ACTIVITY

AIM

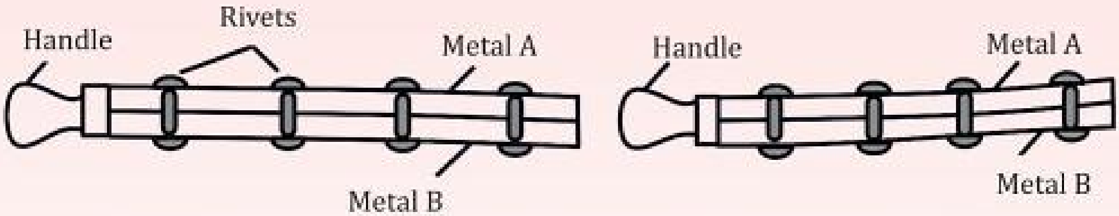
To observe and explain the effect of heating on a Bi-metallic strip.

MATERIAL REQUIRED

Iron-brass bimetallic strip with an insulating handle, heater/burner, clamp stand and thermometer.

DIAGRAM

Bi - metallic strip is made of two bars/strips of different metals or materials having same dimensions. These metallic bars/strips (A and B) are put together lengthwise and firmly riveted. An insulating (or wooden) handle is fixed at one end of bimetallic strip.



A bimetallic in (a) Straight at room temperture and bent positions on heating

At room temperature, the bimetallic strip is straight. When the bimetallic strip is heated, both the metallic pieces expand to different extents because they have widely different values of coefficients of linear thermal expansion. This results in the bending of bimetallic strip.

THEORY

When there is a change in length of a bar on heating, linear thermal expansion is said to be occurred. Let L_1 and L_2 be the lengths of rod/bar of a metal at temperatures t_1 °C and t_2 °C such that $t_2 > t_1$. Change in length $(L_2 - L_1)$ is directly proportional to the original length and the rise in temperature $(t_2 - t_1)$. Then,
and,

$$(L_2 - L_1) \propto L_1 \qquad \text{......(i)}$$

$$(L_2 - L_1) \propto (t_2 - t_1)^2$$

$$L_2 - L_1 = \propto L_1(t_2 - t_1) \qquad \text{....... (ii)}$$

From eq. (i) and (ii), where α is the coefficient of linear thermal expansion of the material.

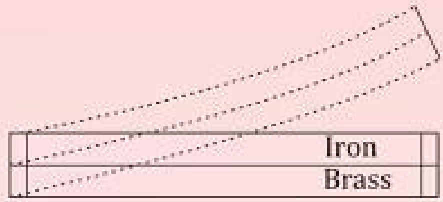
$$\propto = -\frac{L_2 - L_1}{L_1(t_2 - t_1)}$$

Thus, the coefficient of linear thermal expansion (∝) is the increase in length per unit length for unit degree rise in temperature of the bar. Its S.I. unit is K^{-1}.

PROCEDURE

HEATING THE BIMETALLIC STRIP

1. Hold the bimetallic strip made up of two strips of different materials (iron and brass) with the help of insulated handle in such a way that it should be kept in horizontal position. Note down the initial temperature of the strip.
2. Mark as A and B on the two halves of bimetallic strip and turn ON the burner or switch ON the electric heater.



Bi -metallic strip

3. Heat the bimetallic strips with the help of burner/heater.
4. Note the side of the bimetallic strip which is in direct contact of heat source.

EFFECT OF HEATING ON THE BIMETALLIC STRIP

5. Observe the heating effect of the strip and the direction of the bending of the free end of the strip, i.e., upwards, or downwards.
6. Identify which of two metallic strips A or B is on the convex side of the bimetallic strip and which one is on the concave side.
7. Now identify the metallic strip which has larger linear thermal expansion. The metallic strip which on the convex side of the bimetallic strip will expand more and has larger linear thermal expansion.
8. Note down the values of coefficient of linear thermal expansion of two metals A and B from the standard table.
9. Now verify the direction of bending of the metallic strip (whether it is downward or upward) is on the side of that strip which is made up of metal having lower coefficient of linear thermal expansion.

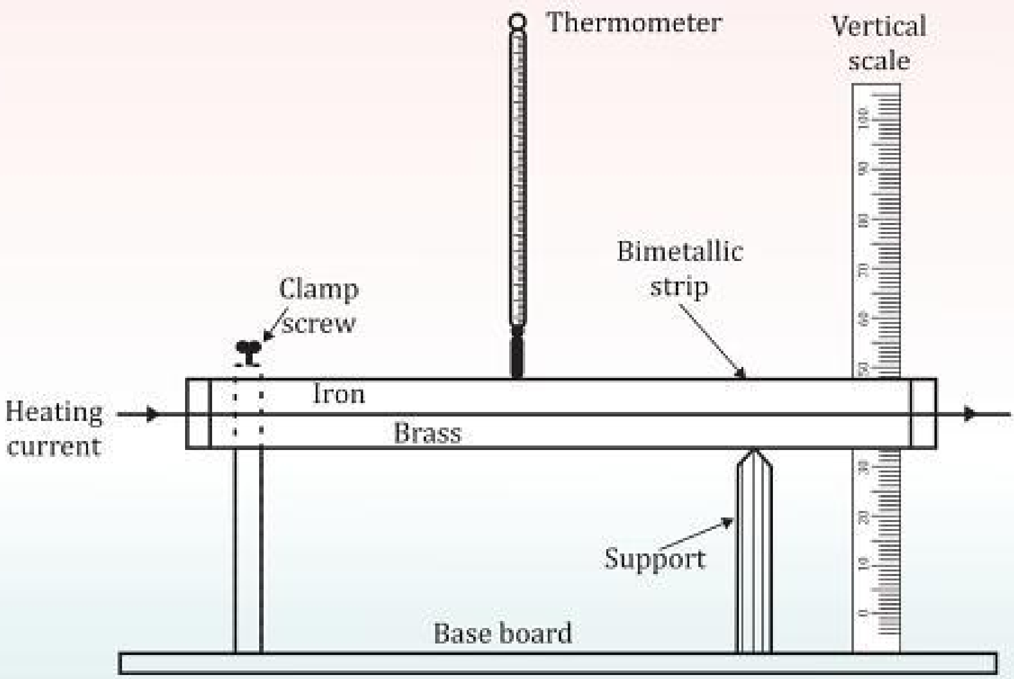


Fig. Bending of a bi- metallic strip

10. Take the bimetallic strip away from the heat source. Allow the strip to cool to room temperature.
11. Repeat steps to heat the other side of the bimetallic strip.
12. Observe the direction of bending of the bimetallic strip.

OBSERVATIONS

1. Room temperature = 30 °C
2. Least count of vertical scale = 1mm

TABLE FOR TEMPERATURE AND VERTICAL SCALE READING

Serial No.	Temperature of Bi – metallic strip t (°C)	Position of upper edge of Bi-metallic strip x (mm)	Amount of bending upward (mm)
1.	30 °C	x_1=	$X_1 - x_1$ =
2.	32 °C	x_2 =	$X_2 - x_1$ =
......	....	....	....
11.	50 °C	x_{11} =	$X_{11} - x_1$ =

RESULT

It has been verified that on heating, the bending of a bimetallic strip takes place due to the difference in coefficient of linear expansion of the two metals of the strip.

PRECAUTIONS

1. The thickness of the bimetallic strip should be small, and its length should be large as compared to its cross-section.
2. The two strips/bars should be firmly riveted near their ends.
3. Heating of whole bimetallic strip should be uniform over its entire length.
4. Care should be taken at the time of verifying the expansion with the standard value of coefficient of linear thermal expansion of both the strips.

SOURCES OF ERROR

1. The metallic strips may not be riveted firmly.
2. Heating of bimetallic strip may not be uniform.

VIVA VOCE

Q1. You have been given bars of identical dimensions of following metals along with their values, for making a bimetallic strip:
Aluminum ($\alpha = 23\times10^{-6}$ k^{-1}), Nickel ($\alpha = 13\times10^{-6}$ k^{-1}), Copper ($\alpha = 17\times10^{-6}$ k^{-1}), Invar ($\alpha = 0.9\times10^{-6}$ k^{-1}), Iron ($\alpha = 12\times10^{-6}$ k^{-1}), Brass ($\alpha = 18\times10^{-6}$ k^{-1})
Which pair of metals/materials would you select as best choice for making a bimetallic strip for pronounced effect of bending? Why?

Ans. The pair of aluminum and invar would be the best choice for making a bimetallic strip because pair of metals with wide difference in their expansivities are selected.

Q2. What would be the effect on the bending of the bimetallic strip if it is heated to a high temperature?

Ans. When a bimetallic strip is heated to a high temperature, then the direction of bending changes.

Q3. Name a few devices in which bimetallic strips are generally used as thermostat.

Ans. Bimetallic strips are generally used as thermostat in geysers, air conditioners, automobiles, etc.

Q4. What is the basic cause of bending of a bimetallic strip?

Ans. The basic cause of bending of a bimetallic strip is the difference between the coefficients of linear expansions of two metals of which strip is mode.

Q5. What are the different types of thermal expansion?

Ans. The different types of thermal expansion are:

(i) Linear expansion

(ii) Superficial expansion

(iii) Cubical expansion

Q6. Which pair of metals is used in your activity?

Ans. A pair of brass and iron is used in the activity.

Q7. What is the relation between the coefficients of thermal expansion?

Ans. The relation between the coefficients of thermal expansion is $\gamma = 3\alpha$ and $\beta = 2\alpha$ or $\gamma = \frac{3\beta}{2}$.

Where, α = linear expansion,

β = superficial expansion and

γ = cubical expansion