Thermal Expansion

Motivation and Aim

All materials expand when heated and contract when cooled. Heating changes the length, area, as well as the volume of the substance. The rate of change of length of a substance with temperature is called the coefficient of thermal expansion α of that material. In this experiment α is measured for three metals.

Apparatus

1. Pullinger's Apparatus
2. Thermometer
3. Brass, Aluminium and Copper rods
4. Steam bath

Procedure

Place the brass rod in the apparatus along with the thermometer. Ensure that the thermometer is in contact with the rod. Note the position of the top end of the rod by moving the spherometer and getting it to just touch the end face of the rod. Contact will be indicated by the buzzer or LED connected to the spherometer. After noting the spherometer reading move the spindle away from the rod face.

Heat the rod by passing steam through the jacket of the apparatus. Wait until the temperature of the rod becomes steady, and reaches close to the steam temperature.

Turn the spherometer spindle downwards until it just touches the rod and note the temperature of the rod. Repeat this as the rod cools down and note the spherometer reading each time, until the rod returns to room temperature.

Theory

It is empirically observed that the change in length due to temperature depends on both, the initial length and the change in temperature of a substance. For solids close to room temperature, the dependence can be taken to be linear, thereby obtaining the equation:

$$\Delta L = L_0 \alpha (T - T_0)$$

However this linear dependence is not universal. There are exceptions to this, a prime example being the behaviour of water near 4 °C.

Analysis

1. Plot a graph of spherometer reading vs. Temperature.
2. From the slope of this graph determine the coefficient of thermal expansion.

Points to Ponder

1. It is possible to note the rod length as the rod is heating up and while it is cooling down. Which readings will be more reliable? Why?
2. What are the major sources of systematic errors in this experiment?
3. To what extent does the error in initial length measurement affect the outcome of the experiment?