Experiment 6

Thermal expansion of solid bodies

1- Objects of the experiment

- Measuring the linear thermal expansion of a brass tube as a function of the overall length.
- Measuring the linear thermal expansion of glass, steel and brass tubes and determining their linear expansion coefficients.

2- Principles

The length *s* of a solid body is linearly dependent on its temperature T:

$$S = S_0(1 + \alpha . T) \qquad (1)$$

S_0: length at 0°C, T: temperature in °C.

The linear expansion coefficient α is determined by the material of the solid body. For a given temperature difference between room temperature T_1 and steam temperature T_2, the change in length ΔS is closely proportional to the overall length s_1 at room temperature:

$$\Delta S \propto S_1 \qquad (2)$$

Specifically, we can say:

$$\alpha = \frac{\Delta S}{S_1} \frac{1}{T_2 - T_1} \qquad (3)$$

In this experiment, measurements of thermal expansion are conducted on thin tubes through which steam is channeled. The effective length S_1 of each tube can be set as 200, 400 or 600mm by mounting it in a corresponding manner. A dial gauge with 0.01mm scale graduations is used to measure the change in length.

3- List of Equipments

Apparatus	Catalogue Number
1 Expansion apparatus	38134
1 Holder for dial gauge	38136
1 Dial gauge	36115
1 Steam generator, 550 W/230 V	30328
1 Silicone tubing, dia. 7X1.5 mm, 1 m	667194
1 Petri dish, 150 X 25 mm	664185
1 Thermometer -10°C to 110°C	38234

4- Setup

- Set up the experiment as shown in Fig. 1.

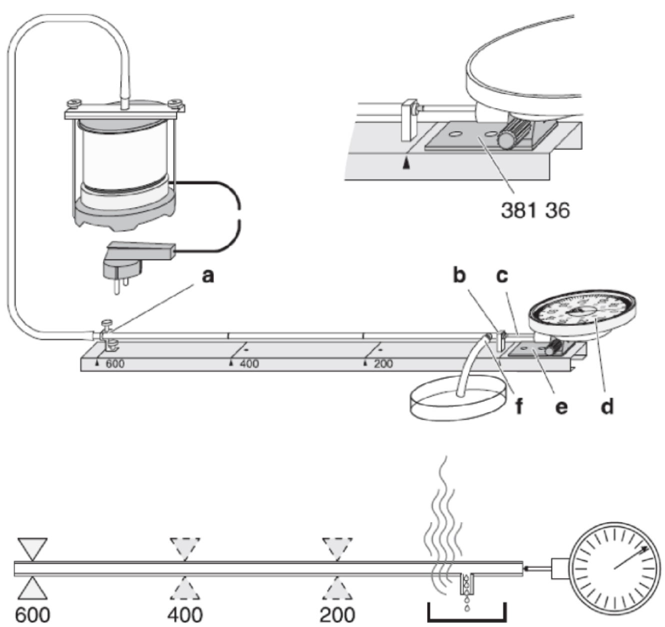

Fig. 1 Experiment setup for measuring the linear thermal expansion with the expansion apparatus

- Screw on the holder for dial gauge (e) and clamp the dial gauge in place.
- Attach the fixed bearing (a) of the expansion apparatus at the 600 mark and slide the open end of the brass tube into the fixed bearing.

- Slide the closed end of the brass tube into the guide fitting (b) so that the hose nipple (f) is pointing laterally downwards.

- Tighten the screw to fix the brass tube in the fixed bearing (the screw must engage the ring groove of the tube).

- Insert the extension piece (c).

- Cut off a 20cm length of silicone tubing, slide the section over the hose nipple (f) and place a Petri dish below this to catch the condensation.

- Use the long tubing section to connect the open end of the brass tube to the steam generator.

5- Carrying out the experiment

- Determine the room temperature T_1 and write this down.

- Read off and write down the zero position of the dial gauge.

- Fill the steam generator with about 2cm of water, close the apparatus and plug it in.

- Read off and write down the maximum pointer deflection of the dial gauge.

- Allow the brass tube to cool down to room temperature.

- Attach the fixed bearing of the expansion apparatus at the 400 mark and tighten the screw so that it engages the ring groove of the tube.

- Refill the steam generator with water, check the zero position of the dial gauge and repeat the measurement.

- Move the fixed bearing to the 200 mark and repeat the experiment.

- Replace the brass tube with the steel tube; attach the fixed bearing at the 600 mark and repeat the measurement.

- Conduct the same measurement on the glass tube.

- Complete the following table.

Table 1: Linear expansion ΔS between room temperature T_1 and steam temperature T_2 as a function of the effective length S_1 of the material.

Material	S_1(mm)	ΔS (mm)
Brass	600	--------
Brass	400	--------
Brass	200	--------
Glass	600	--------
Steel	600	--------

- Determine T_1 , T_2 and $T_2 - T_1$.
- Prepare a sheet of graph paper for plotting ΔS of a brass tube versus S_1. You should make ΔS the vertical axis and S_1 the horizontal axis. Each axis should be labeled and appropriate units indicated. The graph should have a title.
- Plot your data on the graph.
- Determine the slope and the y-intercept point by using the least square method (see appendix).
- Draw best fit line to the points on your graph.
- Use the measuring results of table 1 and equation (3) to determine the linear expansion α for different materials.

Table 2. Linear expansion coefficient α for different materials

		Measurement	Literature
Material	S_1(mm)	α (K^{-1})	α (K^{-1})
Brass	600	-----------	$18 . 10^{-6}$
Steel	600	-----------	$11 . 10^{-6}$

Glass	600	-----------	$3 . 10^{-6}$

- Compare these results with literature values and discus your results.