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Experiment Number (3)

Digital Joulemeter

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Abstract:

An electronic device called joulemeter is used to measure how much energy is being transferred across a circuit in order to determine the specific heat capacity and latent heat of a metal, which was for this experiment aluminum. According to the experiment's findings, aluminum had a specific heat of 1128.481 (J/ (kg. k) and a latent heat of vaporization of 1965 (J/ (kg. k). The goal of the following part of the experiment, was to examine a tiny electrical motor's efficiency and analyze how it changed with load and applied voltage, the motor was given a voltage by a power supply, so the motor can lift the weight, the input energy was determined by a joulemeter, the efficiency was calculated by dividing the input and output energies. Moreover, the outcomes demonstrated that altering the mass lifted or the voltage had an impact on the efficiency.

how??

water

latent heat capacity for liquids not for metals

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Result

Experiment 1: Determine the specific heat capacity for a metal

The experiments were performed at 22°C under atmospheric pressure.

Table (1): Results of Specific heat Capacity of a metal experiment

Mass of Aluminum Block (g)	Joule meter reading (J)	T_1 (°c)	T_2 (°C)	C_p theoretical (J/(Kg.K)	C_p experimental (J/(Kg.K)
1011.98	1142*10	25	35	4150	1128.481

Experiment 2: Determine the latent heat vaporization for a liquid

Table (2): Results of Specific latent heat of vaporization of liquids experiment (Boiling point of water was 89 °C)

Change in Mass of liquid (g)	Temperature of liquid (°C)	Joule meter reading (J)	λ theoretical (KJ/Kg)	λ experimental (KJ/Kg)
10	89	1965*10	2285	1965

Experiment 3: Determine the efficiency of a small electrical motor

Table (3): Results of efficiency of a small electrical motor experiment (current was 0.7 A)

	At constant voltage (5 V)				At constant mass (220.23 g)		
Change in height (cm)	Mass lifted (g)	Total Mass (g)	Joule meter reading (J)	η (%)	Voltage (V)	Joule meter reading (J)	η (%)
50	200	220.23	2	54.01%	4	4	27.01%
Mass of hanger (g)	300	320.23	5	31.41%	5	2	54.01%
20.23	400	420.23	8	25.77%	6	2	54.01%

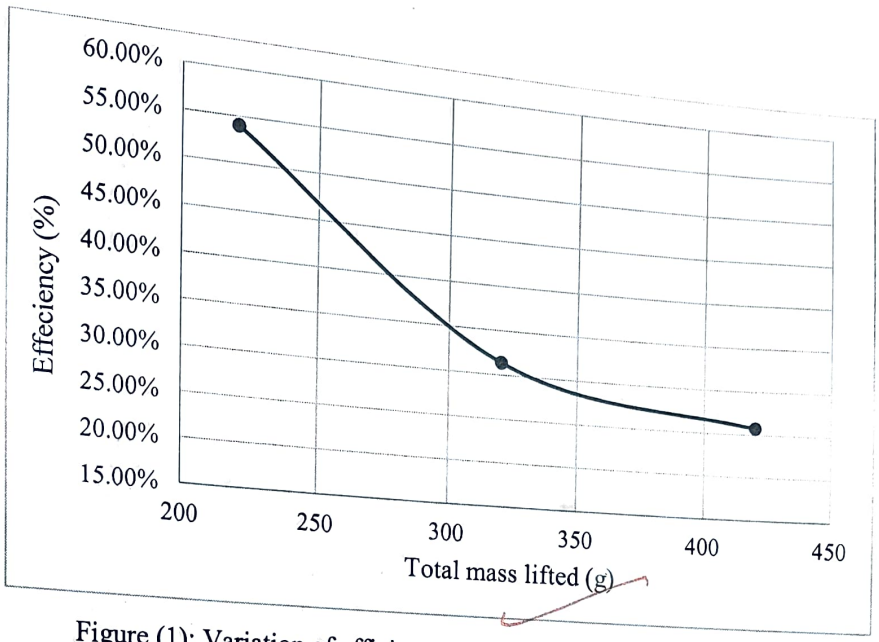

Figure (1): Variation of efficiency with load at constant voltage (5 V)

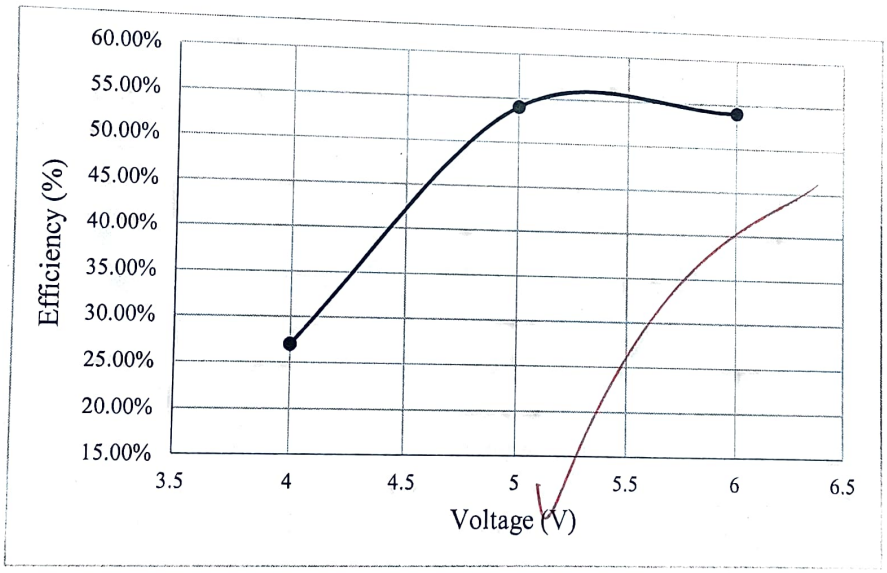

Figure (2): Variation of efficiency with applied voltage at constant mass (200.23 g)

Discussion

Experiment 1: Determine the specific heat capacity for a metal

Specific heat, Csp, is the amount of heat required to change the heat content of exactly 1 gram of a material by exactly 1°C. In this experiment, the amount of electrical energy transferred from a 12volt and 50 ampere power resource as a form of heat to rise the temperature of the aluminum block by 10 C , was measured using the digital joulemeter.

As shown in table (1) the amount of heat transferred is 11420J and the specific heat calculated from experimental data is 1128.481 J/(Kg.K). The tabulated specific heat capacity Cp,s for aluminum is 890 (J/kg °C) . The 26.74% error in the data may be due to the poor insulation around the aluminum block, or personal error in reading the temperature from the thermometer.

From where? last Ref.

Experiment 2: Determine the latent heat vaporization for a liquid

When a substance in the liquid phase is given energy (heat), the temperature will increase to a certain point and then stop increasing, that is when the phase changes from liquid to vapor. Once all that substance is in the vapor phase, heating it will increase its temperature.

The energy absorbed in changing the phase from liquid to vapor without changing the temperature is called the latent heat of vaporization, and it is a physical property of a substance. The latent heat of vaporization of water at 100 C and 1 atm is about 2260kJ/Kg which is equal to 40.8kJ/mol. In this experiment the atmospheric pressure was 680mmhg it was expected that the boiling point for water will be less than 100 c, since its 100C at 760 mmHg.

why

As shown in table (2) the latent heat of vaporization calculated from experimental data at 89C is 1965 (KJ/Kg), the tabulated data for the latent heat of vaporization for water at 89C IS 2285 (KJ/Kg).

we measure the water boiling temp.

The 14% error in the result could be caused by a false reading for the boiling point from the thermometer due to personal or systematic errors, knowing that the boiling point for water at 680mmgh should be around 96C, that error could also be caused by the impurities in water.

→ as a reference
→ explain why our experimentally boiling point was much lower than 100°C

Experiment 3: Determine the efficiency of a small electrical motor

In this part, the efficiency of the motor has been calculated by finding the ratio between the electrical energy provided to the motor to the mechanical energy -which is the desired form of energy to be converted to-.

According to the first law of thermodynamics, energy can neither be created nor destroyed, only altered in form. In the electric motor, part of the electric energy is converted to an unwanted form of energy such as heat or energy needed to resist friction.

Increasing the mass increases the energy needed to move the weights, using more energy means more energy is lost during the proses which explains decreasing the efficiency when increasing mass as shown in figure(1).

Although increasing the voltage while using fixed mass decreases the energy needed to lift the weights, achieving higher efficiency, as shown in figure (2).

Conclusion

- There is some inaccuracy in calculating the specific heat, where the error rate is approximately 26.74%, and this is due to two possibilities: The first is a personal error while reading the temperature from the thermometer . The second is the most likely and is the weakness of the insulation around the aluminum block.
- Voltage and power supply effectiveness are inversely correlated.
- When energy (heat) is applied to a substance in the liquid phase, the temperature will rise to a certain degree and then level off; at that point, the phase transition from liquid to vapor occurs , when all of that stuff has vaporized. It will become hotter when heated.
- The boiling point for water is less than 100°C according to atmospheric pressure (680) .
- The efficiency decrease when the total mass lifted increased at constant voltage 5 V as we see in figure(1) .
- Constant mass, variable voltage; as the voltage rises, the motor's efficiency increases (direct relation).
- As mass grows, more energy is required to move the weights.

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Appendix

Experiment 1: Determination of the specific of heat capacity of metal

Mass of (Al) block = 1011.98g

Joule meter reading (Q) = 11420 J

Initial temperature(T_1)= 25 °C

Final temperature(T_2)= 35 °C

Temperature difference (ΔT) = $T2 - T1 = 35 - 25 = 10K$

$Q = m * C_p * \Delta T$ $C_p = \frac{Q}{m*\Delta T}$

$C_p = \frac{11420\ J}{\left(\frac{1011.98}{1000}\right)kg*(35-25)k} = 1128.48 \frac{J}{(Kg.k)}$

Experiment 2 : Determination of the specific latent heat of vaporization of liquid

Mass of vaporized water = 10g

Temperature of liquid water = 89 °C

Joule meter reading (Q) = 19650 J

$\lambda = \frac{Q}{m_{evaporated}} = \frac{19650/1000}{(10/1000)} = 1965 \frac{KJ}{kg}$

Experiment 3 : Investigation of efficiency of small electrical motor and study its variation with load and applied voltage

- **Taking the first raw as sample of calculation**

1. At constant voltage = 5v

Change in height = 50cm

Mass of hanger =20.23g

Mass added =200g

Total mass = mass added + mass of hanger

= 20.23 + 200 = 220.23 g

Joule meter reading = 2J (input energy)

$\eta = \frac{input}{0utput} * 100\% = \frac{potential\ energy}{electrical\ energy} * 100\% = \frac{m * g * h}{Q} * 100\%$

$$= \frac{\left(\frac{220.23}{1000}\right)Kg * 9.8 * \left(\frac{m}{s^2}\right) * \left(\frac{50}{100}\right)m}{2\,J} * 100\% = 54.01\,\%$$

2. At constant mass =220.23g

Change in height = 50cm

Voltage = 4 v

Joule meter reading = 4 J

$$\eta = \frac{\text{input}}{\text{0utput}} * 100\% = \frac{\text{potential energy}}{\text{electrical energy}} * 100\% = \frac{\text{m} * \text{g} * \text{h}}{\text{Q}} * 100\%$$

$$= \frac{\left(\frac{220.23}{1000}\right)Kg * \frac{(9.81)m}{s^2} * \left(\frac{50}{100}\right)m}{4J} = 27.0\%$$

Digital Joulemeter Data Sheet

1. Specific heat Capacity:

Mass of AL-Block	1011.989
Joule meter reading	1142*10 J
T_1	25 °C
T_2	35 °C

2. Specific latent heat of vaporization:

Initial mass of liquid	10g
Final mass of liquid	10g
Temperature of liquid	89°C
Joule meter reading	1965*10 J

3. Efficiency of a motor:
   Change in height=…~~70~~-~~20~~=50…cm
   Mass of hanger=…~~20~~.~~23~~……..g

a. At constant Voltage=…..5……V

Mass lifted (g)	Joule meter reading
200	2
300	5
400	8
500	

a. At constant mass=….~~200~~ 300…..g

Voltage (V)	Joule meter reading
5	2
4	4
6	2

Instructor signature:	Aw
Date:	2/11/2022