DESIGN AND FABRICATION OF THERMOELECTRIC HEAT EXCHANGER: UTILISING HEAT FOR ELECTRCITY

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Abstract - This project presents the design and fabrication of a thermoelectric heat exchanger integrating Peltier modules for the conversion of heat energy into electricity. By employing thermoelectric generators, the system offers a novel approach to harnessing waste heat for sustainable power generation. Through meticulous design considerations and fabrication techniques, the device aims to optimize energy conversion efficiency, paving the way for applications in energy recovery and thermal management in various industries.

***Key Words*: Thermoelectric heat exchanger, Peltier module, Sustainability, Industrial energy efficiency.**

1.INTRODUCTION

Large amounts of heat are produced as result of industrial processes, and this heat is frequently released into the atmosphere, wasting a large amount of energy. The inefficiencies are a significant obstacle to the sustainability of the environment and the economy. In the pursuit of resource optimization and energy efficiency, the use of industrial waste heat has become essential. Novel approaches to this problem are being investigated, such as the creation of Peltier module-based thermoelectric heat exchangers. These modules present a viable method of recovering and using waste heat from industrial operations.

Creating a thermo-electric heat exchanger that can efficiently capture waste heat and transform it into useful energy is the main goal of this research Through the use of Peltier modules, which take use of the thermoelectric effect, this system seeks to illustrate an effective way to recover and use heat. Numerous factors, including thermal conductivity, heat transfer efficiency, and system reliability, will be considered and optimized during the design and fabrication phases.

This research aims to solve the urgent problem of industrial heat waste by putting forth a novel solution that improves energy production while simultaneously reducing environmental impact. The suggested system provides an adaptable and scalable method of recovering waste heat by integrating Peltier modules into the heat exchange process. Furthermore, the design and fabrication process's incorporation of cutting-edge materials and technical methods should result in a reliable and reasonably priced solution.

To summarise, the development and construction of a thermoelectric heat exchanger that use Peltier modules signifies a noteworthy advancement in tackling the issue of industrial heat waste. By providing an effective and workable solution for waste heat recovery and utilization, this initiative seeks to improve sustainable industrial practices.

1.1 OBJECTIVES OF STUDY

The goal of the project is to develop a thermoelectric heat exchanger prototype that is suited for industrial environments with an emphasis on waste heat recovery. The goal is to maximize heat transfer efficiency while keeping fabrication methods economically viable by carefully adjusting design parameters and material selection. Peltier modules will be incorporated into the heat exchanger to take use of the thermoelectric effect and produce useful energy from heat that has been captured. To evaluate the performance of the exchanger and adjust operational settings for maximum energy recovery, extensive real-world testing will be carried out. A thorough examination will examine the financial feasibility and ecological consequences of putting this technology into practice, taking into account aspects like scalability and possible uses in a variety of industrial domains

The creation of thorough deployment guidelines that enable the smooth integration of thermoelectric heat exchangers into industrial infrastructures will be the project's ultimate goal. By utilizing previously squandered heat

resources, the project ultimately hopes to spark a paradigm shift towards sustainable energy practices, supporting resource conservation and the worldwide necessity of reducing climate change

1.2 PROBLEM STATEMENT

The effective use of waste heat by the industrial sectors is severely hindered, which results in energy loss and negative environmental effects. The goal of this project is to create a thermoelectric heat exchanger that can absorb and transform waste heat from industry into useful energy by employing Peltier modules. The aim of this study is to tackle the demand for an affordable and expandable approach to improve energy efficiency and reduce environmental deterioration in industrial environments.

2. DESCRIPTION OF WORK

1. Peltier Module: - A Peltier module, sometimes referred to as a thermoelectric cooler or TEC, is a solid-state apparatus that, when subjected to an electric current, produces a temperature differential.
2. GA Sheet (Galvanized Iron Sheet): A sheet made of galvanized iron is one that has had a layer of zinc applied to it to prevent corrosion, either on steel or iron.GA sheets might be utilized in your project to build the heat exchanger's exterior casing or enclosure, which would protect and stabilize the internal components.
3. Heat Induction Exchanger: An induction exchanger is a part that is used to help transfer heat without direct contact between two fluids or media. The heat induction exchanger in your idea most likely acts as a conduit between the Peltier modules and the industrial waste heat source. In order to minimize heat loss, maximize heat transfer efficiency, and guarantee the durability of the Peltier modules, the heat induction exchanger is essential.

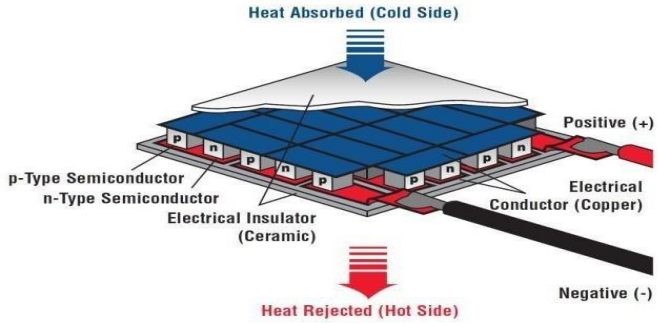


Fig 2.1 : Peltier module internal working

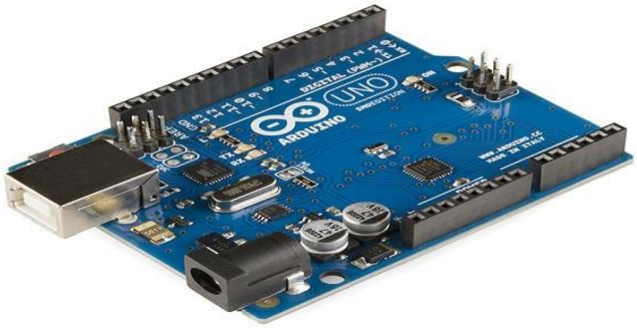
3. METHODOLOGY

The project's methodology consists of multiple crucial components. Initially, a great deal of planning and study is done to establish the goals of the project and develop the thermoelectric heat exchanger's design. After that, the required parts are purchased, including GA sheets, Peltier modules, and materials for heat induction exchangers. The heat exchanger system is then built in accordance with the finalized design during the assembly and manufacturing phase, with careful component integration and connections to an Arduino Uno for control. The heat exchanger's ability to collect and transform waste heat into useful energy is then evaluated through extensive testing and optimization, and any necessary modifications are made to improve efficiency. In order to assess the project's environmental impact and economic viability, data analysis and recording of test results are finally carried out. This process yields insightful information and suggestions for future implementations.

3.1 AURDINO UNO

The Arduino Uno is a microcontroller board developed on the Arduino-designed Microchip ATmega328P microprocessor, offered as open-source hardware. It boasts analog input/output (I/O) pin sets that facilitate interfacing with various expansion modules and circuits. Featuring 14 digital I/O pins (six with PWM capability) and 6 analog I/O pins, the board is programmable through the Arduino Integrated Development Environment (IDE). The term "Uno" originates from Italian and signifies the launch of Arduino Software (IDE) version 1.0 and the corresponding Uno board. Initially introduced as the flagship Arduino USB board, the Uno board serves as the foundation for subsequent Arduino iterations and advancements in the platform.

Fig- 3.1: - Arduino Uno



1.1 HEAT INDUCTION PROGRAM

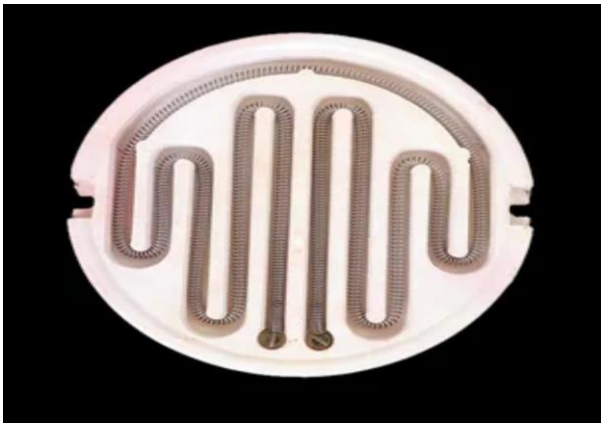


Fig 3.3 Heat induction exchanger

4. ADVANTAGES

- Increased energy efficiency: By efficiently capturing and converting industrial waste heat into useable energy, the thermoelectric heat exchanger maximizes energy productivity while lowering total energy consumption.
- Cost-effectiveness: The project provides a cost-effective solution for waste heat recovery by using Peltier modules, which minimizes operating costs and may result in significant cost savings for industrial facilities.
- Environmental benefits: By lowering the dependency on fossil fuels for energy production and reducing greenhouse gas emissions linked to industrial operations, the initiative helps to maintain a sustainable environment. 8.
- Resource conservation: The project reduces the environmental impact of industrial operations and helps save natural resources by recycling previously squandered heat resources.
    - Scalability and adaptability: The technology created for this project is both scalable and versatile, providing a solution for a range of industrial sectors and applications requiring waste heat recovery.

5.1 AURDINO UNO PROGRAM

```
float temp;
int tempPin = 0;

void setup()
{
Serial.begin(9600);
}

void loop()
{
temp = analogRead(tempPin); temp = temp * 0.48828125;
Serial.print("TEMPRATURE = ");

Serial.print(temp); Serial.print("*C");
Serial.println(); delay(1000);

}
```

6.CONCLUSIONS

In conclusion, we effectively created a thermoelectric heat exchanger that captures and transforms waste heat from industry into useful energy using Peltier modules. The exchanger has shown to be a financially viable way to improve energy efficiency in industrial operations through testing and adjustment. When put into practice, it has measurable advantages for environmental sustainability and resource conservation. The initiative emphasizes the value of innovation in solving energy-related problems and the potential of waste heat recovery technology to advance environmentally friendly industrial processes.

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