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Automated Recycling Mechanism for Waste-yard

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Abstract—This project presents an innovative, fully automated waste management system that significantly reduces human involvement in the collection, transportation, and disposal of garbage. The system employs a driverless, garbage carrying rail running on a narrow track between waste collection points and a designated dumping yard. Citizens deposit their waste into the container, and once it is full, the system is activated by pressing a start button. The rail moves the container to the dumping yard, where a limit switch ensures it halts at the precise location adjacent to a unique furnace equipped with thermodynamic devices. The garbage is automatically unloaded into the furnace's hot chamber, where it is incinerated. The furnace converts the generated heat energy into electrical energy, which is further transformed into a 230V AC single-phase supply.

***Keywords*— Automated Waste Management, Generating electrical energy from heat, Rail-Based Waste Transport, 89C2051 Microcontroller, PWM IC, Motor Driver Circuit.**

I. INTRODUCTION

The Recycling mechanism described in this project work is very useful for the department of Municipal corporations where every day lot of trucks that contains full of garbage usually transported to the city outskirts dumping yards. Since 100's of trucks are engaged to this activity, here transporting rail is designed by which huge quantity of garbage is transported single time. The garbage transporting mechanism designed here is very useful for metro cities where 1000 of tones of waste is produced every day, presently waste carrying trucks are in use and hundreds of such trucks are in use for collecting the junk from various parts of the city.

A. SCOPE AND OBJECTIVES

The primary objective of this project is to develop a fully automated, intelligent, and sustainable waste management system that addresses the limitations of conventional manual waste disposal methods. By integrating automation, thermo-electric energy generation, and smart control systems, the proposed project aims to create a self-operating mechanism that can reduce human involvement, minimize environmental impact, and recover useful energy from waste.

Develop a rail-based waste transport system that autonomously shuttles between collection points and dumping yards without the need for human drivers. Implement a tilt-based dumping system that unloads waste into a furnace using sensors and actuators controlled by a microcontroller. Build a prototype furnace that incinerates waste efficiently and transfers the resulting heat to Thermoelectric Generator (TEG) modules. Utilize the Seeback effect to convert thermal gradients into usable DC power for battery storage and inverter operation. Implement an inverter circuit using PWM ICs and MOSFETs to deliver AC power from the stored DC voltage, enabling grid use or local application.

II. SYSTEM DESCRIPTION

The project system consists of a microcontroller-controlled rail mechanism for transporting waste from collection points to a dumping yard. The rail vehicle operates autonomously between two reference points, identified by magnetic sensors. At the dumping yard, the garbage is unloaded into a custom-built burning furnace, constructed from mild steel and aluminum sheets. This furnace is equipped with Thermoelectric Generator (TEG) modules on its hot surfaces. These modules utilize the Seeback effect to convert heat from the burning waste into DC electrical power. This power is used to charge a 12V battery, which in turn feeds a PWM-based inverter circuit to generate a 230V AC supply. The key system components include: A narrow rail track with an autonomous carrier. Dumping mechanism controlled via limit switches and DC motors. A furnace integrated with heat sinks and TEG modules. Rechargeable battery and inverter for AC power output.AT89C2051 microcontroller and L293D motor driver.

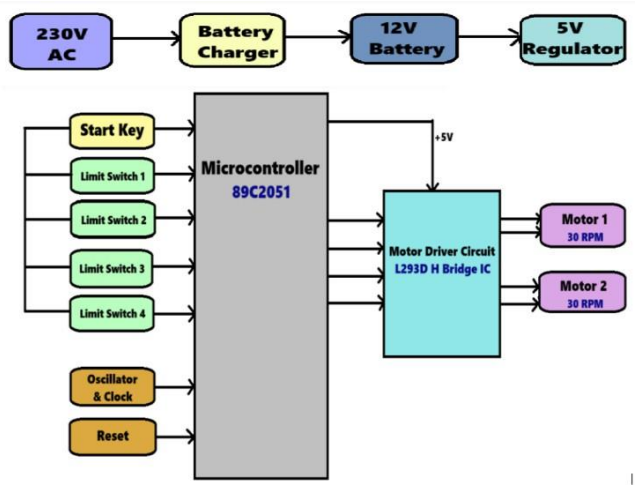


Fig 1: Block Diagram of Automated Dumping Rail

The proposed Automated Recycling Mechanism system is designed to streamline waste management processes in waste yards. It automates waste collection, dumping, and energy conversion processes, increasing efficiency and reducing labor costs. The system uses thermodynamic devices to convert heat energy generated from waste burning into electrical energy. A microcontroller-based control system ensures reliable operation and minimizes downtime. Overall, the system promotes environmental sustainability by converting waste into valuable energy.

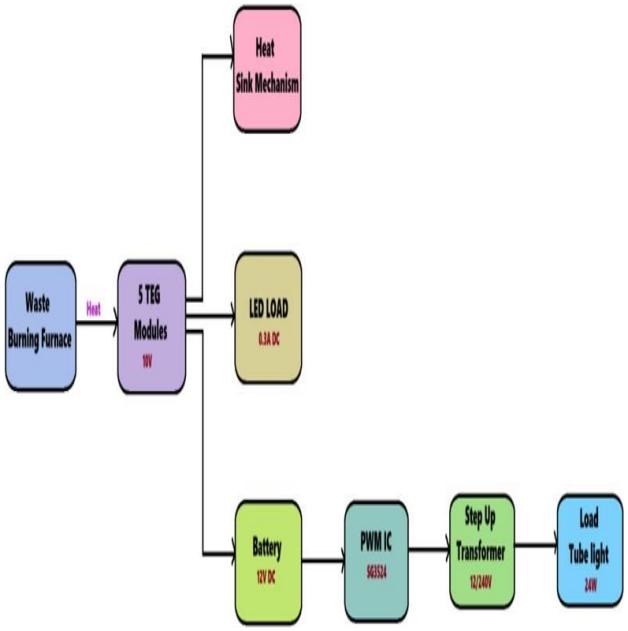


Fig 2: Block Diagram of Waste Burning Furnace

The hot chamber is designed to burn the waste is constructed with special mechanism which is aimed to generate 230v ac through Thermo-Electric generators (TEG) attached to the hot body of Furnace. The mechanism constructed to generate electricity is aimed to maintain the flow of heat through the hot body to cold body of TEG modules. The hot body of the device is directly attached to the hot chamber and where as the cold body is attached to the heat sink mechanism which is aimed to radiate the heat in to the space to maintain temperature difference between hot body and cold body.

Here with the help of specially designed aluminum vessel that contains water will be attached to the cold body of TEG module by which cold body temperature is lowered and maintains the thermal difference between two bodies. A thermoelectric device creates voltage when there is a different temperature on each side.

The main concept, as stated by the manufacturer of TEG module, this device is having hot and Cold bodies, the hot body must be attached With the hot body of furnace, whereas the cold body must be attached with Large heat sink mechanism.

III. CIRCUIT LAYOUT

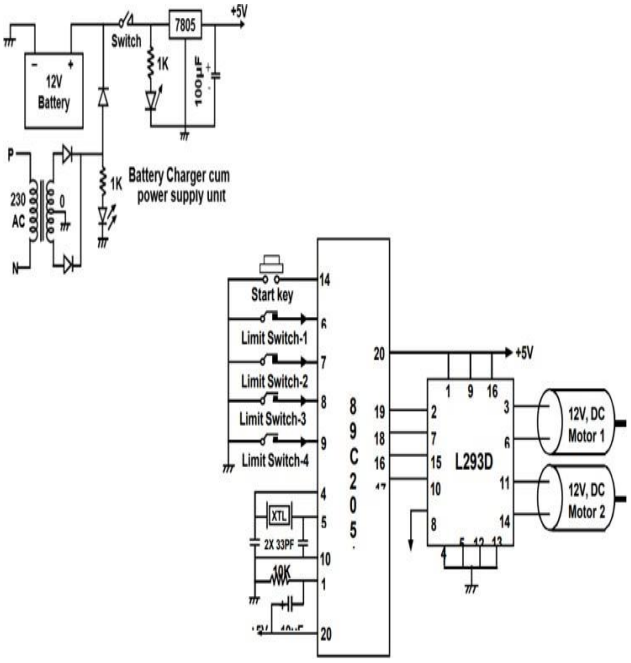
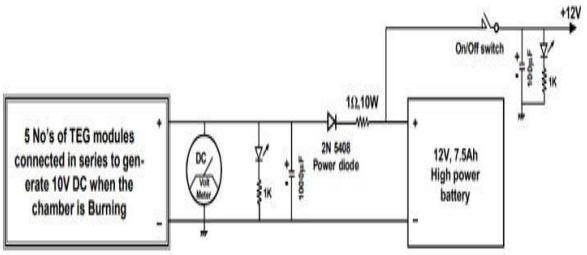


Fig 3: Circuit Diagram of Automatic Dumping Rail



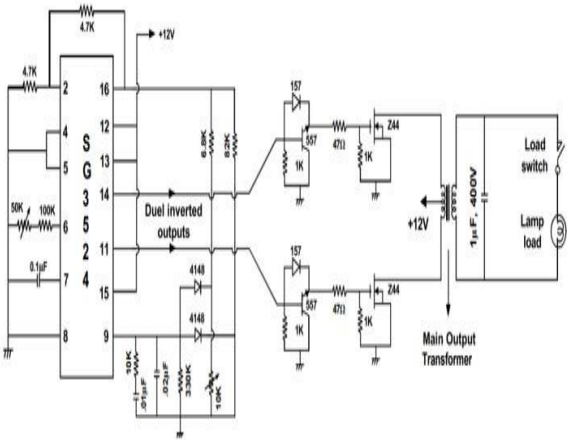


Fig 4: Circuit Diagram of Waste Burning Furnace

IV. WORKING PRINCIPLE

The process begins with the start key, as always the vehicle remains in its home position, the start key must be activated to start the dumping process. The function of this key is to activate the rail and the program for the controller is prepared such that whenever it gets a signal from the start key, the controller drives the 1st DC motor through its driver circuit designed with L293D H bridge IC. This motor coupled with the axel at front side of the chassis carries entire load accommodated over it. This part will be explained later, now as the motor moves in forward direction, the rail starts traveling towards dump yard, and here at the dump yard with the help of a permanent magnet fixed at one point, halting point will be identified. As the rail moves in forward direction at its left side of the chassis at rear side magnetic switch is arranged, whenever the rail reaches to this reference point, magnetic switch will be activated automatically.

A. POWER SUPPLY UNIT:

Battery Charger: A battery charger converts AC mains electricity (230V) into DC voltage suitable for charging a 12V battery. It ensures the battery is safely charged without overcharging or damaging it.

12V DC Battery: The 12V DC battery acts as the primary power source for the entire waste carrying cum dumping vehicle when not connected to mains AC power. It provides the necessary energy to operate: DC motors (used for movement and dumping operations), Microcontroller system (via voltage regulation),Sensors and limit switches. The 12V battery is connected directly to the power supply section of the circuit. It feeds direct 12V to the L293D motor driver IC, which then powers two DC motors. It also supplies input voltage to the 7805 voltage regulator, which steps it down to 5V for microcontroller and logic components. When mains power is available, the battery can be recharged using the battery charger unit built into the system.

Voltage Regulator: The 7805 voltage regulator provides a fixed 5V DC output regardless of input voltage variations (typically 7–15V DC input). It is crucial for powering sensitive components like the microcontroller and logic ICs, which require a precise 5V. L293D motor driver and microcontroller require regulated 5V to operate efficiently and reliably. The 7805 ensures a clean power supply even if the battery voltage fluctuates.

B. PROCESSING AND CONTROL CIRCUIT

The main processing and control circuit is designed with 89C2051 microcontroller chip, this IC belongs to Atmel series is having 20pins and out of 15 pins can be utilized as input or output pins. Means depending up on the program prepared for the IC, input and output pins must be segregated, the input pins are denoted as source input pins or information gathering pins. These pins acquire data from sensors or interrupt signals from switches. Output pins are used to drive the motors and other devices like relays, LED indicators, power components like mosfets, etc. Here the main function of this chip is to drive the garbage dumping rail which performs the function of carrying and dumping the garbage at specific point automatically.

C. CONVERSION OF HEAT INTO ELECTRICITY

The function or process begins with the array of TEG modules connected in series, a Thermoelectric generator or TEG is a solid state device that converts heat directly into electrical energy through a phenomenon called the Seeback effect (a form of thermoelectric effect). Here in this project work, this kind of thermoelectric generators are used and are attached to the body of burning chamber at one side of the furnace which is constructed with aluminum plate. Since it is a prototype module very few TEG modules are used, but for real time applications all sides of the furnace can be constructed with Aluminum plates and N number of TEG modules can be attached to the hot body to generate required voltage and current.

The power generating from the TEG modules depends up on the maintenance of temperature differences between the hot and cold bodies of the TEG modules. When the temperature difference is high, maximum voltage can be acquired from the devices.

when the furnace is burnt and when the hot bodies of the TEG modules temperature raises grater than 85^0 C, it is observed that all devices together generates nearly 10V DC. This voltage source is enough to charge the battery. Since current is also important factor, we found that entire power source is generating grater than 300ma, so power = V X I,

i.e. 10 X .3 = 3 watts approximately, means the battery is charged with .3amps current.

D. CONVERSION OF 12V DC TO 230V AC

The main function of this circuit is to generate 230V AC from a DC Source of 12V. Here IC 3524 is a PWM IC and of is used to generate AC Signals at Dual inverted output. Z44 npn power Mosfets pare used in the dry state to amplify the current. The dry stage is configured in push pull mode of operation such that the switching losses can be reduced and efficiency increased. With the help of a step up Transformer 12V AC signal will be converted into 230VAC.

The power system that generates 230V AC from 12V DC is designed with SGS3524, this is a PWM chip generally used to construct inverters and converters. The oscillator circuit designed with 3524 chip can generate inverted square pulses at two different output pins of the IC. Based on this signal, the drive stage is configured in push-pull mode of operation. The main output transformer used in the driver stage is designed to deliver 0.35 amps current at the secondary. This is a step up transformer and the primary of this transformer is designed for 12V. This is a center tapped primary transformer and the primary is wounded with by- filler winding, i.e., the primary is wounded with two copper

enameled wires simultaneously. Starting of the one winding is clubbed with ending of another wire to form a center tap. The advantage of adopting by-filler winding concept at primary side of the transformer is to maintain the accurate balance; there by the current flowing through both sections of primary remains equal.

V. RESULT

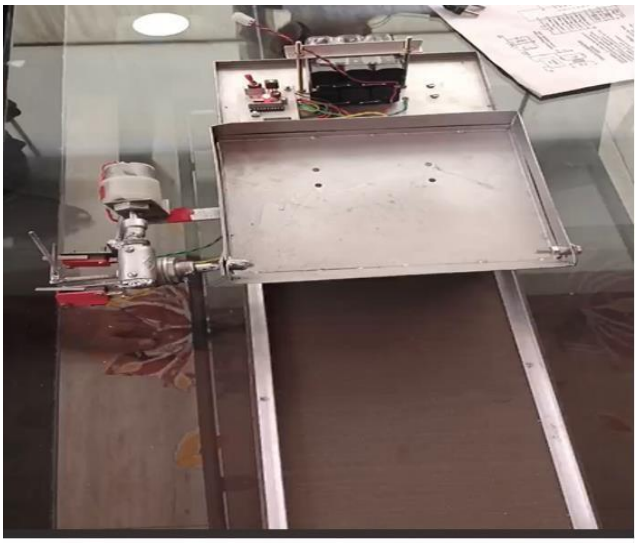


Fig 5: Waste Carrying from Home Position to Furnace

Fig 6: Burning Furnace and Heat Sink Mechanism

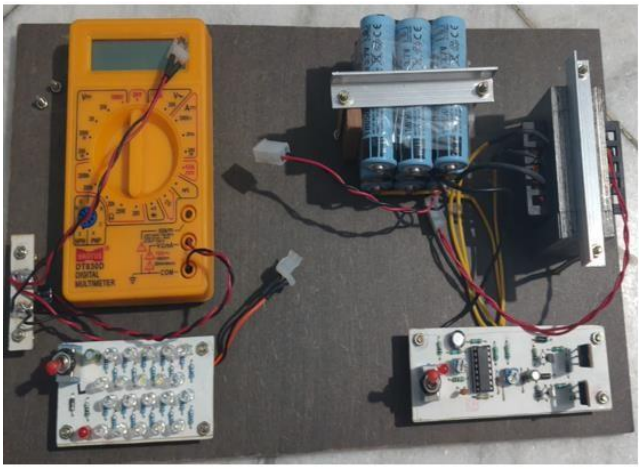


Fig 7: Generating 230V AC from 12V DC

VI. CONCLUSION

The project work “Fully Automated Recycling Mechanism Designed for waste yard” stands as a testament to the powerful intersection of automation, sustainability, and smart engineering. Through the seamless integration of mechanical structures, embedded systems, and renewable energy technologies, this project offers a practical and forward-thinking solution to the ever-growing issue of urban waste management. By automating the entire cycle-from garbage collection and transportation to waste incineration and power generation-this mechanism drastically reduces the need for human intervention in a typically labor-intensive and hazardous domain. The use of a narrow-track, driverless garbage rail, along with a precision-controlled dumping mechanism, ensures not only efficiency but also safety and hygiene in the waste disposal process. Most notably, the inclusion of Thermoelectric Generator (TEG) modules within the furnace design demonstrates a sustainable innovation—converting otherwise wasted thermal energy into usable electrical power. During our trail runs we found that, when the furnace is burning, all 5 TEG modules connected in series are generating nearly 10v DC. As per the specifications mentioned by the manufacturers of these TEG modules, each TEG modules is supposed to generate 4.5V at 150^0C Temperature, but in fact they are not up to the mark and generating less voltage and there by 5 TEG modules are used and are connected in series. All modules attached to the hot body of furnace will be heated up equally when the hot chamber is burnt with full of flames. The current output of each module each module is giving only 300milliamps at 6V, when devices are connected in series, only voltage will be increased but where as current remains same and therefore finally we are getting 300milliamps current at 6V DC.

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