UE2030300 INCREASE OF INTERNAL ENERGY BY MECHANICAL WORK

EXPERIMENT PROCEDURE

- **Measuring the temperature of the aluminium body as a function of the number of rotations against the friction cord.**
- **Investigating the proportionality between the temperature change and the frictional work, and thereby verifying the First Law of Thermodynamics.**
- **Determining the specific heat capacity of aluminium.**

OBJECTIVE

Verifying the First Law of Thermodynamics.

SUMMARY

The experiment is to investigate the increase of internal energy of an aluminium body caused by friction. The increase can be observed by measuring the increase in the temperature of the body, which is proportional to the work done, as the body undergoes no change in the state of aggregation and no chemical reaction occurs. To eliminate the effect of heat exchange between the aluminium body and the environment as far as possible, begin the series of measurements slightly below room temperature and end the series at a temperature slightly above room temperature. The difference below and above room temperature prior to starting the measurements and at the point of concluding them should approximately be the same.

REQUIRED APPARATUS

Quantity	Description	Number
1	Heat Equivalent Apparatus	**1002658**
1	Digital Multimeter P1035	**1002781**
1	Pair of Safety Experiment Leads, 75 cm	**1017718**

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BASIC PRINCIPLES

According to the First Law of Thermodynamics, the change of the internal energy of a system ΔE is equal to the sum of the work performed ΔW and the transferred heat ΔQ. It can be measured as the proportional change in the temperature of the system ΔT, provided that there is no change in the state of aggregation and that no chemical reaction occurs.

The experiment is conducted to investigate the increase in the internal energy of an aluminium body caused by mechanical work. The cylindrical body is rotated about its axis by means of a hand-operated crank. A cord running over the curved surface provides the friction to heat the body. The frictional force F corresponds to the weight of a mass that is suspended from the end of the friction cord. The suspended mass is balanced by the frictional force. Therefore, the work performed against friction during n revolutions of the body is

(1) $$\Delta W_n = F \cdot \pi \cdot d \cdot n$$

d: Diameter of the cylindrical body.

During the n revolutions, the frictional work raises the temperature of the body from the initial value T_0 to the final value T_n. At the same time the internal energy is increased by

(2) $$\Delta E_n = m \cdot c_{Al} \cdot (T_n - T_0)$$

m: Mass of the body

c_{Al}: Specific heat capacity of aluminium.

To avoid a net exchange of heat with the environment as far as possible, the body is cooled, before starting the measurement, to an initial temperature T_0 that is only slightly below room temperature. The measurement is concluded as soon as the body reaches a final temperature T_n that is slightly above room temperature.

Note: The difference below and above room temperature prior to starting the measurements and at the point of concluding them should approximately be the same.

This ensures that the conversion of internal energy matches the work done. Thus, we have the following relation:

(3) $$\Delta E_n = \Delta W_n$$

EVALUATION

From Equations 2 and 3, we derive the relation

$$T_n = T_0 + \frac{1}{m \cdot c_{Al}} \cdot \Delta W_n$$

It is therefore necessary to plot the measured final temperatures T_n as functions of the work performed W_n on a graph (see Fig. 1). The values measured in the vicinity of room temperature lie on a straight line. It is possible to determine the specific heat capacity of aluminium from its gradient. In the region below room temperature, the measured temperatures rise faster than would correspond to the gradient of the straight line, as the aluminium body absorbs heat from the surroundings. Conversely, in the region above room temperature heat is lost to the surroundings.

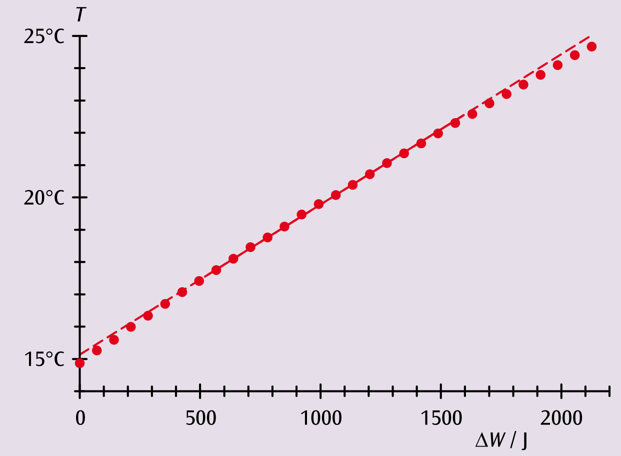

Fig. 1: The temperature of the aluminium body as a function of work performed against friction