

# Linear Thermal Expansion of Solids

## 1 Objective

- Study the linear expansion of two solid rods with temperature.
- Find the linear thermal expansion coefficient  $\alpha$  for the different solid rods.

## 2 Prelab Questions

1. Write an expression for the volume of a rod with two pointed tips. The total length of the rod is  $L$  and the length of the pointed tip is  $d$  with a radius of  $r$ .
2. Which equation will you be using:  $L = L_0(1 + \alpha\theta)$  or  $L = L_0(1 + \alpha\Delta\theta)$  to describe how the length varies with temperature? Why?
3. Describe a way to measure the length of a rod about  $0.5\text{cm}$  accurately to at least three significant figures, using an apparatus present in the lab.

## 3 Principles

- The length of a metal rod  $L$  varies with temperature.
- Two different metal rods will be heated by steam and left to cool while recording the temperature  $\theta$  and its length.

## 4 Apparatus

- Steam generator.
- Silicone tubing for connections.
- Clamps.
- Expansion apparatus with dial gauge and a thermometer.

## 5 Precautions

1. Make sure not to touch the equipment or bang the table, since any slight movement of the rod will make the recorded data invalid.
2. The steam generator produces steam the temperature of which is approximately  $100^{\circ}\text{C}$ . Be very careful when handling it or the tubing system as any escaped steam will cause burns.

## 6 Experimental Steps

1. Fill up the steam generator to half of its volume with water.
2. Measure the length of the rod  $L_0$  and record the temperature in the Lab  $\theta_0$ .
3. Place the rod in the tube and close the ends with the rubber stoppers. Make sure that the rod is free to move.
4. The tip of the rod must touch the dial gauge without displacing it and the other end should be held in position by tightening the screw.
5. Connect the silicone tubing to the openings at the ends. One to the steam generator and the other to the sink, for drainage.
6. Make sure that the silicone tubing is tight so that steam is trapped. You may need to tighten the clamps.
7. Turn on the hot plate and allow water to boil.
8. Allow steam to flow until the thermometer reads approximately  $100^{\circ}\text{C}$  and remains at this temperature for 10 minutes or so. This step ensures that thermal equilibrium has been reached.

9. Switch off the hot plate and record the temperature  $\theta$  of the cooling rod and the dial reading for every  $5^\circ$  drop in temperature until the temperature of the rod reaches  $30^\circ\text{C}$ .
10. Repeat the experiment for the other rod following the same steps.

## 7 Evaluation

1. Plot the temperature against the dial reading.
2. Find the slope of the graph then find the coefficient of linear expansion  $\alpha$ .
3. Measure the length of the rod to three significant figures.
4. From the volume and mass of the rod find the density then identify the material of the rod.
5. Compare the value of  $\alpha_{exp}$  to the real value.
6. Repeat the calculation for the other rod.

## 8 Postlab Questions

1. How does the coefficient of linear expansion vary with temperature?
2. From the volume and mass of the rod find the density then identify the material of the rod.
3. From the data you obtained of the density and the value of the coefficient of linear expansion, are your results consistent?
4. Could you describe other ways of identifying these materials or ways to refine your measurements.

## 9 Helpful Sites (clickable links)

- Measuring the linear expansion of solids as a function of temperature.