ADVANCED THERMODYNAMICS LABORATORY REPORT

First law analysis using a heat pump and heat engine

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1.Aim

Analysing the first law of thermodynamics using heat engine and heat pump with the aid of Peltier device.

2.Introduction

First law of thermodynamics is also called as conservation of energy principle, provides a solid basis for the study of relations between the different forms of energy and energy interaction. So, first law of thermodynamics 'that the energy can be neither created nor destroyed, it can only change forms. So, here in this experiment follows this principle.

Firstly, close the circuit towards the heat pump. Then the energy will be created and supplied to the Peltier and the Peltier will pumps heat from one aluminium block to the other. When there is temperature difference, which is established in between the blocks. Then the next step is to switch the Peltier into Heat engine mode. So, heat will flow through the higher temperature block to cold block through the Peltier. When the heat flows from the hot block through Peltier creates electrical energy and transmits to the load resistor. The temperature of the aluminium block reaches 90 degree Celsius.

3. Method

3.1 Equipment Used

The equipment used for experiment are as follows:

- Thermoelectric circuit board foam insulator (2 Nos)
- Banana patch cords (5 Nos)
- Temperature cables (2 Nos)
- DC power supply (10V, 1A)
- PASPORT voltage/current sensor
- PASPORT quad temperature sensor
- PASPORT interface
- Pascoe Capstone software
- Conservation of energy configuration file for Capstone software

3.2 Experimental Setup

1. Before connecting the input power, check the Heat pump/Heat engine is in neutral position

2. Use banana patch cords to connect the power supply to the input terminals on circuit board. Also note down the polarity.
3. Link a terminal jumper at board bottom to terminal B and it makes a total load resistance of 10 ohm
4. Connects cables to quad temperature sensor from the temperature port. Also, link the cold side to sensor channel 1 and the hot side to the channel B as shown in figure 1.
5. Connect voltage sensor to the voltage port and note down the polarity.
6. Link different cords of red and black banana patches from the voltage sensor to voltage port and note the polarity.
7. Finally, connect the laptop through the PASPORT interface.

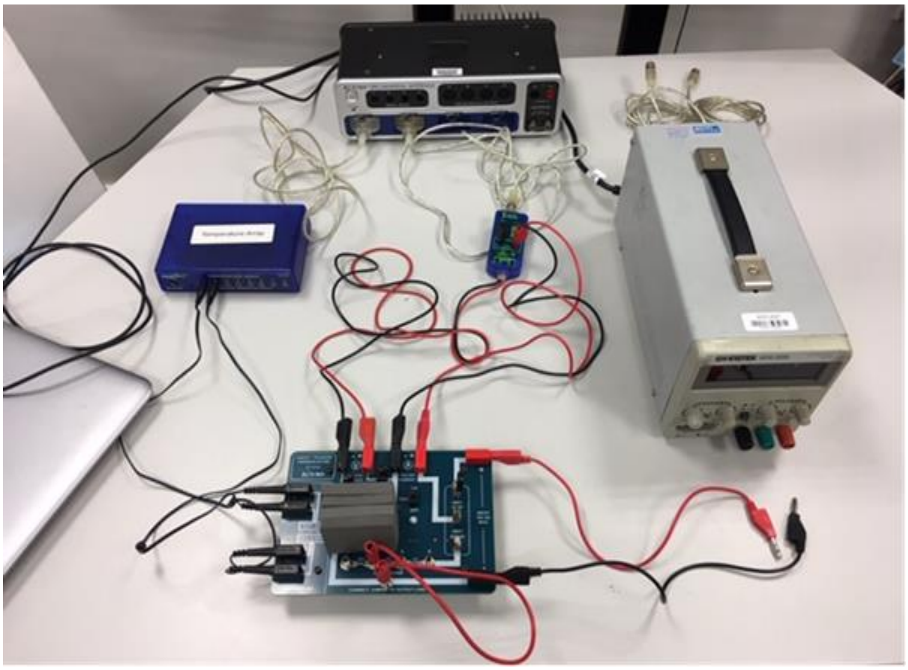

Figure 1: Experimental setup

3.3 Experimental Procedure

- All the equipment listed are connected using the appropriate cables to obtain the data in digital form using PASCO Capstone software when the experiment is carried out. Initially the aluminium blocks should be kept room temperature and the knife switch should be in neutral position.
- Turn on the circuit and 3.5 volts DC supply is maintained. The data are recorded using the Capstone software.
- Using the knife switch the circuit is set to heat pump mode. This mode is maintained for about 120 seconds.

- The circuit is shifted to heat engine mode with the aid of knife switch. The recording of data is continued for another 120 seconds
- The area under the graph obtained in digital form represents the power generated during the heat engine mode and the power used during the heat pump mode.
- The heat energy supplied from the Peltier moves in and out of aluminium blocks as a result the temperature of aluminium block changes.
- The values obtained are used for calculating the heat loss and efficiency of the cycle

4. Formula used

4.1 Heat Pump

Qhot theory = Qcold +W

Qhot is the actual heat added hot reservoir

Qcold is the heat rejected from the cold reservoir

Qhot theory is the theoretical value of heat added to the hot reservoir

Qlost = Qhot actual – Qhot theory

COP = 1/(1-Tmin/Tmax)

4.2 Heat Engine

Qhot theory = Qcold + W

Qhot is the heat flow out of the hot reservoir

Qcold is the heat flow in the cold reservoir

Qhot theory is theoretical value of heat flow out of the hot reservoir

Qlost = Qhot actual – Qhot Theory

Thermal Efficiency = W/ Qhot actaul

4.Results

4.1 Heat Pump

Table 1:calculations of Heat pump

Qhot actual (Joules) Heat addition	Qcold (Joules) Heat Rejection	W Power Used	Qhot Theory (Joules)	Qlost (Joules)	COP
170.55	125.02	74.82	199.84	29.29	1.947368421

4.2 Heat Engine

Table 2:Calculations of Heat engine

Qhot actual (Joules) Heat flow out	Qcold (Joules) Heat flow in	W Power generated	Qhot Theory (Joules)	Qlost (Joules)	Thermal efficiency (%)
102.24	101.27	0.53	101.8	0.44	0.518388106

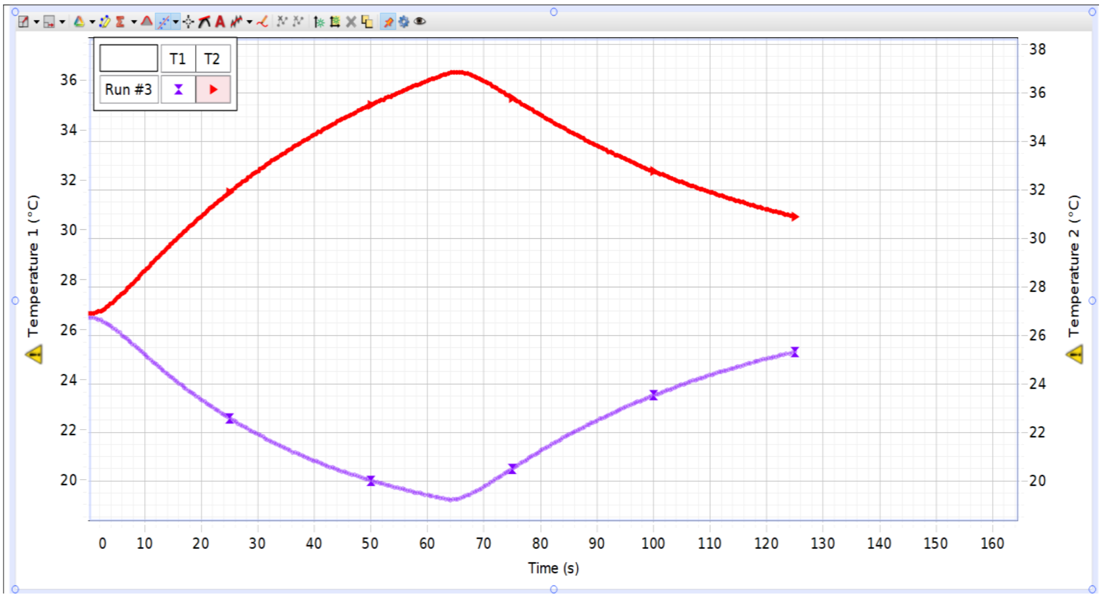

Figure 2:Temperature vs time graph

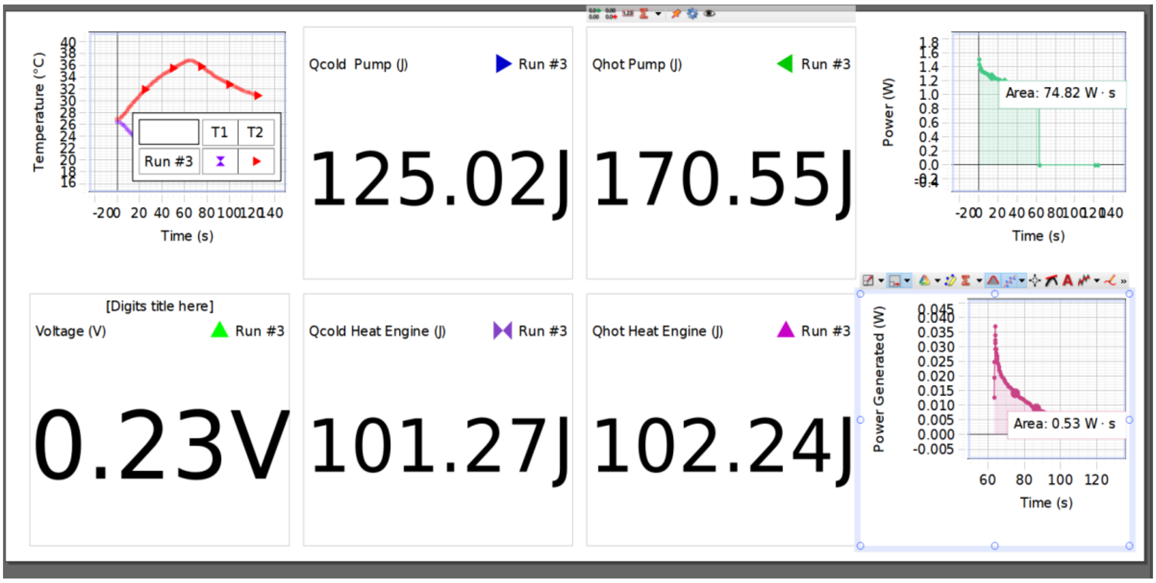

Figure 3:Results of heat pump and heat engine

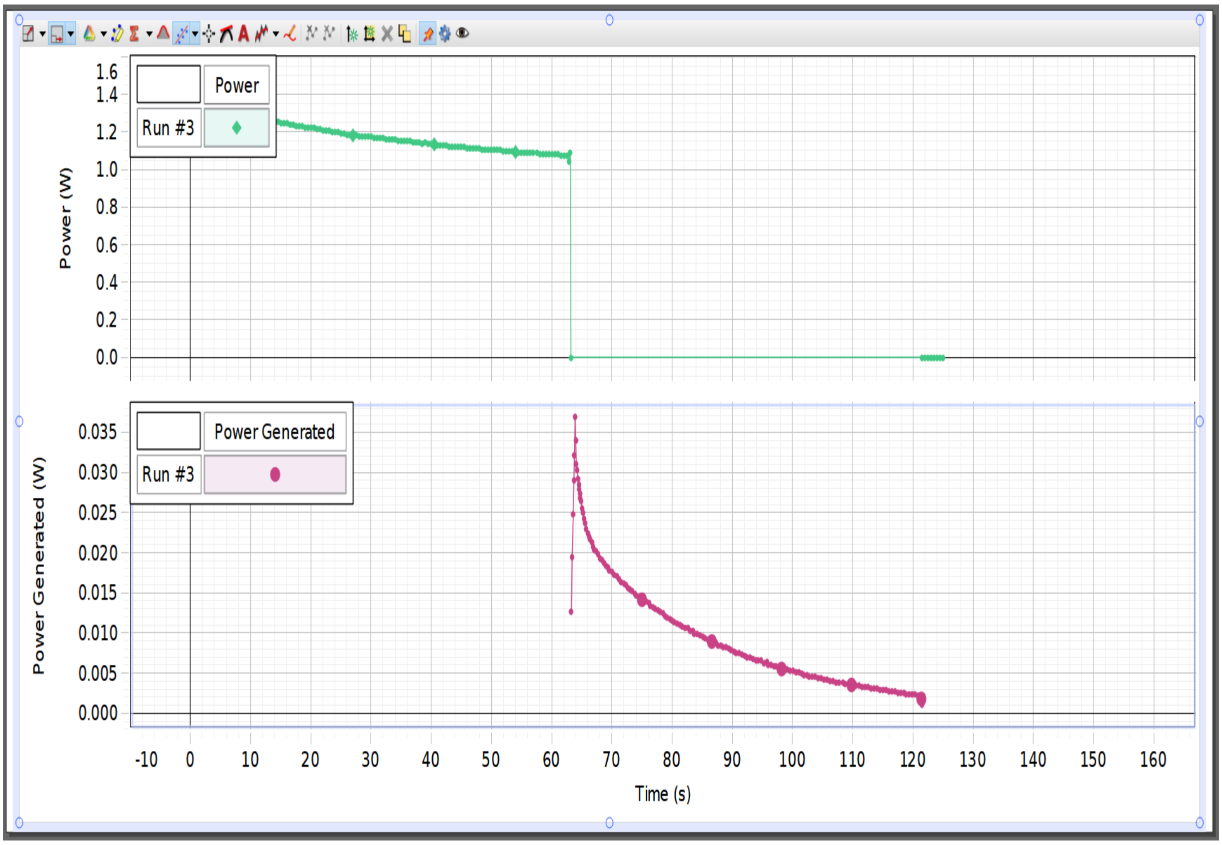

Figure 4:power, Temperature vs time graph

5. Discussion

5.1 Heat pump Mode

- In the case of heat pump the heat energy is pumped out of the cold reservoir to the hot reservoir.

- As per the first law of thermodynamics, the work done to pump the heat energy and the heat flow out of the cold reservoir should be equal to the heat added to the hot reservoir.
- The power used to pump the heat energy is 74.82 J and the heat energy out of the cold reservoir is 125.02 J.
- The Qhot actual is the heat energy flows into the hot reservoir Qhot actual value is 170.55 J
- The theoretical value as per the fist law of thermodynamics is 199.84 J.The difference between the Qhot actual and Qhot theoretical is the heat lost to the environment.
- 29.9 Joules of heat energy is lost to the environment.
- To find the coefficient of performance of the heat pump the formula mentioned above is used.
- From figure 4 the maximum temperature is 37 and minimum temperature is 18.
- The COP of the heat pump in this case is 1. 974.The higher the COP value lesser the operating costs of the pump.
- To increase the efficiency of the heat pump we should reduce the temperature difference.
- Lesser the temperature difference higher the COP of the pump.
- So there is a significant heat loss of 29.9 Joules in this case. If we can reduce the heat loss to the environment, it will reduce the temperature difference.

5.2 Heat Engine Mode

- In case of heat engine, the heat is converted into work and the remaining is transferred to the cold reservoir.
- As per the first law of thermodynamics the heat flows out of the hot reservoir should be equal to the work done and heat flows into the cold reservoir.
- There will be always losses in a system and to find the heat energy lost to the atmosphere we use the first law of thermodynamics.
- The power generated in this test is 0.53 J. This is the work output from the heat engine.
- As we can see form table 2 the Qhot actual value and Qhot theoretical value are not the same.

- There is difference of 0.44 joules between these values. This is the heat lost to the environment.
- The thermal efficiency of the heat engine is work output by heat flow out of the hot reservoir.
- In this case the efficiency of the heat engine is 0.51%. This is because the work done is very less compared to the heat flows out of the hot reservoir.
- To increase the efficiency of the heat engine the work done should be much more than the heat transferred to the cold reservoir.
- So, in this case if the work output is more than 50 J, then the efficiency of the heat engine will be 48%.
- When the work output increases the heat transferred to the cold reservoir decreases.
- Another method to improve efficiency is by reducing the heat lost to the environment, but in this case the heat lost is only 0.44 joules which is almost a negligible value.

6.References

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