ISLAMIC UNIVERSITY OF TECHNOLOGY

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Project No : 01

Project Name : Electricity Generation Using Thermoelectric Plates

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Objective:

This project aims to demonstrate the practical application of thermoelectric generators (TEGs) as a reliable and sustainable method of electricity generation. With the increasing global demand for alternative energy sources, thermoelectric power production offers a promising solution due to its solid-state design, low environmental impact, and ability to convert waste heat into usable electrical energy.
The project focuses on harnessing solar heat and other accessible thermal sources to power TEGs, particularly in portable setups suitable for remote areas, rural environments, and emergency situations where conventional power infrastructure is unavailable. By utilizing the Seebeck effect, thermoelectric modules convert temperature gradients into electricity, enabling the capture of waste heat from domestic and industrial sources.
A key component of this project is the design and evaluation of a lightweight, cost-effective, and user-friendly portable thermoelectric generator based on Peltier plates. The system is intended to supply low-voltage power for essential electrical devices, illustrating the feasibility of decentralized, clean energy generation in real-world scenarios.

Description:

Our end goal is to create a mechanism that can generate electricity with the help of thermoelectric plates, magnifying glass and dry ice. The basic principle that we will be using here is the Seebeck effect.

TEGs are devices that convert heat into electricity. They work on the principle of the thermoelectric effect, which is the phenomenon of electrical voltage being generated when there is a temperature difference between two different materials. TEGs are typically made up of two dissimilar materials, called the p-type and n-type semiconductors, which are sandwiched together to form a thermocouple. When a temperature gradient is applied to the thermocouple, a flow of electrons is generated, producing a voltage.

One of the key benefits of TEGs is their versatility. They can be used to generate electricity from a variety of heat sources, including wood stoves, biomass cookstoves, and waste heat from industrial processes. They can also be used in conjunction with renewable energy sources, such as solar panels or geothermal heat pumps, to generate electricity.

TEGs have several advantages as a means of electricity generation. They are reliable and have a long lifespan, with no moving parts to wear out. They are also relatively simple and inexpensive to manufacture, making them a cost-effective option for generating electricity. In addition, TEGs can operate in a wide range of temperatures and environments, making them suitable for use in a variety of applications.

One common application for TEGs is in remote or off-grid locations where access to the grid is limited or unavailable. They can also be used to power remote sensing and communication systems, as well as for emergency backup power.

Despite their many advantages, TEGs have some limitations as a means of electricity generation. One limitation is that they are not very efficient, with typical conversion efficiencies ranging from 5% to 15%. This means that a significant portion of the heat input is lost as waste heat. In addition, TEGs are only capable of generating small amounts of electricity, making them less suitable for large-scale power generation.

In conclusion, TEGs are a promising technology for generating electricity in a variety of applications, particularly in remote or off-grid locations. While they have some limitations, their versatility, reliability, and simplicity make them an attractive option for generating electricity from heat sources.

Electricity generation using dry ice, also known as cryogenic energy, is a relatively new and innovative method of producing electricity that has gained attention in recent years due to its potential to provide a clean and renewable energy source.

Dry ice, also known as solid carbon dioxide, is a type of frozen carbon dioxide that is commonly used as a refrigerant and as a cooling agent in various industrial and scientific applications. It has a temperature of -109.3°F (-78.5°C) and is produced by cooling and pressurising liquid carbon dioxide until it turns into a solid.

One way that dry ice can be used to generate electricity is through the use of thermoelectric generators (TEGs). These generators work by using the temperature difference between two materials to produce an electrical current. When dry ice is placed in contact with a warmer material, such as a metal conductor, the temperature difference between the two materials causes the flow of electrons, which can be harnessed to generate electricity.

Another way that dry ice can be used to generate electricity is through the use of a cryogenic turbine. In this process, dry ice is vaporised and used to turn a turbine, which in turn generates electricity. This method is similar to the way that traditional power plants generate electricity using steam, but with the added benefit of using a clean and renewable energy source.

One potential advantage of using dry ice to generate electricity is that it is a clean and renewable energy source. Carbon dioxide is a naturally occurring gas that is present in the Earth's atmosphere, and the production of dry ice does not generate any harmful emissions or contribute to air pollution. Additionally, dry ice can be produced using carbon dioxide captured from industrial processes, such as the burning of fossil fuels, which can help offset the carbon emissions associated with these activities.

Another potential advantage of using dry ice to generate electricity is that it is a relatively low-cost and efficient energy source. Dry ice is readily available and can be produced in large quantities, making it an attractive alternative to traditional energy sources such as coal and natural gas. Additionally, the use of dry ice to generate electricity is highly efficient, with some estimates suggesting that it can produce up to 70% of the electricity that is used to produce it.

There are also some potential challenges to the use of dry ice to generate electricity. One challenge is that dry ice is solid at room temperature, which means that it must be stored and transported at low temperatures. This can be a logistical challenge, as it requires special equipment and handling to prevent the dry ice from melting.

Another challenge is that the use of dry ice to generate electricity is still in the early stages of development, and more research is needed to optimise the technology and bring it to a wider market. However, with continued research and development, it is possible that dry ice could become a viable and cost-effective alternative to traditional energy sources.

Electricity generation using dry ice is a promising new method of producing electricity that has the potential to provide a clean and renewable energy source. While there are still challenges to overcome, the use of dry ice to generate electricity has the potential to revolutionise the way we think about energy production and consumption.

Keywords:

Thermoelectric Generators(TEG), Seebeck Effect, Solar Energy, Green Energy, Solar Intensity Tracker, Dry Ice, Thermal Paste, Highly Capable Magnifying Glass, LDR, Arduino, Servo Motor

Working Principle:

Thermoelectric Plates use the principle of Seebeck Effect. When a temperature gradient is applied to two dissimilar conductors, then charge carriers tend to drift away from the hot side to the cold side. This results in a flow of electrons. With proper care, this phenomenon can be utilised to produce electricity.

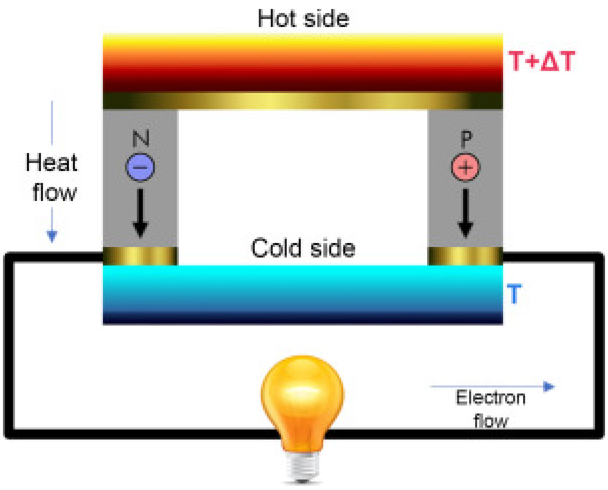

Figure: A simplified demonstration of Seebeck effect

Thermoelectric Generators make use of this phenomenon. Thermoelectric Generators have many N type and P type couples. All of them are electrically connected in series and thermally connected in parallel. A single unit of those Thermocouples are shown below.

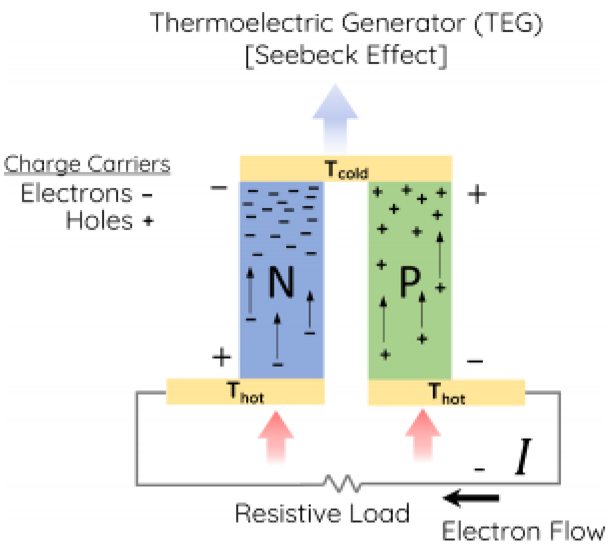

Figure: Thermocouple

The N type material works as the electron supplier and the P type material works as the electron collector.

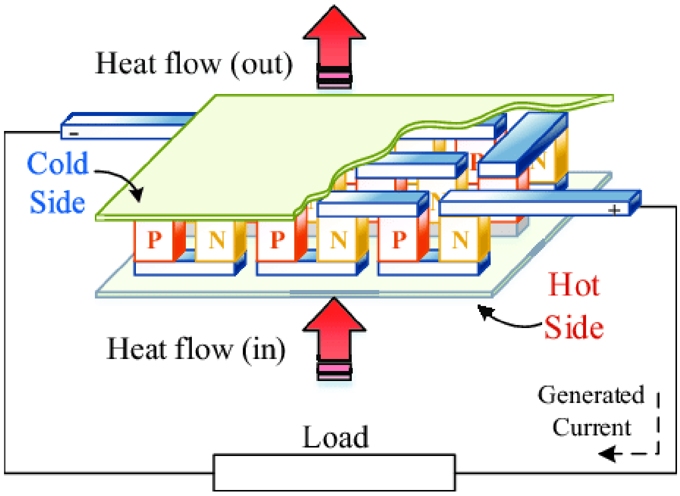

Figure: Series Connection of Thermocouples

Combining all these units, a single Thermoelectric Generator Module(TEG) is made.

Figure: TEG Module

Many TEG modules can be electrically connected in series and thermally connected in parallel, to increase the power obtained from the Thermoelectric Generators.

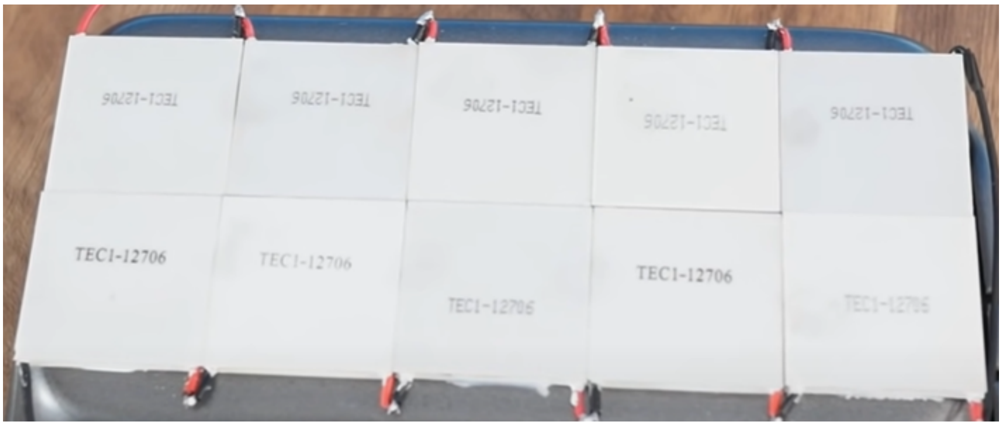

Figure: Many TEG modules connected in Series

For these Thermoelectric Generators to work, there must be a temperature difference between the two surfaces of the TEG. We wanted to use Solar Energy to heat up one of the surfaces and Dry Ice to cool down the other surface. This will cause a temperature difference between the two surfaces of the TEG. To distribute the heat properly between all the TEG modules, thermal paste has to be used. A highly capable magnifying glass has to be used to concentrate the Solar energy on a small area of the surface of the TEG modules. The position of the sun varies with time throughout the day. To always get the maximum intensity of the sun, a Solar Intensity Tracker was made.

The Solar Intensity Tracker was made using two LDR and a Servo Motor.

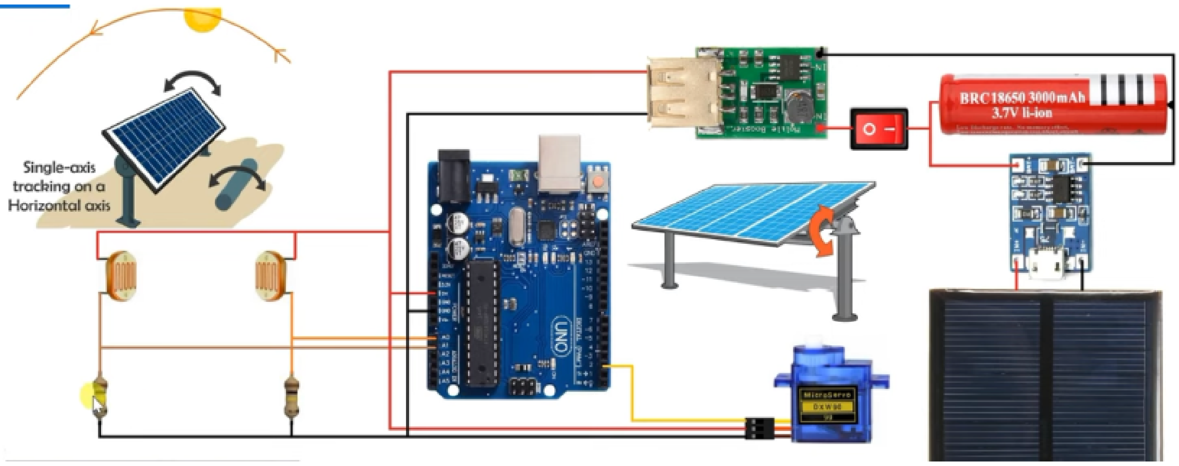

Figure: Circuit Diagram of the LDRs and Servo Motor

The Two LDRs were placed on the two sides of the cork sheet which contained the magnifying glass. The LDRs were directly powered by a 5V battery. Two resistors were connected with the LDRs. The other end of the two resistors are grounded. The resistance of the LDRs varies as the light intensity falling on it varies. Consequently the potential drop across the two resistors also varies as light intensity varies. The potential drop across the resistors are sent as input signals to the Analog A0 and A1 pin of the Arduino. As long as the difference between the two potentials is less than a certain threshold value, the Arduino won’t send any signal to the servo motor. When the potential across the two resistors vary more than the threshold value, the Arduino will send a signal to the servo motor to rotate its position towards the LDR that has more intensity of light falling on it. This will ensure that the TEG plates always get the maximum intensity of light falling on them.

Arduino Code:

```
#include <Servo.h> //includes the servo library

Servo myservo; //myservo-->servo object

#define ldr1 A0 // set ldr 1 Analog input pin of East ldr as an integer
#define ldr2 A1 // set ldr 2 Analog input pin of West ldr as an integer

int pos = 90; // initial position of the Horizontal movement controlling servo motor
int tolerance = 10; // allowable tolerance setting - so solar servo motor isn't constantly in motion

void setup() {
  myservo.attach(2); // attaches the servo on digital pin 2 to the horizontal movement servo motor
  pinMode(ldr1, INPUT); //set East ldr pin as an input
  pinMode(ldr2, INPUT); //set W `est ldr pin as an input
  myservo.write(pos); // write the starting position of the horizontal movement servo motor
  Serial.begin(9600);
  delay(1000); // 1 second delay to allow the solar panel to move to its staring position before comencing solar tracking
}

void loop() {
  int val1 = analogRead(ldr1); // read the value of ldr 1
  int val2 = analogRead(ldr2); // read the value of ldr 2
  Serial.println(val1);
  Serial.println(val2);
  Serial.println(pos);
  if ((abs(val1 - val2) <= tolerance) || (abs(val2 - val1) <= tolerance)) {
    //no servo motor horizontal movement will take place if the ldr value is within the allowable tolerance
  } else {
    if (val1 > val2) // if ldr1 senses more light than ldr2
    {
      pos = pos - 1; // decrement the 90 degree poistion of the horizontal servo motor - this will move the panel position Eastward
    }
    if (val1 < val2) // if ldr2 senses more light than ldr1
    {
      pos = pos + 1; // increment the 90 degree position of the horizontal motor - this will move the panel position Westward
    }
  }
  if (pos > 130) {
    pos = 130; // reset the horizontal postion of the motor to 130 if it tries to move past this point
  }
  if (pos <60) {
    pos = 60; // reset the horizontal position of the motor to 60 if it tries to move past this point
  }
  myservo.write(pos); // write the starting position to the horizontal motor
  delay(50);
}
```

Explanation of the Arduino Code:

At first the servo.h library was included. The servo motor being used was named myservo. Then pin A0 and A1 was defined as the input pin corresponding to the two LDRs. The initial position of the servo motor was set 90 degrees. The tolerance between the two LDR was set at 10 units. Pin 2 of the arduino was attached to the servo motor. Pin A0 and A1 were set as the input pin. The data stored inside the pos variable was set as the input to the servo motor. A serial monitor was initialised with the Baud rate set at 9600. The analog potential drop across the two resistors was read and stored in two variables named ‘val1’ and ‘val2’. The serial monitor was made to print the values of val1, val2 and pos. If the difference between the values of val1 and val2 is less than the tolerance, then the servo will remain as it is, i.e. it won’t rotate. If the difference between the values of val1 and val2 is greater than tolerance, then the value of pos is increased or decreased by 1 degree depending on where the intensity is more. The maximum rotation angle is set between 60 and 130 degrees, to prevent the system from being rotated towards its maximum limit. The delay between each 1 degree of rotation is set to 50ms to prevent the system from rotating too fast.

Conclusion:

Thermoelectric plates have a cap on efficiency. However, it is very reliable and economical if the temperature difference is created using renewable energy or waste heat energy. Many studies have already been conducted in this field which have shown a lot of potential, particularly in space probes and medical applications. Because thermoelectric plates require only temperature difference, it can be used in areas where conventional green energy would prove to be futile. For instance in extremely cold areas, the sunlight can barely be noticed, thereby making solar energy less workable. But here thermoelectric plates can be used in large scale to leverage the extremely cold temperatures.