EP06 Young's modulus

OBJECTIVE

1. To familiarize the student with the use of micrometer and reading microscope

2. To familiarize the student with the graphic method, and to measure the Young's modulus of steel using it.

THEORY

The terms 'stress' and 'stain' are introduced which are used when referring to the deforming force and the deformation it produces.

Stress is the force (1 N) acting on unit cross-section area ($1m^2$). For a force F and area A we can write: stress=force/area. The unit of stress is the pascal (Pa) which equals one newton per square metre (that is, $1Pa=Nm^{-2}$).

Stain is the extension of unit length (1m). We can write: stain=extension/original length. Stain is a ration without unit.

The stress required to produce a given strain depends on the nature of the material under stress. The ratio of stress to strain, or *the stress per unit strain*, is called an elastic modulus of the material. The larger the elastic modulus, the greater the stress needed for a given strain.

In the case in which the force causes elongation, stress is measured as the force per unit cross sectional area and strain is the increase in length of unit length. The modulus is then known as Young's modulus (E) and hence

$$E = \frac{tensile\ stress}{tensile\ strain} = \frac{F/S}{\Delta l/l} = \frac{F \cdot l}{S \cdot \Delta l} \qquad (1)$$

Where F is the force in N;S is the cross sectional area in m^2; Δl is the increase in length (in m)caused by F; and l is the original length of the wire in m.

In the lab , F ,S ,l can be obtained easily, so how to measure Δl is the key.

Attach suitable hanger for weights and cross board for reading to the end of the wire (see fig1).Adding weights (M),the force acting on the wire will increase by F

$$F = Mg \qquad (2)$$

and the wire elongate Δl , that is the tensile strain is Δl . At the same time the cross-wire descend Δl , and Δl can be measured directly using the microscope.

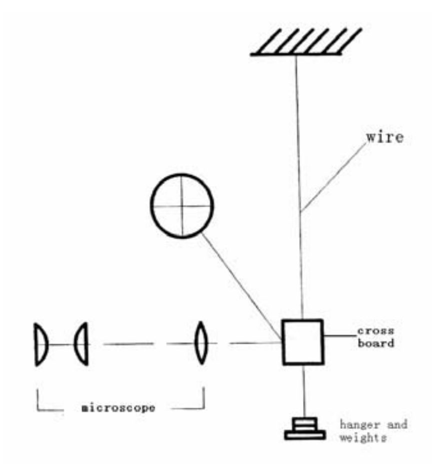

Figure.1 the principle of the lab

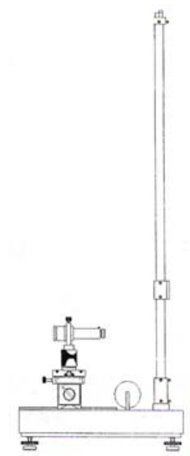

Figure.2 the device of the lab

If the value of the diameter of the wire is d, the cross sectional area equal to $\frac{1}{4}\pi d^2$, so

$$E = \frac{F \cdot l}{S \cdot \Delta l} = \frac{4Mgl}{\pi d^2 \Delta l} \qquad (3)$$

Where $g(acceleration\ of\ gravity) = 9.788 m/s^2$ in Guangzhou, l, M are given in the lab, if Δl is measured , E can be obtained.

PROCEDURE

(1) Measure the diameter of the wire at five different points along its length and find a mean value. This measurement must be done carefully with a micrometer caliper.

(2) Adjust the screws under the base until the base is level, at that time the frame is parallel to the wire, and the scale seen in microscope is parallel to "|" of the cross board.

(3) Adjust the ocular of the microscope until the scale is clear. Move slightly the base until the image of the cross is clear seen from the microscope, then lock the base. Use the fine adjustment to ascend or descend until some reticule in the scale coincides with "—"in the cross, read the readings on the scale, that is C_0.

(4) Load the weights one by one on the hanger nine times (every time the weight added is 0.200Kg). Take the corresponding readings after each addition ,that is C_i(i=1,2,...,8,9)

(5) Unload the weights one by one, take the corresponding readings at each stage, that is C_i' (i=8,7,...,1,0),then $\overline{C_i} = \frac{C_i + C_i'}{2}$ (i=8,7,...,1,0).

(6) $\Delta l_i = \overline{C_i} - \overline{C_0} (i = 0,1,2,\cdots,8)$.

DATA RECORDING AND PROCESSING

micrometer caliper: zero reading $d_0(m)$ =________

$d(m)$	1	2	3	4	5	average

m_i(Kg)		$c_i(load)$ $(\times 10^{-3} m)$		$c'_i(unload)$ $(\times 10^{-3} m)$		$\bar{c} = (c_i + c'_i)/2$ $(\times 10^{-3} m)$		$\Delta l = \bar{c}_i - \bar{c}_0$	
m_0		c_0		c'_0		$\bar{c}_0$			
m_1		c_1		c'_1		$\bar{c}_1$		Δl_1	
m_2		c_2		c'_2		$\bar{c}_2$		Δl_2	
m_3		c_3		c'_3		$\bar{c}_3$		Δl_3	
m_4		c_4		c'_4		$\bar{c}_4$		Δl_4	
m_5		c_5		c'_5		$\bar{c}_5$		Δl_5	
m_6		c_6		c'_6		$\bar{c}_6$		Δl_6	
m_7		c_7		c'_7		$\bar{c}_7$		Δl_7	
m_8		c_8		c'_8		$\bar{c}_8$		Δl_8	
m_9		c_9							

Since $E = \frac{4Mgl}{\pi d^2 \Delta l}$, so $\Delta l = \frac{4Mgl}{\pi d^2 E}$, a graph of Δl against M will be a straight line and its gradient will be $k = \frac{4gl}{\pi d^2 E}$,from the equation, E can be obtained.