Measurement of specific heat of graphite

Aim: Estimation of the specific heat of graphite

Apparatus: (i) Graphite sample, (ii) Heater filament, (iii) Stop watch (iv) Variac (variable transformer), (v) Voltmeter, (vi) Ammeter and (vii) Chromel (Nickel-Chromium alloy) Alumel (Nickel-Aluminium alloy) thermocouple and (viii) temperature reader

Part I: A graphite sample is heated by a variable power unit called variac. The variac supplies a constant voltage to the coils as shown in fig. 1. To measure the temperature of graphite rod connect the Chromel-Alumel (Type K) thermocouple to the graphite rod assembly. Apply constant voltage with variac to the heater filament (say 30 V). Record the thermoelectric voltage with time on a graph paper. Wait till graphite attains equilibrium temperature (T_{eq}). At equilibrium, the rate of loss of heat by the Graphite is equal to the rate at which the heat is supplied. Therefore we can write,

$$Q = m\, s\, \Delta T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (1)$$

Or

$$\frac{dQ}{dt} = ms\,\frac{dT}{dt} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (2)$$

where Q is the heat supplied; m is the mass of the sample;

s is the specific heat of the sample; ΔT is the change in the temperature.

But at equilibrium, the rate of heat supplied, $\left(\frac{dQ}{dt}\right)_{\mathrm{Teq}}$,equals the rate of heat lost by sample due to radiation. Therefore,

$$\left(\frac{dQ}{dt}\right)_{\mathrm{Teq}} = P_{\mathrm{Teq}} = V\, I \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where P_{Teq} is the power input at T_{eq};

V is the voltage applied to the heating coil;

I is the current through the heating coil.

From Eq. (2) and (3), we get

$$ms\left(\frac{dT}{dt}\right)_{T_{eq}} = P_{\mathrm{Teq}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (4)$$

Record the equilibrium temperature and estimate the P_{Teq} by measuring voltage supplied (V) and current in the circuit (I).

Part – II: This part of the experiment is carried out in order to determine dT/dt at T_{eq}, i.e. $[dT/dt]_{Teq}$

To find the $\left(\frac{dT}{dt}\right)_{T_{eq}}$, Graphite is heated to a temperature slightly above T_{eq} by increasing the supplied voltage to the filament. Ensure that graphite is heated to T_{eq} +5 °C and then turn off the variac. Temperature of the sample continuously falls down due to radiation. Record the temperature of graphite versus time. Slope of the tangent drawn at T_{eq} of T vs. t graph provides us with $[dT/dt]_{Teq}$

Thus the specific heat at a temperature T_{eq} is given by,

$$s(\mathrm{T_{eq}}) = \frac{P_{\mathrm{Teq}}}{m\left[\frac{dT}{dt}\right]_{Teq}} \text{ J/Kg/}^{0}\text{C} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

here time 't' should be recorded in seconds.

Experimental Setup: The figure 1 gives a diagrammatic sketch of the apparatus consisting of the sample with a built-in heating element, a thermo-couple and variac. The voltmeter and the ammeter are used for measuring voltage and current, respectively.

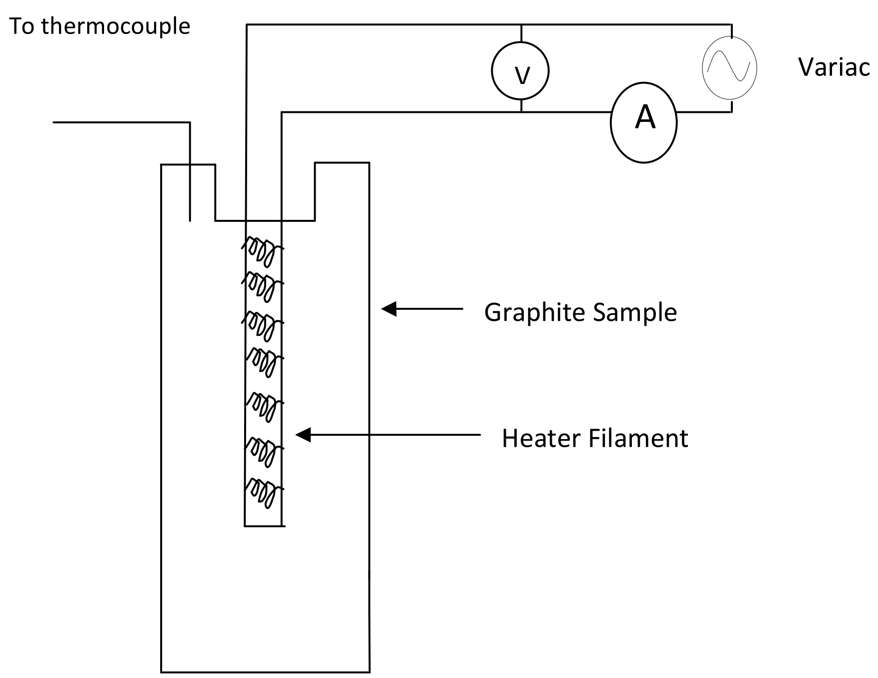

Figure 1: Schematic diagram of specific heat of graphite experiment

Procedure:

1) Make connections and give an AC voltage of about 25- 35 V by using Variac to heat the Graphite.
2) Record the temperature while heating and plot it simultaneously till temperature of graphite becomes constant and estimate the equilibrium temperature.
3) At the equilibrium, note down the voltage across the heater and current passing through it, as displayed respectively by the voltmeter and ammeter.
4) After reaching the equilibrium, increase the voltage by 5 V and observe that temperature increases by few degrees.
5) Switch off the power supply and then record the voltage/temperature versus time while cooling.
6) Plot Temperature 'T' vs time 't' graph and then determine specific heat.

Questions: 1) What are Seebeck, Peltier and Thompson effects?

2) Does specific heat vary with temperature? Is it same for every material?

3) What are the possible errors in this method? How one can improve the accuracy?

4) What is the relation between thermoelectric voltage and temperature difference of the junctions?

Additional reading: Susane Picard, David T Burns, Philippe Roger, Determination of specific heat of graphite sample using absolute and differential methods, Metrologia 44 (2007) 294-302

Thermocouple reference: http://www.nist.gov/pml/mercury_thermocouple.cfm