. This device is user-friendly, featuring a single button, and is equipped to perform heating, cooling, and grinding functions. Its advantage lies in the reduction of waste management costs at landfills, as traditional machinery demands substantial logistical energy for the transportation of food waste. This product holds considerable potential for use by home cooks and commercial food producers, including medium to large enterprises that generate substantial amounts of raw waste. In summary, this device automates the conversion of food waste into usable fertilizer.

Keywords: *Kitchen Waste, Vegetable Peelings, Biodegradability Biological Composting, Composting Apparatus, Household Composting, Fermentation, Organic Matter.*

How to Cite: Manali P. Thorushe; Sonal Santosh Thorath; Manali Suhas Pore; Tushar Pravin Mali; Faizan Shafi Mujawar (2025) Creation and Design of an Automated Kitchen Waste Composting System for Homes. *International Journal of Innovative Science and Research Technology*, 10(5), 3696-3703. https://doi.org/10.38124/ijisrt/25may2120

I. INTRODUCTION

S families and communities seek safe and effective methods for managing kitchen waste, composting emerges as a more appealing option. This approach not only adds value to waste but also reduces the volume that needs to be disposed of. While informal recycling of waste materials is prevalent in developing nations, the treatment and utilization of the biodegradable organic fraction, particularly kitchen waste, remains relatively limited. Increasingly, both international and municipal authorities are exploring innovative strategies for managing organic solid waste through the establishment of composting facilities in developing countries. This initiative serves as an excellent means to prevent the wastage of valuable natural resources and mitigate environmental issues, while simultaneously producing a high-quality and cost-effective soil amendment. The first industrial facility for converting urban organic materials into compost was established in Austria in 1926. Composting is a biological process that transforms organic waste, such as kitchen scraps, manure, leaves, grass clippings, worms, and coffee grounds, into a highly beneficial humus-like substance through the action of various microorganisms, including bacteria, fungi, and actinomycetes, in the presence of oxygen. omposting refers to the biological breakdown of organic materials, either aerobically or anaerobically, under optimal temperature and moisture conditions that support microbial activity, resulting in a stable end product suitable for storage and application to soil without causing negative environmental effects. This procedure entails the breakdown of organic waste by microorganisms within a regulated environment.

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Considering that organic waste makes up a substantial fraction of municipal solid waste, it has prompted significant environmental issues, with estimates indicating that around 50 percent of this waste is suitable for composting. Regrettably, a considerable amount is instead sent to landfills or incinerated. By composting organic waste, we can preserve resources and produce a valuable byproduct that functions as a locally sourced fertilizer. Nevertheless, current compost bins face numerous challenges, such as problems with messiness and odor, a lengthy processing duration of 30 to 45 days, vulnerability to pests, and cleaning difficulties. Furthermore, some bins contribute to greenhouse gas emissions. There are also financial concerns related to certain automatic and premium compost bins. This initiative aims to create a compost bin specifically designed for Indian households that is user-friendly, odor-free, ergonomic, and visually appealing. According to a report from the Government of India's Ministry of Urban Development, approximately 101,066.27 metric tons of municipal solid waste (MSW) are produced daily in India. As urban regions grow rapidly due to significant rural-to-urban migration, the amount of MSW continues to increase. Much of this waste is subjected to unscientific landfilling or irregular dumping on the peripheries of cities, significantly contributing to global warming due to the greenhouse gases released from these landfills. The existing MSW management system, which includes collection, storage, transportation, segregation, disposal, and processing of waste, is insufficient. A primary challenge encountered by municipalities is the rising volume of solid waste, combined with the inability of government agencies to manage it effectively.

A study conducted by the Natural Environmental Engineering Research Institute (NEERI) in Nagpur across 59 cities estimates that approximately 57,000 tons of municipal solid waste (MSW) are generated daily. An effective approach to managing organic waste is through composting, which can be utilized in agricultural practices. Composting is an aerobic process wherein microorganisms break down organic waste into nitrogen-rich fertilizer. Currently, only 9-10% of the organic waste produced is processed through composting. Various methods are employed by different enterprises and governmental organizations to convert organic waste into compost. The quality of the compost is influenced by factors such as the type of organic waste, the composting process, and the duration of composting. In India, the estimated annual production of organic waste is approximately 4.4 million tons. A major obstacle in the creation of high-quality compost is the insufficient management of municipal solid waste (MSW). Effective segregation of biodegradable from non-biodegradable waste is essential for producing quality compost. Composting provides a multitude of advantages, such as improving soil fertility, stabilizing the environment, alleviating global warming, and enhancing waste management systems. Moreover, the composting process diminishes the volume of organic waste and eradicates pathogens. Additionally, organic composting converts ammonia waste into a valuable nitrogen- rich resource. The application of manure to soil significantly boosts its fertility. Natural organic composting, which is driven by microorganisms, generally takes about 30 to 40 days. Although segregation is vital for successful natural organic composting, optimal conditions for microorganisms can considerably shorten the compost production time. Nevertheless, the scattered nature of kitchen waste generation, along with high moisture and organic matter levels, can result in acidification, mildew, and decay, leading to the spread of various pathogenic microorganisms. This situation poses a risk of secondary environmental pollution during the centralized recycling and transportation processes. Despite the establishment of waste classification policies in several developed cities in China, the recycling of kitchen waste has not achieved the expected results due to difficulties in policy management and a lack of public awareness regarding the hazards and potential resources linked to kitchen waste. In China, a considerable amount of kitchen waste is disposed of via landfilling, which negates the advantages of recycling. At present, there are two main types of kitchen waste disposal devices available on the market. The first type is a kitchen waste compost bin, which utilizes composting principles for the manual pretreatment and composting of kitchen waste. The second is a kitchen waste pulverizer, equipped with mill blades that grind kitchen waste into smaller pieces for integration with sewage treatment systems. While this pulverizer can decrease the volume of kitchen waste, it does not facilitate the secondary use of the waste and can generate unpleasant odors, create breeding grounds for pathogens, and directly pollute the environment, thereby increasing the burden on urban sewage treatment facilities. Composting is a process wherein microorganisms decompose organic materials.

II. RELATED WORK

The design and development of home automatic kitchen waste composting devices is supported by extensive related work in areas such as automation in composting, organic waste management, user-centered design, and sustainable practices. Prior research into the technologies that enable fast, efficient, and odorless composting at home has provided the groundwork for the continued improvement and adoption of these devices.

➢ *Automatic Composting Machines*

- *Research on Automatic Composters:*

There are several models of automatic composting systems developed for both household and industrial purposes. Research often focuses on improving efficiency, minimizing odor, reducing composting time, and automating various stages like grinding, fermentation, and temperature control. Examples include products like Zera Food Recycler and FoodCycler, which focus on turning food scraps into compost automatically within a few hours.

- *Previous Designs of Home Composters:*

Earlier models focused on manual or semi-automatic processes, while recent works aimfor fully automated

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systems. Studies highlight systems with features such as heating, cooling, grinding, and odor control mechanisms

➢ *Composting Techniques and Principles*

- *Biodegradability of Organic Waste:*

Research in the field of organic waste decomposition, particularly related to the biodegradability of kitchen waste (vegetable peelings, food scraps, etc.), focuses on how effectively different organic materials can be converted into compost.

- *Composting Process Optimization:*

Numerous studies investigate how biological composting can be enhanced by controlling key factors such as moisture content, temperature, and aeration. These factors influence the rate of microbial activity and the speed at which waste turns into nutrient-rich compost.

- *Fermentation and Microbial Activity:*

Several works delve into optimizing fermentation for efficient composting. This includes studies on bacterial strains, enzymes, and conditions that accelerate the composting process.

➢ *Organic Waste Composting Techniques*

- *Biodegradability of Organic Waste:*

The biodegradability of kitchen waste like vegetable peelings, fruit skins, and food scraps has been well-researched. Studies emphasize the importance of controlling the carbon-to-nitrogen ratio (C/N ratio), which affects the speed and quality of compost. Automatic composters are often designed to manage these variables for optimal decomposition.

- *Mechanical Pre-Treatment and Fermentation:*

The integration of pre-treatment mechanisms like shredders or grinders has been shown to improve composting by increasing the surface area of organic material. In related work, devices utilize mechanical components such as wringer blades or broken baffles to aid in material breakdown. This enhances microbial activity and accelerates the process.

- *Odor Control:*

One of the key challenges for home composting is odor management. Research has been done on various techniques, including the use of activated carbon filters or biofilters, which help neutralize the unpleasant smells that are typically associated with composting. Modern composting devices integrate these technologies to make the process more household-friendly.

➢ *Sustainability and Environmental Impact*

- *Waste Reduction and Recycling:*

Automatic composting systems are positioned as solutions to reduce the amount of food waste sent to landfills, which in turn decreases the environmental burden of waste management. Many studies focus on how household composting can contribute to sustainability goals by reducing methane emissions from landfills and producing nutrient-rich fertilizers that can be used for gardening or agriculture.

- *Energy Efficiency:*

Energy consumption is a factor to consider in automated systems. Research into the energy footprint of composting devices shows that minimizing energy use while maintaining effective composting processes is crucial. Studiessuggest that systems utilizing low-energy heating elements, efficient aeration, and renewable energy sources can significantly reduce the carbon footprint of such devices.

➢ *Technological Advances in Composting Devices*

- *Automation and Smart Composting:*

Modern composting machines, particularly those meant for household use, increasingly integrate automated systems that control parameters like temperature, humidity, and oxygen levels. Many studies discuss how automation enhances user convenience by eliminating the need for constant supervision. Key components include sensors, temperature regulators, and stirring mechanisms that ensure even decomposition of organic matter.

- *Sensors and IoT Integration:*

Research also highlights the incorporation of sensors and Internet of Things (IoT) technology in composting machines. These sensors monitor critical variables such as moisture levels, oxygen, and the state of decomposition, providing real-time feedback via smartphone apps or other interfaces. Such advancements make it easier for users to maintain the machine and optimize composting efficiency.

➢ *User-Centered Design and Usability*

- *Ease of Use and Accessibility:*

Usability is critical for widespread adoption of home composters. Previous work on user-centered design for composting devices suggests that simplicity is key. Automated composters that operate with minimal human intervention, such as one-touch controls or preset composting programs, are more likely to be adopted by households. Studies also explore how intuitive interfaces can improve user interaction with the composting process.

- *Safety Considerations:*

Safety is another area where related research has focused, particularly in ensuring that the mechanical components (like grinders and heating elements) are designed with safety features to prevent injury or accidental misuse.

III. PROPOSED SYSTEM

The huge amount of waste is produced through daily operations in India. Processing of this waste is very

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25may2120

challenging task for government machinery. The main problem is to collect the waste from each house daily. Instead of collecting the waste, transporting it and processing, there should be machine which process the waste at location where it is generated. This helps in reduction of cost for transportation of waste. The machine should have the cost, affordable to middle class and should be small is size as the sizes of houses in Indian cities are also small. In this Proposed System An electrical organic waste treatment machine designed to convert food waste into compost. The Hopper is the initial component where food waste is deposited. It serves as the entry point for the waste into the machine. After entering from the Hopper, the food waste moves to the Mixer and Heater. Mixer and Heater mixes the waste to ensure uniform heating and initiates the decomposition process by applying heat. Heating accelerates the breakdown of organic material by promoting microbial activity. Grinder the heated and mixed food waste is then sent to the Grinder. The Grinder reduces the particle size of the waste, making it easier to break down and compost. The Controller is central to managing the machine's operations. It receives inputs from sensors (such as object sensing) and monitors temperature to regulate the processes in the Mixer and Heater. It also manages the operation of the Grinder and coordinates the entire composting process. The Display provides real-time information to the user, such as operational status, temperature, and any alerts. The Buzzer sounds to notify users of specific events, such as the completion of the composting process or any errors.

➢ *System Requirements and Design Method*

The design and implementation of an automatic gate control system with number plate recognition involve several key components working in synergy to achieve efficient vehicle access control. Here is a detailed explanation of each component's role and their integration into the overall system:

- *Input (Food Waste)*

Food waste is the raw material input, consisting of vegetable peels, fruit scraps, and other organic kitchen waste. This is fed into the system via a hopper.

- *Hopper*

The hopper acts as a container that receives the food waste. It provides an entry point into the system and ensures that the waste is gradually fed into the subsequent components for further processing.

- *Mixer and Heater*

✓ The Mixer is responsible for stirring and aerating the food waste to ensure an even distribution of moisture and heat.
✓ The Heater maintains the optimal temperature required for composting, promoting microbial activity and speeding up the decomposition process.
✓ This component ensures that the waste is properly broken down into smaller particles and that microbial fermentation occurs efficiently.

- *Grinder*

✓ The Grinder crushes and shreds the food waste into smaller particles. This increases the surface area of the waste material, enhancing the speed of microbial breakdown and the overall composting process.
✓ The grinding process helps in reducing the bulk volume of the waste and prepares it for transformation into compost.

- *Controller*

✓ The Controller is the brain of the system, responsible for managing the operations of various components like the mixer, heater, and grinder.
✓ It monitors and adjusts the temperature, mixing speed, and grinding process to ensure optimal composting conditions.
✓ It also controls the overall process flow, ensuring the food waste transitions through the system smoothly and in a timely manner.

- *Display & Buzzer*

✓ The Display provides users with real-time information about the status of the composting process, such as current temperature, remaining time, and any errors in the system.
✓ The Buzzer provides auditory notifications, alerting the user when the process is complete or if any maintenance is required.

- *Output (Food Compost)*

✓ Once the composting process is complete, the final output is food compost. This nutrient-rich material can be used as organic fertilizer for plants and gardens.

➢ *System Design Method*

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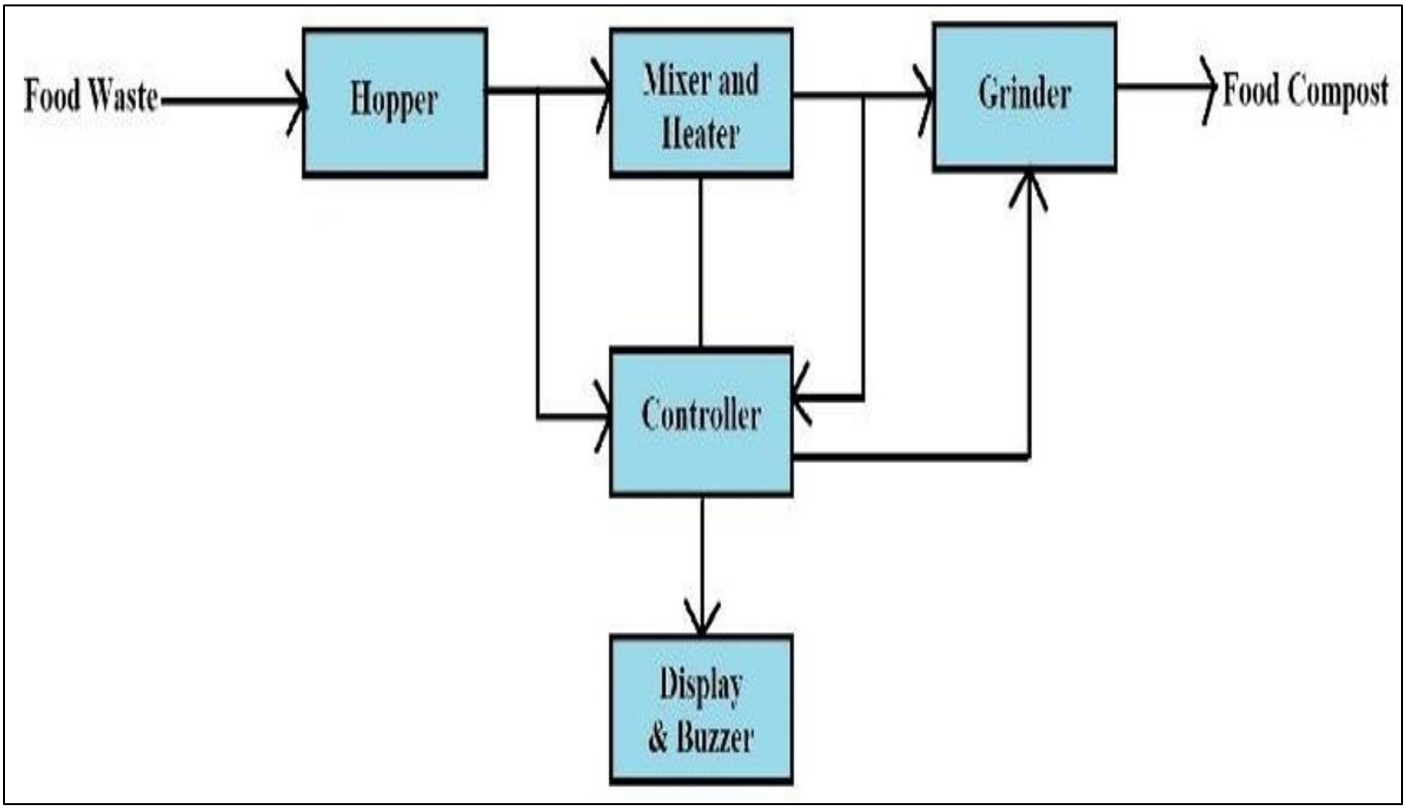

Fig 1 Block Diagram

The block diagram represents an electrical organic waste treatment machine designed to convert food waste into compost. The Hopper is the initial component where food waste is deposited. It serves as the entry point for the waste into the machine. After entering from the Hopper, the food waste moves to the Mixer and Heater. Mixer and Heater mixes the waste to ensure uniform heating and initiates the decomposition process by applying heat. Heating accelerates the breakdown of organic material by promoting microbial activity. Grinder the heated and mixed food waste is then sent to the Grinder. The Grinder reduces the particle size of the waste, making it easier to break down and compost. The Controller is central to managing the machine's operations. It receives inputs from sensors (such as object sensing) and monitors temperature to regulate the processes in the Mixer and Heater. It also manages the operation of the Grinder and coordinates the entire composting process. The Display provides real-time information to the user, such as operational status, temperature, and any alerts. The Buzzer sounds to notify users of specific events, such as the completion of the composting process or any errors.

➢ *Challenges*

- Managing kitchen waste at home without the need for transportation to landfills.
- Ensuring the composting process is efficient, odor-free, and requires minimal user intervention.
- Developing a compact, affordable, and user-friendly system for households.

➢ *System Design*

- *Component Identification:*

✓ Hopper for food waste input.

IV. METHODOLOGY

This methodology ensures the development of a high-performance, sustainable, and user-friendly composting device that can be adopted in households, helping reduce food waste and contribute to environmental sustainability.

➢ *Problem Identification*

Objective: To reduce kitchen waste in households by converting it into nutrient-rich compost in an eco-friendly, efficient, and automated manner.

✓ Mixer and Heater to aid in the decomposition process by ensuring uniform heating and mixing of the waste.
✓ Grinder to shred the food waste into smaller pieces for faster decomposition.
✓ Controller to manage the operation and automation of the system.
✓ Display and Buzzer for real-time feedback and user interaction.

- *Design Layout:*

The components are arranged to form a system that moves food waste from input to final compost output. The layout was visualized through block diagrams (like the one provided earlier).

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➢ *Component Selection*

- *Hopper:*

Chosen based on size and material that can handle food waste without clogging. Durable materials like plastic or stainless steel are preferred for easy cleaning and long life.

- *Mixer and Heater:*

Selected to ensure uniform distribution of heat and mixing of waste. Temperature sensors were included to maintain the optimal conditions for microbial activity.

- *Grinder:*

Selection was based on a blade system capable of breaking down different types of food waste into smaller pieces.

- *Controller:*

A microcontroller was chosen for automating the system, handling sensor data, and controlling the motors for the grinder and mixer.

- *Odor Control:*

Activated carbon filters or equivalent technologies were integrated to neutralize any odors generated during the composting process.

- *Display and Buzzer:*

Simple LCD and auditory alarm were selected for easy operation and notifications.

➢ *System Assembly*

The various components were assembled according to the design specifications.

➢ *Electrical connections:*

Set up between the controller, sensors (temperature, humidity), the grinder motor, the mixer motor, the heater, and the display/buzzer unit.

➢ *Mechanical assembly:*

The hopper, grinder, and composting chamber were built in a compact form, ensuring they fit well together and allow for easy user access.

➢ *Odor management:*

Activated carbon filters were installed in the airflow to remove odors effectively.

➢ *Testing and Calibration*

- *Prototype Testing:*

A prototype was built and tested with different types of kitchen waste to evaluate the system's performance.

- *Efficiency Testing:*

Measured the time taken to convert various kitchen wastes into usable compost.

- *Temperature Control:*

Tested to ensure that the heating system maintained the correct temperature range (e.g., 50- 60°C for efficient composting).

- *Odor Testing:*

Evaluated the effectiveness of the activated carbon filter or any other odor-reduction technology.

- *Noise and Energy Consumption:*

Ensured that the grinder and mixer operated within acceptable noise levels and that the system consumed minimal energy.

➢ *Adjustments:*

Based on test results, adjustments were made to the system to improve performance, such as fine-tuning the grinding mechanism or tweaking the temperature control.

➢ *Final Product Development*

The final design was refined for mass production, with attention to cost-effectiveness, durability, and user experience.

- *Materials Selection:*

The final product was made using materials that balance cost, durability, and eco-friendliness.

- *Safety and Compliance:*

The device was evaluated to meet safety standards for household appliances, including electrical safety and safe handling of food waste.

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EXPERIMENTS AND RESULTS

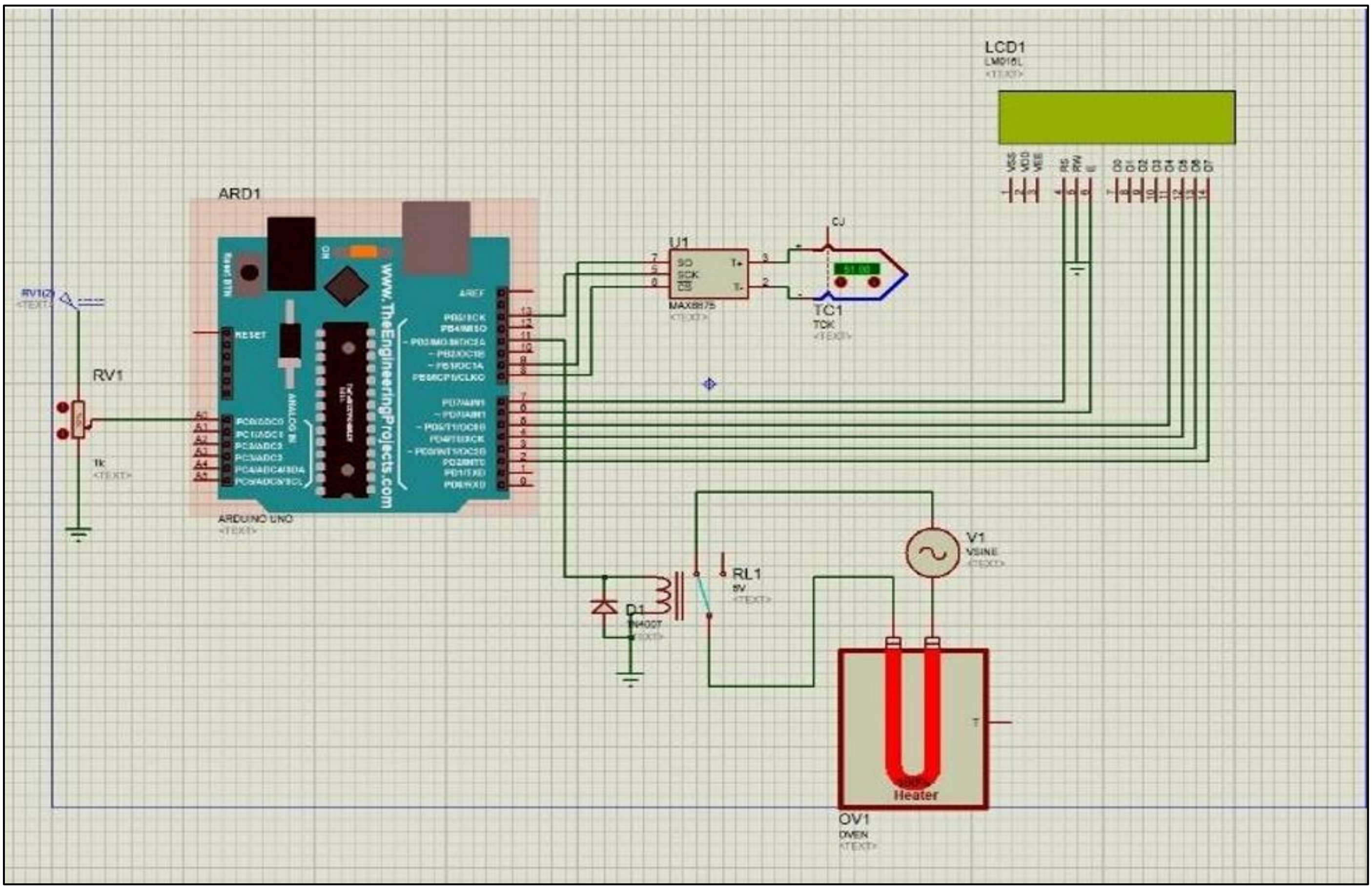

Fig 2 Proteus Simulation for Temperature Control

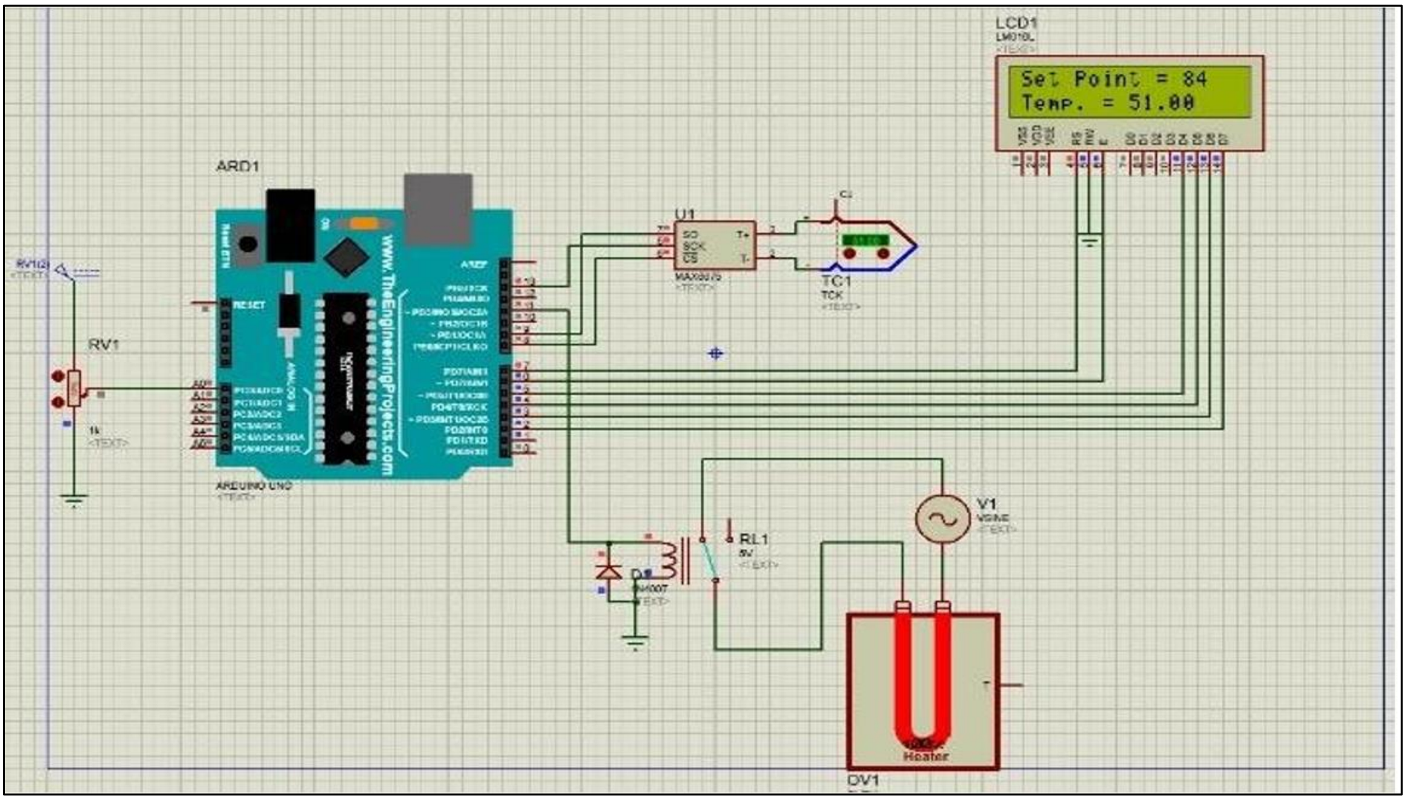

Fig 3 Temperature Controlled

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➢ *Results:*

- Arduino Uno – Atmega328
- Relay for switching Heater ON/OFF - 5V,7A
- Thermocouple K type Maxx6675 - for Measure the actual temperature
- Heater as Heating Element - 500 to 750watts
- Display for Indication of Actual & Set point Temperature.

V. CONCLUSION

The design and development of the Home Automatic Kitchen Waste Composting Device demonstrate the feasibility and practicality of converting food waste into nutrient-rich compost through an automated, eco-friendly system. This device effectively addresses the growing concerns of food waste disposal by offering a convenient, sustainable, and energy- efficient solution for households and small-scale industrial use. The Home Automatic Kitchen Waste Composting Device is a promising solution to food waste management challenges. Its combination of efficiency, environmental benefits, and ease of use positions it as a valuable addition to both homes and industries looking to reduce waste and promote sustainability. With further refinement, the device has the potential to gain widespread adoption and contribute significantly to waste reduction efforts globally.

FUTURE WORK

The Home Automatic Kitchen Waste Composting Device can be improved further, increasing its functionality, efficiency, and appeal to a broader range of users. These advancements could play a crucial role in global efforts to reduce food waste, promote sustainable living, and mitigate the environmental impact of organic waste disposal.

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