Mechanical Equivalent of Heat

'J' Apparatus

HL3800-001 With Electric Heater

Description:

Energy appears in several forms and is able to be converted from one form into another. In this experiment mechanical and electrical energy are converted into heat. An increase in heat energy is indicated by a rise in temperature.

Experiment #1): A copper drum is wrapped with a cord and a weight is hung from the end of the cord. To create friction to the drum. The handle is turned to create heat in the copper drum. The temperature rise is measured by a glass thermometer inserted into the drum.

By knowing the number of turns, the tension in the cord and the time for which the drum was turned, the work done on the drum can be calculated. Knowing the mass of the drum and the specific heat of copper, the temperature rise on the drum can be determined. It can be proven that mechanical energy is converted to heat energy.

Experiment #2): The kit includes a holder so that the copper drum can be heated electrically by passing current through a resistor embedded inside the drum. The temperature of the drum is monitored and, by measuring volts, amps and time, the conversion from electrical energy to heat energy can be studied.

Length: 310mm	Width: 125mm	Height: 90mm	Weight: 1.2kg

Formulae:

Mechanical energy is given by $F \cdot d$

where: F = constant force (Newtons)
d = distance moved (metres)

Electrical energy is given by $V \cdot I \cdot t$

where: V = potential difference (volts)
I = current (Amp)
t = time (seconds)

Heat energy is given by $c \cdot m \cdot T$

where: c = specific heat capacity (joules / kg / ^{o}K)
m = mass (kg)
T = change in temp (^{o}K)

These formulae above will be used in the following experiments to calculate the equivalents of the different types of energy.

Apparatus:

- Specific Heat of Solids Apparatus (including thermometer & calorimeter)
- Ammeter for heater current measurements.
- Voltmeter for heater voltage measurements.
- 12 volt power supply to operate heater.
- Electronic stop clock or stopwatch.

Additional item required and not supplied in kit:

- Load mass (8 - l2 kg) to attach to cord (use a house brick or similar).

Notes:

- The best accuracy is achieved if the initial temperature of the calorimeter body is approx. the same number of degrees below ambient temperature as you expect the final temperature to be above ambient temperature. Therefore, cool down the calorimeter body in cold water to about 5 to 10 degrees below ambient temperature. Avoid wetting the electrical contact area.
- Ensure that both the nylon friction cord and the body of the calorimeter are very clean and dry.
- Check that the points and contacts of the heating element on the end of the calorimeter are clean to ensure good electrical contact when placed on the heating support unit.

Instructions For Use:

Fix the mechanical 'J' apparatus to a table edge so that the weighted cord wound on the calorimeter (metal drum) clears the table edge. (Clock-wise rotation of the handle should try to raise the weight). If preferred, the 'G' Clamps may be detached and the base may be screwed directly to the table top as a permanent fixture.

Weights (or a house brick) are attached to the nylon cord which is then wrapped around the calorimeter a sufficient number of turns, in 'capstan' fashion, so that rotating the handle raises the mass about 25mm from the floor, thus leaving the free end of the cord just slack. The drum diameter is machined so that the circumference is 100mm. The mass (to the nearest gram) is stamped on the drum.

Record the initial temperature of the calorimeter drum by placing a thermometer in the socket provided and retaining it in place with the rubber cap. If conductive paste is used to improve thermal conductivity, the cap will also retain the paste.

Rotate the handle steadily and count the number of turns rotated. The rate of rotation should be such that about 150 to 160 turns are made in 2 minutes.

When 150 turns have been completed, lower the load (8 to 12kg typical) to the floor and record the maximum temperature reached by the calorimeter as indicated on the thermometer.

Allow calorimeter to cool to room temperature. (To reduce cooling time, unscrew the drum and stand it in cold water for a few minutes. Avoid wetting the electrical contact area).

If wet, dry the calorimeter and re-wind 5 or 6 turns of the cord around the drum. Fit the thermometer and place the assembly between the 3 plastic guides on the Electrical "J" apparatus heating unit so that the contacts on the stand are in proper contact with the small heater terminals at one end of the copper calorimeter. Connect terminals on the heating unit to a l2 Volt power supply (normally DC). Connect ammeter and voltmeter so that watts may later be calculated. Switch on for a second or two to ensure that there is good electrical contact (the current should be about 0.6 Amp at 12 volts).

Note the initial temperature of the calorimeter. Pass current through the heater for 2 minutes and note the average ammeter and voltmeter readings during this time. At the end of the heating time, record the highest temperature reached by the drum.

Mechanical Experiment:

Record the following data:

Initial temperature of the calorimeter =

Maximum temperature reached =

Temperature increase (T) =

Mass of the load (M) =

Number of turns made (n) =

Circumference of drum (p) = 0.10 m

Calculate the mechanical work done = F · d

(force x distance) = Mg · np

= Joules

Energy supplied / K = Mg · np / T Joules/K...(1)

Electrical Experiment:

Record the following data:

Initial temperature of calorimeter =

Maximum temperature reached =

Increase in temperature (T) =

Current through heater (I) = Amp

PD. across heater (V) = Volts

Time of heating (t) = Seconds

Calculate electrical energy supplied:

V · I · t = Joule

Energy supplied / K = Joule / K...(2)

How do results of Mechanical and Electrical compare ?.

If a choice of copper or aluminium calorimeter is provided in the kit, specific heat may be calculated for the different metals. To calculate the specific heat results, (1) or (2) must be divided by the mass of the calorimeter (m). Do this and determine which of the two experiments provided the more accurate result.

Specific Heats:

Copper: 390 Joules / kg / K (K = degrees Kelvin)

Aluminium: 918 Joules / kg / K

Designed and Manufactured in Australia