THE UNIVERSITY OF JORDAN

FACULTY OF ENGINEERING AND TECHNOLOGY

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DEPT.OF CHEMICAL ENGINEERING

Chemical Engineering laboratory 2 (0915461)

Section no. (1)

Experiment Number (3)

Digital Joulemeter

Short report

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1. ABSTRACT

The main goals of this experiment are to find the specific heat capacity of metal (Aluminium) and latent heat of vaporization of liquid (water) by using a digital joulemeter device that measures the energy in joule and power in watts. It can be used with both direct and alternating current according to the need for the type of current. And to find the efficiency of the electrical motor with different loads and voltage by calculating the input energy (electrical energy) divided by the output energy (mechanical energy) consumed to the left Weights.

The result:

1. The efficiency increases with voltage

2. Latent heat of vaporization of water experimental =1310 j/g

3. Specific heat capacity of Aluminum experimental =11.23j/g.k

2. RESULTS

Table (1): Specific heat Capacity experiment

mass of the block (g)	1012.23
Joule meter reading (J)	12490
T1	30
T2	40
calculated Cp (J/g.k)	1.233909289
true Cp of Al	0.903
Erorr(%)	36.645547

Table (2): Specific latent heat of vaporization experiment

Mass Difference (Initial mass – Final mass) (g)	10
T(ºC)	89
T(K)	362.15
Joulemeter Reading (J)	13100
Calculated Latent Heat of Vaporization of water at T(ΔHvap) (J/g or KJ/Kg)	1310
True Latent Heat of Vaporization of water at T($\Delta Hvap$) (J/g or KJ/Kg)	2282.5
Error (%)	42.6067908

Table (3): Efficiency of a motor at constant voltage 5v

Mass Lifted (with the mass of the hanger) (g)	Joulemeter Reading (input) (J)	Potential Energy mgh (output) (J)	Efficiency %
120.23	2	0.58972815	29.48641
220.23	2	1.08022815	54.01141
320.23	6	1.57072815	26.1788

Table (4): Efficiency of a motor at constant mass 200g

Voltage	Joulemeter Reading (input) (J)	Potential Energy mgh (output) (J)	Efficiency %
4	4	0.981	24.525
5	2	0.981	49.05
6	2	0.981	49.05

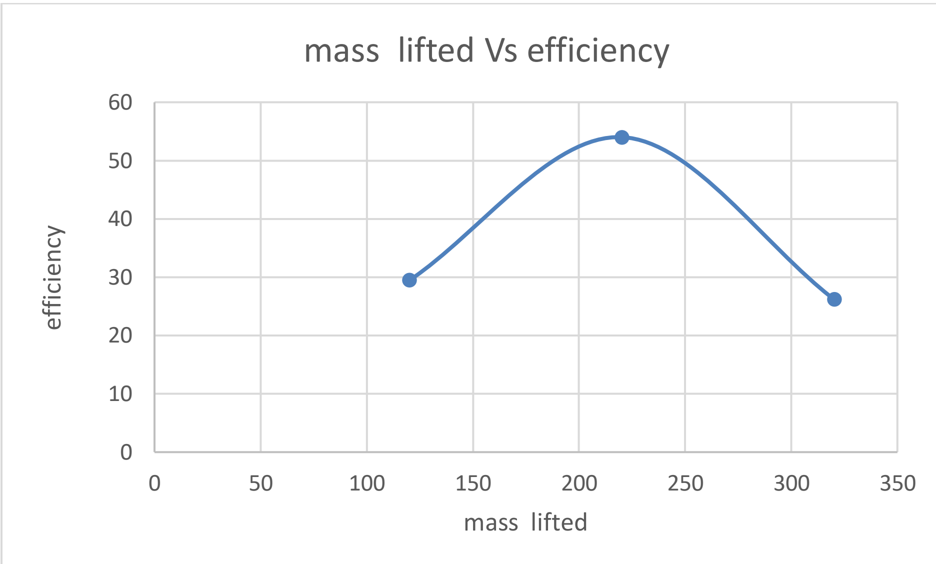

Figure 1 : parametric study when variating mass lifted at constant voltage

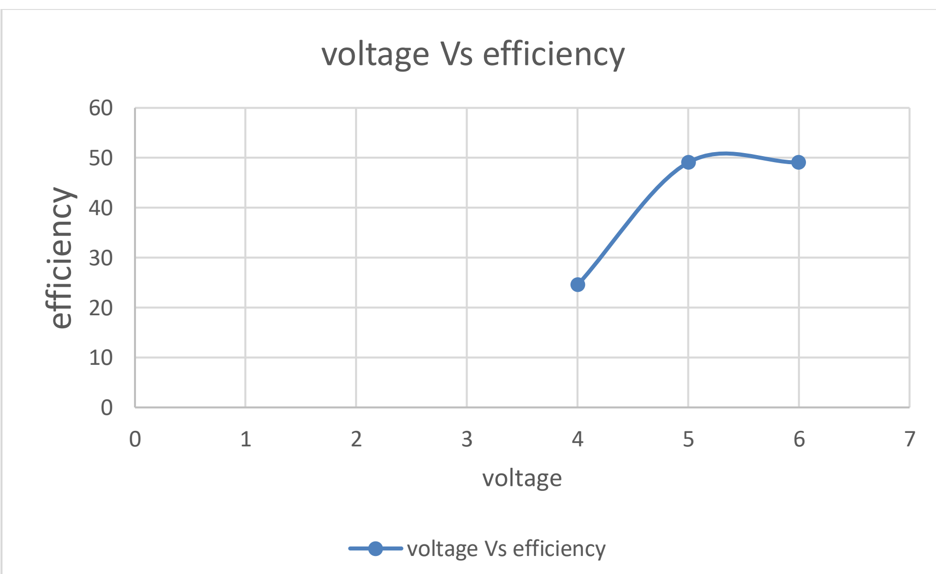

Figure 2 : parametric study when variating voltage at constant mass lifted

3. DISCUSSION

For the first part of this experiment, We used the joulemeter as a source of heat, which transferred to the block of aluminum, the specific heat of the block is experimentally found to be 1.2339 $(J * g^{-1}k^{-1})$. comparing this value to the referenced one (which is 0.903 $(J * g^{-1}k^{-1})$. we get an error of 36.65%, this error is relatively high. Most probably, this error emerged due to the poor installation of the insulating material. Hence, this will probably lead into heat loss that eventually will change the value of the heat capacity, make it larger, and that is what we have witnessed.

Another source of error could occur of not knowing how pure the block was, we don't know exactly in this experiment whether the block was 100% pure aluminum or not, if not, it is very likely that the value of specific heat that we would get be higher from the pure specific heat as proposed by Kopp.

For the second part of the experiment, we calculated the heat of vaporization of water at 89ºC which was 1310 $(J * g^{-1})$. while the real value found in tables such as (NIST values found in the appendix of most thermodynamics books such as Y.cengel:(thermodynamics an engineering approach) was 2282$(J * g^{-1})$. with an error of 42.6%, this error is also considered to be relatively high, one source of this error was not calculating the pressure (saturation pressure), if we look up to the tables In Cengel's textbook, we can notice that every value of temperature is accompanied with a value of pressure. In the lab, we have dealt with constant pressure process (a good approximation) to the real simulation. The error emerged for not calculating the pressure, which lead to not calculating the right temperature, to overcome this relatively large error, we could use any kind of correlation that combine temperature and pressure at saturation to determine the real temperature at which water boils at certain pressure such as Antoine equation for example and this reason is enough to explain this huge error.

In the third part, we have calculated the efficiency of an electrical motor and this part of the experiment was divided into 2 parts, the first one is to fix the voltage of the motor with increasing the lifted mass, we expect that the efficiency of the motor will decrease each time new mass is added, the reason for this is that whenever we increase the mass, it will require more energy to lift the object up and therefore more work done by the electrical motor, comparing this theoretical analysis with real values of what we have got actually from the experiment we notice a good analogy, which is very logical, the more mass you add, the less efficient your motor due to the increment of the input power into the motor, we noticed that, we have some illogical values, which indicates that a serious error had occurred when we dealt with this experiment, the source of error emerged at this part was personal error and with a bit of a systematic error

When we fix the mass and change the voltage, we expect that the joulemeter's readings for every increment of voltage will decrease, as the amount of energy required for every voltage increment will be less and less, as we shown from table (4), if we increase the voltage, the efficiency will increase too.

4. conclusion

Experiment (1) :Specific heat capacity

- Isolating the metal from the surroundings with a good insulating material increases the accuracy of the heat reading.
- The amount of heat is directly proportional to the specific heat capacity.
- Specific heat is the amount of heat required to raise the temperature of 1 kilogram of a substance by 1 degree Celsius

Experiment (2) :Latent heat of vaporization

- Latent heat is defined as the heat or energy that is absorbed or released during a phase change of a substance
- Latent heat of vaporization defined as the amount of heat that is required to evaporate 1 unit mass of a substance at constant temperature.
- The higher the pressure, the lower the boiling point, and thus the pressure is indirectly proportional to the Latent heat of vaporization

Experiment (3) :Efficiency of a small electrical motor

- There is a direct relationship between voltage and efficiency of motor , but the percentage of error in this experiment is large, so the relationship was not clear
- Voltage and mass are factors affecting on motor efficiency

5. REFERENCES

1-Cengel, Yunus A., Thermodynamics: An Engineering Approach, 9th Edition, McGraw Hill Education

6. APPENDICES

1-Sample of calculation

* Experiment 1: Determination of the specific heat capacity of a metal.

*mass of (Al) block (m) =1012.23g= 1.01223 kg

Joule meter reading(Q) =12490 J

Initial temperature (T_1) = 30℃

Final temperature (T_2) = 40℃

*Temperature difference (ΔT) = 10 K

Q=m*Cp*ΔT $Cp=\frac{Q}{m\times\Delta T}$

Specific heat (Cp)=0$\frac{12490}{(1.01223\times10)}$ =1233.90929 J/(Kg K.)

Experiment 2: Determination of the specific latent heat of vaporization of liquids.

Change in mass of liquid= 10 g

Temperature of liquid=89 ℃

Joule meter reading(Q)=13100 J

* Mass of vaporized water(mvap) = 10 g

*latent heat =$\frac{Q}{mvap}$ =$\frac{13100}{0.01}$ =1310000 J/kg

Experiment 3: Investigation of the efficiency of a small electrical motor and

study its variation with load and applied voltage Taking the first raw as sample of calculation.

At constant voltage-5 v

Change in height 50 cm

Mass of hanger=20.23 g

Mass added =100 g

* Total mass =100+20.32 =120.32 g = 0.12032k

Joule meter reading =2 J (input energy)

Potential energy =m*g*z (output energy)

Potential energy =120.32×981×50cm × 10^{-7}= 0.5897J

Efficiency= output energy/input energy

* Efficiency=0.5897 J/2 J = .2949 =29.49%

At constant mass=200g=0.2 kg

Change in height=50 cm

voltage= 4V

Joule meter reading =4 J (input energy)

Potential energy =200×981×50cm × 10^{-7}=0.981

Efficiency= output energy/input energy

* Efficiency=0.981 J/4 J=0.2453%