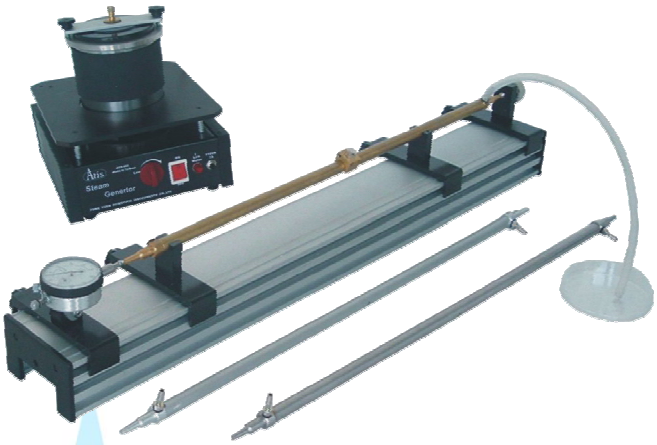
A02-111E-Y22

Experiment: Thermal Expansion Apparatus



Purpose

To use steam heating pot to generate steam. Make the steam flow through the metal rod to make it expand, and then use the dial indicator to measure the length of the metal rod after expansion in order to calculate the coefficient of linear expansion.

Theory

Most solids do expand when heated, and its length changes by an amount proportional to the original length and the change in temperature.

$$L - L_0 = L_0 \alpha T \quad (1)$$

$$L = L_0 (1 + \alpha T) \quad (2)$$

In the equation,

L_0: the length at 0℃

L: the length at T℃

α: the constant of proportionality, called the coefficient of linear expansion

In the equation,

L_1: the length at T_1℃

L_2: the length at T_2℃

So we obtain the equations below,

$$L_1 = L_0 (1 + \alpha T_1) \quad (3)$$

$$L_2 = L_0 (1 + \alpha T_2) \quad (4)$$

$$\frac{L_1}{L_2} = \frac{1 + \alpha T_1}{1 + \alpha T_2}$$

$$\alpha = \frac{L_2 - L_1}{L_1 T_2 - L_2 T_1} \quad (5)$$

The difference of L_1 and L_2 is minimal, so $L_2 \sim L_1$, we obtain,

$$\alpha = \frac{\Delta L}{L_1 \Delta T} \quad (6)$$

In the equation,

$\triangle L$: $L_2 - L_1$

$\triangle T$: $T_2 - T_1$

Linear expansion coefficient is defined as the increment of length of a solid in a unit of length for a rise in temperature of 1° at constant pressure. Instead of the increase of the length, but also consider the expansion in volume. By equation (2), we obtain,

$$V = V_0 (1 + \beta T) \quad (7)$$

In the equation,

V_0: the volume at 0℃

V: the volume at T℃

β: the volume expansion coefficient

Assume that the side length of a cube is L, the volume at T ℃ should be,

$$V = L^3 = L_o^3 (1 + \alpha T)^3 = L_o^3 (1 + 3\alpha T + 3\alpha^2 T^2 + \alpha^3 T^3)$$

Since α is a small number, α^2 and α^3 can be gotten rid of in the equation, that is

$$V = L_o^3 (1 + 3\alpha T) \quad (8)$$

Compare equation (7) to equation (8), we know that the volume coefficient is three times the coefficient of linear expansion, so$\beta = 3\alpha$. Although the conclusion above

But the volume of an object can be divided into many cubes, so for any solid, this conclusion is correct.

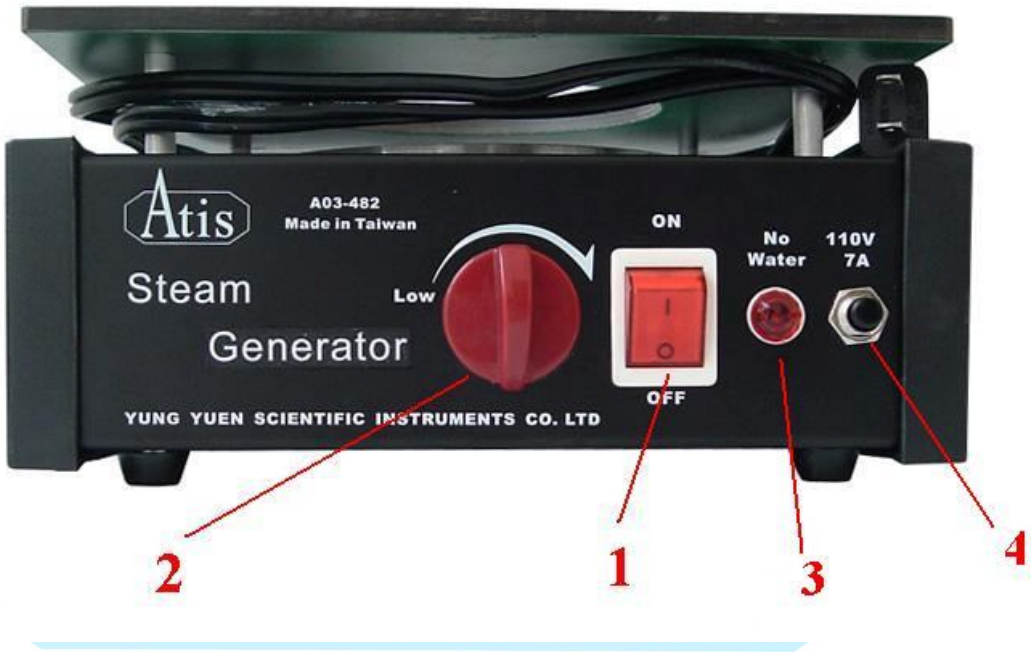
Instrument

Fig. 1

NO	Accessory	Quantity
1	Steam Generator	1
2	Steam Heating Pot	1
3	Steam Heating Pot Lit	1
4	Fixer	1
5	Aluminum Rod	1
6	Metal Rod	1
7	Brass Rod	1
8	Base	1

9	Zeroing Knob	1
10	Metal Rod Supporting Base	2
11	Dial Indicator	1
12	Digital Electronic Thermometer	1
13	Thermometer Socket	1
14	Water Container	1
15	Steam Conduit	2

Steam Generator



HOW TO USE

1. Switch: this switch will illuminate when the heater starts heating.

2. Temperature control knob: temperature control protection switch. The generator starts to heat up when the knob is turned till the switch lights up but No Water Indicator doesn't.

3. No water indicator: the indicator lights up when in a non-heated or no water state.