SPRING-LOADED DIAL INDICATING INSTRUMENT

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Weighing and batching devices with dial indicators are being adopted in various our branches of national economy in the course of production mechanization and automation. The normally-used dial indicators of the quadrant type with ribbon bearings are relatively complicated and require hermetic sealing in dusty atmospheres, for instance, in cement plants, and they cannot withstand shocks or knocks.

In a number of technological processes, however, it is possible, within specified tolerances for scales, to use dial indicators of the spring type, which are simpler in construction and more reliable in operation under the above-mentioned conditions.

The work conducted by the NIKIMP (Scientific Research and Design Institute of Test Machines, Instruments and Equipment for Measuring Mass) to raise the stability of dynamometer spring characteristics has made it possible to produce a spring-loaded dial indicator instrument UTsp-400 (Fig. 1), which consists of a spring-loaded lever system with the lever axle rotating in bearing 1. Lever 2 is provided with two knife-edges, of which knife-edge 4 carries the load, and knife-edge 3 is coupled through a tie and a stiffness regulator 5 with the dynamometer spring 6 and 7. Axle 8 of the lever carries a toothed rack which transmits the movement to pinion 9. A pointer which rotates over a dial scale is mounted on the same axle as the pinion. The rack is pressed against the pinion by its own weight and is secured in position by a support.

Experimental models of these instruments were tested out by the NIKIMP at a constant room temperature, and also in a chamber at higher temperatures up to +50°C and at lower temperatures down to -36°C.

The higher temperatures were obtained by means of a heater, and the lower temperatures by placing inside the chamber a drip pan filled with solid carbon dioxide and alcohol. The heat exchange was improved by directing a jet of air onto the carbon dioxide ice by means of a fan placed inside the chamber. After the lapse of a certain time the temperature inside the chamber became stable and was measured on a thermometer.

The instrument error at normal room temperature is ± 0.4 divisions, which amounts to ± 0.1% of the maximum load.

Test results obtained under varying temperature conditions differed according to the material of the springs. An instrument with alloy N43KhT springs which have a small elasticity modulus temperature coefficient provided an error of 0.2%. The errors did not exceed one division of the scale when the temperature was varied from +50 to -36°C (Fig. 2).

An instrument using springs made of patented carbon steel OVS had a maximum load error of 5 divisions at +50°C and 7 divisions at -36°C, as will be seen from the graphs (Fig. 3).

These experiments lead to an appropriate conclusion about the selection of material for springs in dial gauges according to the conditions of their operation.

The precision and reliability in the operation of a spring-loaded dial gauge depend mainly on the stability of the characteristics of its springs which perform a metrological function.

The stabilization of the measuring spring characteristics was attained by the following set of design and technological measures, which were applied in developing this dial gauge.

Selection of materials for measuring springs. The cited test results of two dial gauges with springs made of OVS steel and N43KhT alloy stress the importance of choosing the correct material for measuring springs. The elasticity modulus of steel varies sharply with temperature. The elasticity modulus temperature coefficient of steel is

$m = \frac{1}{E} \frac{dE}{dT} = -350 \cdot 10^{-6}$ per degree Celsius. Alloys of the type of N41KhT and N43KhT have a relatively constant
modulus of elasticity in the temperature range of \(-180\) to \(+150^\circ\text{C}\), and alloy N43KhT up to \(+200^\circ\text{C}\) with a temperature coefficient of \(m = \pm 30 \times 10^{-6}\) per \(1^\circ\text{C}\) depending on the composition of the melt.

Experience has shown that a temperature change by \(30-40^\circ\text{C}\) provides a change of 1% in the stiffness of springs made of OVS steel, and of 1.4% in springs made of phosphor bronze. The material for measuring springs should be chosen, therefore, according to the conditions of the instrument's operation.

Fig. 1.

![Diagram](image1)

Fig. 2.

![Diagram](image2)

Fig. 3.

Working stress in the spring material. The high operating stresses up to \(0.5 \sigma_e\) and even \(0.7 \sigma_e\) recommended in literature are unsuitable for measuring springs, in view of the rise of the hysteresis and elastic lag with an increasing working stress. The presence of hysteresis causes differences in the instrument readings for the direct and reversed operations, and the elastic lag results in unstable readings and a zero drift after loading. It is, therefore, advisable to use for measuring springs, according to the required precision, stresses of \(r = 0.1-0.2 \sigma_e\), where \(r\) is the twisting stress in kg-wt/mm², and \(\sigma_e\) is the elastic limit of the spring material.