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THE DEFLECTION SENSOR WITH PROTECTION AGAINST DAMAGE

This article examines the construction of sensor for measuring the sagging. It is the frame, which consists of four rods. One of the rods (stock) of is mobile and is found in the contact with the model. Another rod (beam) of is the elastic element, whose deformations are measured with the aid of the strain gage resistors. Remaining two rods lock the kinematics chain, transferring the measured displacement from the stock to the beam. The special feature of sensor is protection from damage, if model will be destroyed or will occur the uncontrollable motion of stock. For this connection of stock and beam it is executed by mobile. As a result this during the uncontrollable motion of stock, which exceeds the range of the measurement of sensor, connection is uncoupled without the destruction. The connection between the displacements of stock and free end of the beam is examined. The relationships between the sizes of rods, which ensure the correct work of sensor, are obtained on this base.

Introduction. In experimental practice the deflection is measured while solving two types of tasks. The first task is measuring the deflections of real constructions and designs with the aim to estimate their durability and rigidity. The second task is measurement of sample deformations in test devices with the purpose to determine rigidity characteristics of the constructional material.

Main part. In the research of mechanical properties of materials tests of samples for a bend are widely used. It is caused by the comparative simplicity of manufacturing samples, and the procedure of the test. The samples have simple and technological form of a direct prism that provides low manufacturing costs. For example, in the test checking stretching, the samples having a shape of a double shovel and there are needed additional technological operations.

It is necessary to measure the deformation of the sample and the force of its resistance to this deformation during the test. Measurement of the force is made by the basic or by the additional dynamometer of the test device without any peculiarities.

There are two widely used methods to measure deformations of the sample. The first is – measurement of deflection in the set section of the sample, the second – measurement of the deformations of its outer layers [1].

In the first case the sensor of the deflection is used. It is mounted on the basis of the test device usually under the sample (external sensor). It measures the sagging of whole the section under which it is mounted.

In the second case various types of special devices called strain-measuring devices are used. These are the devices which are fastened to the sample surface and serve for the measurement of linear deformations in the place of installation. The most widely used for these purposes are foil resistance strain gauge which are pasted on the sample and represent a one piece.

The choice of the method of measurement of the deformation depends on many factors. The main are – the type of the structure of the material and economic reasons.

If the material of the sample possesses high degree of anisotropy, the use of pasted resistance strain gauges can lead to essential error in the measurement, caused by the cross-section sensitivity of the sensor [2]. Besides, for composite materials, especially with layered structure, the result of measurement may depend on the place of the location of the strain gauge [1]. It should be noted that it is the external sensor of deflection that is exposed to graduation now using during measurements. When using bonded resistance strain gauge, there is no such possibility, because in use the average parameters for the group of sensors, and not for this one.

From said above it follows that the use of sensors of deflection is preferable. It is because they are highly accurate and unlike resistance strain gauges, which are disposable, external sensors of deflection can be used again and again that is worth while from the economic point of view.

The analysis of the designs of known sensors of deflection showed drawback, due to which damage of the sensor rod or the elements measuring displacement may occur at the destruction of the sample. [3]

In Fig. 1, *a* the general view of the device, free from the specified drawback is shown.

It consists of the case 1 supplied with the cylindrical shaft 2. There are two directing slots in the case 1, (conditionally are not shown) for the measuring rod 3. Structurally each directing slot represents three tiny ball-bearings established at the angle of 120 degrees in the plane, perpendicular to the axis of rod 3, and contacting by outer cage from its surface. It provides the minimum friction and practical absence of backlash in the guide. The ends of rod 3 are rounded off and have the form of hemispheres.

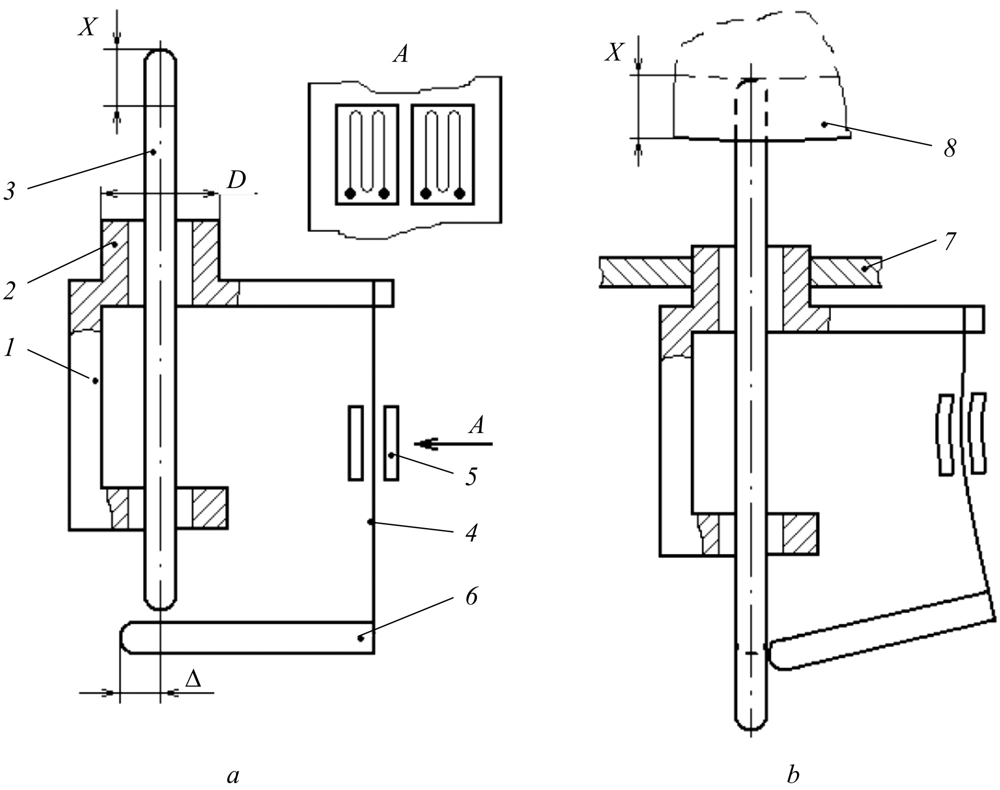

Fig. 1. Schematic diagram of the sensor of the deflection

Strain beam 4 with four pasted on it strain gauge resistors 5 is fastened by one of the ends on case 1. Resistors of strain gauges are connected to a completely active measuring Wheatstone bridge which is connected to the stabilized power source and to the secondary measuring device, for example, to the voltmeter.

The lever 6 attached to the opposite end of the strain beam *4*, closes the cinematic chain, which consist from: the case *1* – rod *3* – strain beam *4*. Lever *6* and rod *3* forming the highest cinematic pair. Thus the free end of lever 6 has the form of the lateral surface of a half of the cylinder with the diameter equal to the thickness of the lever.

The sensor is fixed in the set hole of the device for testing samples for bend *7*, by means of tool shank *2*. Thus rod 3 contacts to the bottom surface of sample *8* (Fig. 1).

The device works as follows: when the sample is bent, its bottom surface moves rod *3* on the distance x, equal to the deflection. This moving through the highest cinematic pair is transferred to lever 6 which bends strain beam *4*, attached to it. Together with it strain gauge resistors *5* are deformed, and their deformation is proportional to displacement of rod *3*, so the output voltage on the measuring diagonal of Wheatstone bridge y is proportional to the measured deflection of sample x.

To calculate the real value of the deflection x based on the output voltage y it is necessary to use calibration characteristic of the device $x = f(y)$ (conversion function). It characteristic usually received before the test. For this purpose the sensor is fixed in the special calibration device and to the rod *3* is given a several displacements x. At the same time variable x and output voltage y are measured by model unit. On the basis of the regression analysis of these data calibration characteristic of device $x = f(y)$ is received.

If the test will sample destruction, rod *3* receives considerable displacement. However it will not lead to the breakage of the device (destruction of strain gauge resistors) as the highest cinematic pair rod 3 – lever 6 will be corroded and rod 3 will move on the necessary distance, without bending strain beam 4 (see Fig. 1). For the next use of the device it is necessary to establish rod 3 into initial position, unbending lever 6.

It is obvious that for providing the established range of measurement x the size of the overhang of the end of lever 6 behind the axis of rod 3-Δ should have a certain value. Let's consider the method of its definition.

Instrument design scheme is shown in Fig. 2 where it is presented in the form of a flat frame ABCD.

Rigidity of the section *BC* formed by strain beam 4, is accepted to be equal *EI*, section *AB* and *DC* are accepted as absolutely rigid. On this basis all displacements in system are due to the deformation of section *BC*.

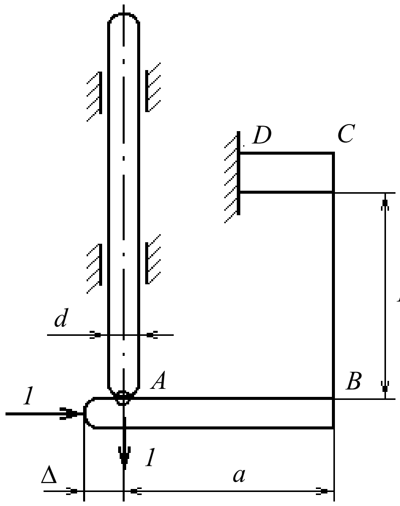

Fig. 2. Instrument design scheme

For the definition of the relation between vertical and horizontal displacements of the point *A*, belonging to lever 6, we use Mohr's integral. For this purpose vertical and horizontal unit load *1* are applied to the lever. Now vertical *x* and horizontal Δ displacements are equal:

$$x = \frac{1}{EI}\int_0^b M_1^V M_1^V dx = \frac{a^2 b}{EI};$$

$$\Delta = \frac{1}{EI}\int_0^b M_1^V M_1^H dx = \frac{ab^2}{2EI}.$$

From here we receive ratio $\Delta = x\frac{b}{2a}$ between the measured displacement *x* and the size of the overhang of the end of lever 6 behind the axis of rod 3 Δ.

Conclusion. In the result of the carried-out analysis of the method of measurement of sample deformations at a bend it is stated that the use of external sensors of deflection is preferable and their design should provide safety of the sensor in case of extreme displacement, for example, at sample destruction.

Developed a sensor design, which corresponds to that requirement. Obtain relations between the size of the sensor elements, which provide the required measurement range and ensure the safety of the sensor when it is exceeded.

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