«ряд». В журн.: Технологии электромагнитной совместимости. 2019. №2(69). - С.73-84.

5. Гигиенический норматив ГН 2.1.8/2.2.4.2262-07. "Предельно допустимые уровни магнитных полей частотой 50 Гц в помещениях жилых, общественных зданий и на селитебных территориях". – М. 2007. С.12.

6. СанПиН 2.2.4.1191–03. "Электромагнитные поля в производственных условиях". – М., 2003. С.18.

7. Салтыков В.М., Салтыков А.В., Беспалов В.А. Сравнение напряженностей магнитного поля в окружающем пространстве от трехфазных трехпроводных кабелей при расположении проводников "треугольником" и "в ряд". В сб. статей «Инновационные технологии в энергетике». II Международная науч.-практ. конференция. МК-114-414. 30 ноября 2014 г. – Пенза: Приволжский Дом знаний, 2014. – С.14-18.

8. Салтыков В.М., Салтыков А.В. Определение допустимых значений напряженности магнитного поля от проводов электрической сети и результаты исследований ЭМП. – Germany: LAP LAMBERT Academic Publishing, 2014. – 108 с.

9. V.Saltykov, A.Saltykov. Determining Permissible Values of Magnetic Field Intensity from Electric Circuit Wires and EMF Study Results. – Germany: LAP LAMBERT Academic Publishing, 2015. – 95 с.

PREPARATION OF TENSORESISTORS AND MEASURING EQUIPMENT FOR EXPERIMENTAL RESEARCH

Fidrovska N.
Doctor of Technical Sciences, Professor,
Kharkiv national automobile and road university
Kharkiv, Ukraine
Slepuzhnikov E.
Candidate of technical sciences,
National University of Civil Defence of Ukraine
Kharkiv, Ukraine
Varchenko I.
Candidate of technical sciences,
National Technical University Kharkiv Polytechnic Institute
Kharkiv, Ukraine

Abstract

Conducting experimental research by tensometry is a very important issue in real time. But for such a study it is necessary to calibrate the strain gauges. Calibration must be performed to identify the functional relationship between the load acting on the test piece and the output signal of the equipment.

Keywords: strain gage, calibration, load, part, deformation.

Complex structural forms of components and parts of modern machines and the variety of loads acting on them, often do not allow determine the stress state by modeling or calculation during the creation of modern machines and structures.

The most optimal method of experimental research of the local area of the installation during operation is strain gauge [1– 3].

Tensoresistors are resistors whose resistance changes with the change of their linear dimensions under the influence of external factors. Tensor resistors are wire, foil and semiconductor. The geometric dimensions of strain gages of the first two types change during their deformation [4].

Calibration of strain gages is carried out in combination with measuring equipment [5]. It consists in finding a functional relationship between the load acting on the test part and the output signal of the equipment.

To do this, creating pre-known loads on the part on which the strain gauges are glued, and comparing the values of these loads with the intensity of the output signal, determine analytically or graphically their ratio [6].

Depending on the sizes, a configuration and other features of the investigated detail use two ways of calibration of strain gages: direct and indirect. To obtain reliable measurement results, the calibration conditions should be as different as possible from the conditions of experimental studies of objects.

This means that the load diagram of the part, the composition of the measuring system, the conditions of its operation both during calibration and testing must be the same.

Therefore, to determine the obtained results of stresses, deformations in the crane beam was carried out direct (static calibration).

In electrotensometry use bridge and semi-bridge measurement schemes. The half-bridge circuit is widely used, especially in static processes, where one strain gage is active, and the other is located in the load area and is used for temperature compensation.

If the test piece is subjected to different types of loads that cause deformation of bending, torsion, shear, compression or tension, the strain gauges must be arranged in the circuit so that they perceive the necessary deformations. To do this, use a half-bridge connection diagram, figure 1.

Figure 1 - Scheme of connection of strain gauges to the analog-to-digital converter ZetLab 210

The circuit uses two active strain gages with orthogonal and opposite arrangement, with thermal compensation. The strain gauge is glued so that the axis of symmetry of the lattice coincides with the direction of deformation, which is measured.

Bending deformation is excluded by connection in opposite directions. In the beams of the bridge crane under load, the predominant tensile deformation. Under load, the beam bends and thus increases its length, and width decreases.

The outer wires of the strain gauges were connected to the wires of the half-bridge circuit, which was connected to the analog-to-digital converter (ADC) ZetLab 210, figure 2.

Figure 2. Connection of strain gauges to the ADC

Data from the ADC is fed to a computer. Calibration was to lift and gradually increase the weight of the cargo from 0.0 kg. up to 3500 kg., with a step of increasing the load to 500 kg.

The weight of the load was measured using a dynamometer DPU-10-2, figure 3. Dynamometer DPU-10-2 (DPU-100-2) general purpose is used to measure static tensile forces, calibrated in kilonewtons, and is designed to operate at ambient temperature from -10 ^{0}C to +45 ^{0}C and relative humidity no more than 60%. Overall dimensions – 780 x 280 x 200 mm.

Figure 3. General view of the dynamometer DPU-10-2

Measurement limits of the dynamometer DP-10-2:

- the smallest - 10 kN (1000 kgf);
- the largest - 100.0 kN (10000 kgf, 10 ts).

The division price is 1.0 kN (100 kgf). Limits of the main consolidated error ± 2%. When removing the load from the dynamometer, the arrow of the reading device is set to zero with an error of not more than 0.5 of the scale division price.

The limits of the additional error of the dynamometer are 10 tons (100 kN), caused by the change in ambient temperature in the operating temperature range other than the temperature of normal conditions, 0.25 of the main error for every 10 ^{0}C.

The limit of the permissible value of the variation of the dynamometer readings does not exceed the absolute value of the limit of the permissible value of the main error. The response threshold is not more than 0.5% of the maximum measurement limit. Permissible overload - 100% of the maximum measurement limit. Weight of the dynamometer DPU-10-2 – 20 kg.

When lifting the load, the delay during each cycle was - 60 seconds. When lowering the load - 180 seconds. The following initial data were used for further calculations:

– length of the working surface (crane span) – l_p=22500 mm .;

– crane bridge material – VMst3ps;

– beam wall thickness – δ=6 mm .;

– duration of lifting of cargo – 180 sec., t_n=60 seconds;

– duration of lowering of cargo – 60 sec., t_o=180 seconds;

– length of strain gage – $l_д$=30 mm .;

– power supply of the tensometric bridge – E_v=1,5 V;

– coefficient of strain sensitivity – $k_д$=2;

– Poisson's ratio – υ=0.3;

– voltage in the crane bridge (obtained experimentally, figure 4) – e_0 mV;

– Young's modulus – E=2,05 · 105 N/mm2.

Voltage in the crane bridge for signal 1:

$$e_0=(E_v/2)\cdot k_д\cdot \mathcal{E}_в, \quad (1)$$

where:

– e_0, the voltage in the crane bridge (obtained experimentally);

– E_v, power supply of the strain gauge bridge;

– $k_д$, strain sensitivity coefficient;

– $\mathcal{E}_в$, relative deformation.

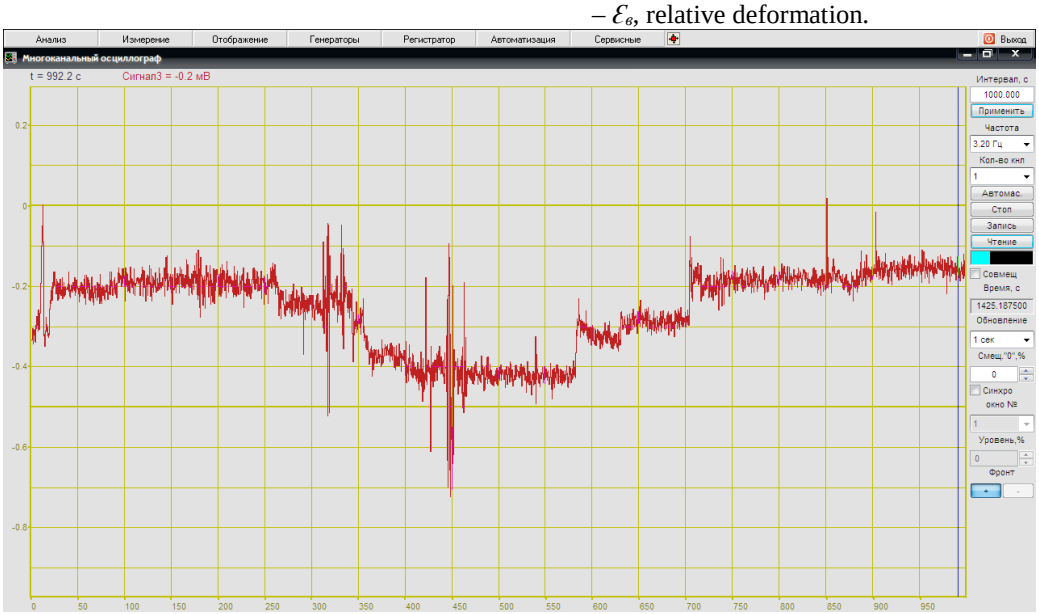

Figure 4 - Stresses in the crane bridge were obtained experimentally using an ADC ZetLab 210

Find the relative deformation:

$$\mathcal{E}_в=dl/l=\mathcal{E}_a/l_д, \quad (2)$$

where:

- $\mathcal{E}_a$, absolute deformation;
- $l_д$, the length of the strain gauge.

Absolute deformation is calculated by the formula:

$$\mathcal{E}_a=2e_0/E_v\cdot k_д. \quad (3)$$

Then the voltage at the point (base of the strain gauge) will be equal to:

$$\sigma=E\cdot \mathcal{E}_в, \quad (4)$$

where E is the Young's modulus (elasticity), for steel VMst3ps E=2,1 · 105 N/mm2.

Conclusion. Selected measuring and recording equipment, software that is part of the measuring complex allows in real time to build functional relationships between the load acting on the test part and the output signal of the measuring and recording equipment installed.

REFERENCES:

1. Ступницький, В.В., Долиняк Я.В. Дослідження залишкових напружень та деформацій методом ультразвукової акустичної тензометрії. Вісник Національного університету «Львівська політехніка». 2015. № 822. С. 58–66.

2. Слепужніков, Є., Варченко, І., Фідровська, Н. Проведення експери-ментальних досліджень методом тензометрії. Матеріали конференцій МЦНД. 2020. С. 85–86. https://doi.org/10.36074/01.05.2020. v2.10

3. Слепужніков Є.Д., Фідровська Н.М., Варченко І.С. Перевірка навантажень виникаючих в металоконструкціях методом тензометрії. Матері-

али IV Міжнародної науково-практичної конференції. Матеріали конференцій МЦНД. 2020. С. 17.

4. Макаров Р.А., Ренский А.Б., Боркунский Г.Х., Этингоф М.И. Тензометрия в машиностроении. Справочное пособие. Москва: «Машиностроение». 1975. 288 с.

5. Калмакова А.В., Дхар П., Узинцев О.Е. Тарировка электротензометра. Вестник РУДН. 2012. №2. С. 1–14.

6. Жуков А.Н., Фадина А.А. Последовательность тензометрических испытаний внутренних элементов железобетонных конструкций. Молодой ученый. 2015. № 7(87). С. 126–129. https://moluch.ru/archive/87/16644/