NATIONAL RESEARCH TOMSK POLYTECHNIC UNIVERSITY

MEASUREMENT OF THE AVERAGE LINEAR EXPANSION COEFFICIENT

Objective:

The goal is measurement of the average linear expansion coefficient based on thermal processes and size measurement of the pipe.

Facilities:

– installation with fixed pipe by dint of one pipe end;

– adjustable calefactor;

– external micrometer,

– temperature sensor.

INTRODUCTION

Most of the objects at higher temperatures increase their size. When the object is heated, its extension strain is given by

$$\frac{dL}{L} = \alpha dt \tag{1}$$

where L is the original length of the object, dt is the temperature change, α is the constant of proportionality, which called the valid linear expansion coefficient and defined as

$$\alpha = \frac{1}{L} \cdot \frac{dL}{dt} \ .$$

The linear expansion coefficient is determined as the extension strain of the object when the temperature changes by one degree. In practice, on small temperature changes the alpha change slightly, so you can use for calculating the value of the average expansion coefficient, it leads to α of the form

$$\alpha = \frac{L_2 - L_1}{L_1 \left(t_2 - t_1 \right)} \tag{2}$$

where t_1 and t_2 are original and final temperatures of the object respectively, L_1 and L_2 are length of the object fit in with temperatures t_1 and t_2. At any temperature, object length can be represented in terms of length at 0^0C. Follows from a formula (2), that

$$L = L_0 \cdot (1+\alpha t) \tag{3}$$

As a result of linear expansion increases the volume of the object. Let us consider a object in the form of a cube with edge *L*. Its original volume at 0^0C:

$$V_0 = L_0^3$$

Obviously, the volume of the body is at a temperature *t*:

$$V = L_0^3 \cdot (1+\alpha t)^3;$$

$$\beta = \frac{1}{V} \cdot \frac{dV}{dt} \tag{4}$$

Raise $(1+\alpha t)$ to the third power, neglect terms containing t^2 and t^3 and consider $\beta=3\alpha$. β means average volume expansion coefficient.. When valid volume expansion coefficient:

$$\beta = \frac{1}{V} \cdot \frac{dV}{dt} \tag{5}$$

FACILITY DESCRIPTION

The device consists of a long metal pipe length of l_1 and a diameter of d_0. One end of the pipe is immovably fixed and the other end is mounted on a sliding support. If heating elements are working, the pipe heating up and extending. For extension logging the end of the pipe is fixed, but other side pushing the indicator. The indicator is high-sensitivity device, which measure the pipe extension Δl. Its graduating mark equal to 0,01 mm.

WORK PROCEDURE

1. Refer to the facility, equipment and work procedure.

2. Measure the original length l_1 and the diameter d_0 of the pipe, the pipe temperature and room air temperature.

3. Turn on the heater and measure the pipe temperature changes in five selected points each 5 minutes.

4. Add the data in table:

T_{pipe}, [°C] = t_{air}, [°C] =					l_0 [mm] = d_0 [mm] =			
τ,hh:mm	Δl	t_1, °C	t_2, °C	t_3, °C	t_4, °C	t_5, °C	T_{ave}*	α

* Average temperature measure be considered on basis of a five-points measurements.

5. When the heating will be in the stationary mode, ie when will stop change of temperature and change of length of the tube, by using the indicator, determine the maximum length change Δl.

6. Calculate the average thermal expansion coefficient by means of change of the extension of the pipe and change of its diameter.

l_0, mm	Δl, mm	Δt, ° C	α, K^{-1}
d_0, mm.	Δd, mm	Δt, ° C	α, K^{-1}

7. Plot dependence $t(\tau)$, $\Delta l(t)$ и $\alpha(t)$. Explain their types

8. Analyze the factors that affect the measurement accuracy of the thermal expansion coefficient.

9. Suggest a way to measure other thermal characteristics according to the available experimental data.