Lab 6

Thermal Expansion

Experimental Objectives

- In this lab, we will use the equation for thermal expansion to identify the composition of three different rods.

You may have noticed that most materials expand as they are heated. This can be seen in a wide variety of situations: Your front door doesn't seal out the colder air, bridges have a gap of a few inches at each end, stuck jars are easier to open when hot water is run over them, etc.

6.1 Pre-Lab Questions

Consider the following situations:

1. If a single rod, 1 m in length, expands by 1 mm when heated a specified amount, how much does a 2 m rod (made of the same material) expand when heated by the same amount as the 1 m rod?
2. If I have a glass jar with a metal lid and heat up both glass and lid by the same amount, do they expand the same amount? If not, which one expands more? Why is it possible to open the heated jar?
3. If my single, 1 m metal rod is heated some amount and expands 1 mm, how much does that same rod expand when heated by twice the original amount?

The answers to these questions show that the expansion of a material depends on it's original size, it's material composition, and the amount that the temperature changes. The equation for linear thermal expansion is

$$\mathbf{\Delta L = L_0}\alpha\mathbf{\Delta T} \tag{6.1}$$

and α (lower-case Greek-symbol alpha) is the coefficient of linear expansion, which is different for each material.

Please note, ΔL is the **absolute expansion**, $\left(\frac{\Delta L}{L_0}\right)$ is the **relative expansion** (the expansion relative to the original length), and $\left(\frac{\Delta L}{L_0} \times 100\%\right)$ is the **percent expansion** (the relative expansion written as a percentage).

In order to experimentally measure the value of α, you must measure the relative expansion and the change in temperature.

1. Based on Equation (6.1), what are the units of α?
2. For reliable temperature measurements, the entire rod should be at the same temperature. This requires a stable temperature environment. List three temperatures that can be conveniently maintained.

3. Ice can be colder than 0 °C and steam can be warmer than 100 °C. How can we use either (specifically steam) to ensure a stable temperature environment?
4. If we immerse our meter stick into the steam bath with the rod to measure the expansion, then we *cannot* trust the reading of the meter stick to accurately determine the new length of the rod... WHY NOT? What does this require of our measuring device?
5. We have an apparatus which will allow steam to enter at one end and water to drain at the other. At what temperature do you expect the rod to be when it is immersed in this steam-water mixture?
6. With several groups creating steam in the same room, why should we worry about the value of “Room Temperature” when we make a second or third measurement?

6.2 The Experiment

Using room temperature and the water-steam temperature interface, experimentally determine the coefficient of linear expansion for three different types of metals. Based on the color, weight, and density, guess the metal composition. Carry out an error analysis and use your error-bars to verify the material of each rod.

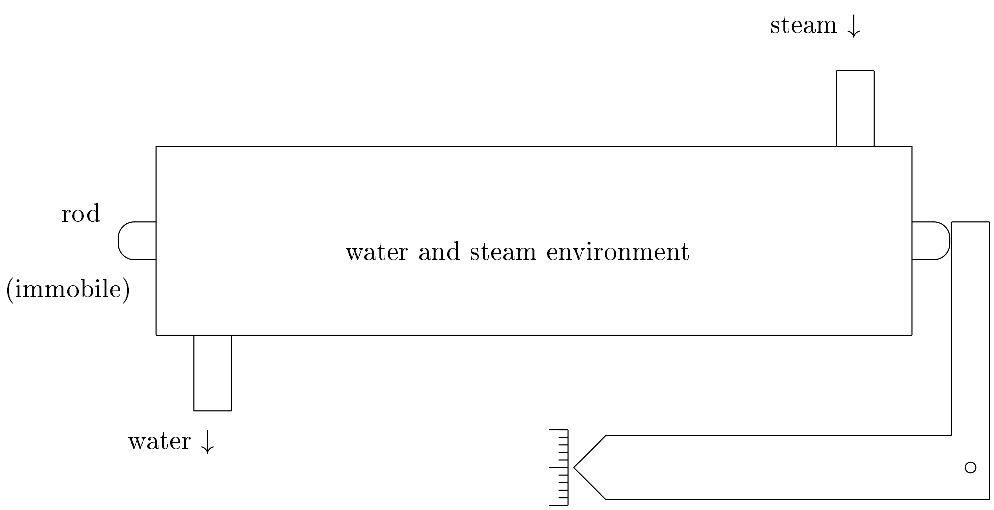

Figure 6.2.1: Apparatus for measuring the coefficient of linear thermal expansion.

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A PDF version might be found at thermal.pdf (87 kB)