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Analysis of Stress and Vibration on the Test Stand

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Abstract. The aim of the research was to define the cause and eliminate sound effect coming from the device. Sound effect derives a pair of highly loaded machinery parts-motion screw and nut. Loaded pair is used in non-standard environments of high voltage electrical equipment in electrical substations. The non-standard environment is seen in the movement of this pair immersed in transformer oil deeply below the surface. Transformer oil has no good mechanical lubricating properties because it does not contain sulfur. Loaded pair cannot be lubricated, because there would be oil contamination and deterioration of its electro-insulating properties. The causes were sought in the structure of the machine, frame stiffness, mechanical strength machine and used materials.

Introduction

At the present time, make high demands on minimizing the noise of industrial equipment and machinery, which are caused by vibrations from the machine. The same is true for electrical devices that operate at high voltage in substandard conditions. In this case was solved the arc suppression device of natural connections (Petersen coil). Arc reactor is used to compensate for capacitive currents when a ground faults in the electrical network. They are connected to a node in the distribution network and are continuously tuneable.

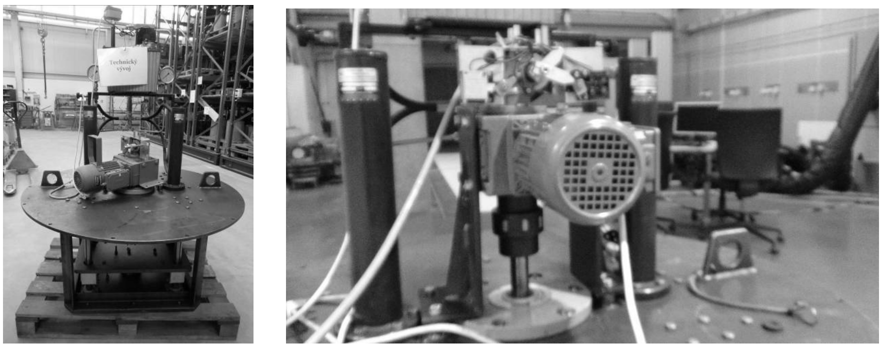

Fig. 1. Test Equipment (left), a flexible drive coupling (right).

Description of the Solution

Experimental Analysis

One of the reasons maybe stick-slip effect. Stick-slip can be described as surfaces alternating between sticking to each other and sliding over each other, with a corresponding change in the force of friction. Typically, the static friction coefficient (a heuristic number) between two surfaces is larger than the kinetic friction coefficient. If an applied force is large enough to overcome the static friction, then the reduction of the friction to the kinetic friction can cause a sudden jump in the velocity of the movement. This effect is reflected irregularly in the form of vibration equipment (Fig. 2 left). It is accompanied by increased noise levels [1]. It was necessary to determine the friction coefficient of friction twin bronze (CuSn8) a steel pin (11500.1). Technique "pin-on-disc" was used to determine the friction coefficient. The principle of this technique consists of placing the body in the form of a non-rotating pin on the surface of the sample. There is placed a pin loaded predetermined force in a selected distance from the centre of the sample. The disc starts to spin at a certain rate and executes a predetermined number of revolutions. Tests were carried out by Bruker instrument in the following conditions: load 200 N, pin diameter 4 mm, temperature 23° C, linear velocity 0.1 m/s, radius 16 mm of the moving pin body, length sliding tracks 1 km, lubricating fluid - machinery oil or transformer oil 50 ml. In the Fig. 2 right, there are graphs comparing the friction coefficient obtained during tests for friction twin bronze and a steel pin, using the classical lubricating or transformer oil. The measurement results are strictly necessary for the calculation of contact pressure screw and nut. They were scanned vibrations on face of the nut (Fig. 3) and was measured using strain gauges the deformation in the bolt due to tension, torsion and bending from the drive motor with gearbox.

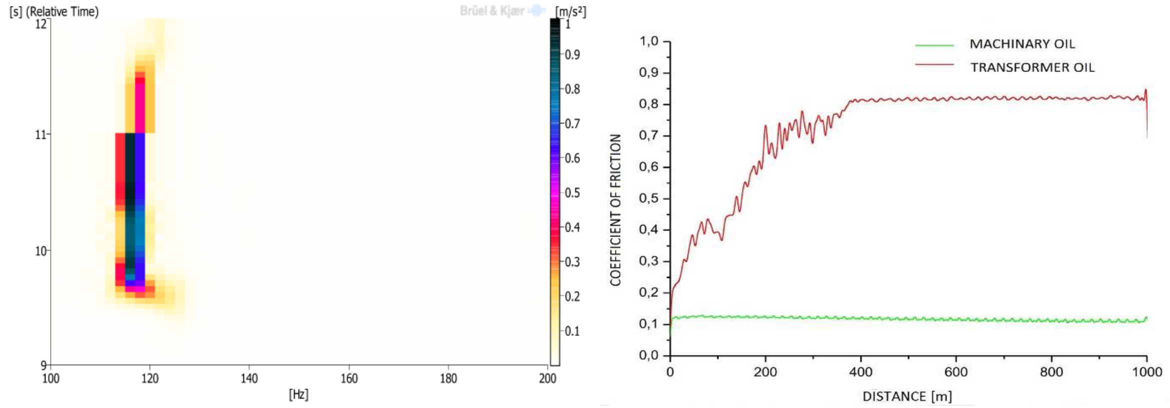

Fig. 2. Multivibration spectrum-the screw in the direction perpendicular to the axis (left), Measurement of coefficient of friction (right).

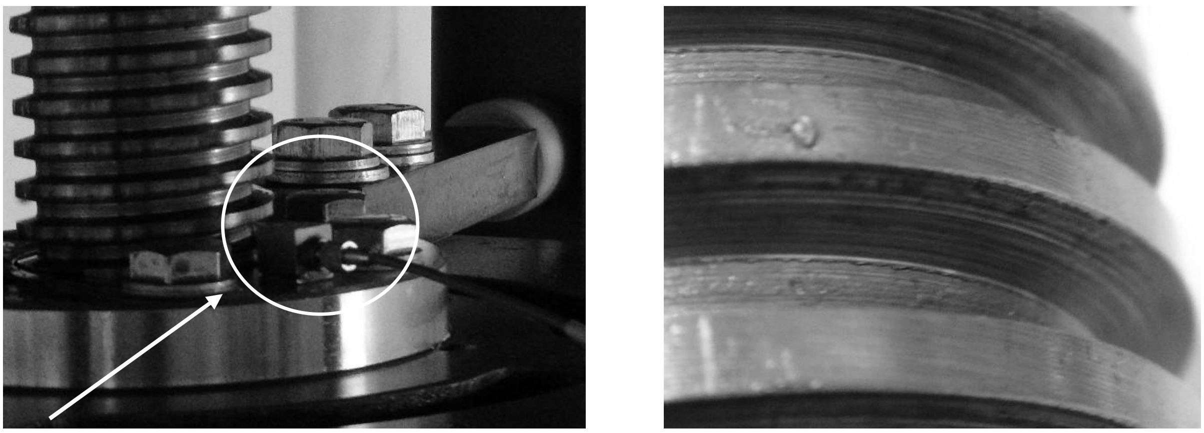

Fig. 3. Sensing of the mechanical values (left), detail (right).

The results of calculations and measurements have been tested for long-term operation. Was reduced stiffness of nut using cutting of threads in different shapes and sizes to create the grooves, (Fig.4 left). These grooves should also bring oil between the contact surfaces. The results of tests were that the groove has no effect on reducing unwanted noise and vibration. More important problem was the failure for the entire test matrix to smooth out the surface glistened. The rough surface of the matrix see (Fig. 4 right) is a sign of tearing the surface of the matrix due to high contact pressures, or dirt. For this reason, the product is disassembled, thoroughly cleaned and reassembled. After a while, operation of these impurities appeared again. Chemical analysis was carried out impurities. An analysis was carried lubricant adhering to the end positions of the bolt. Smear was done on paper that soaks up oil and solid residues remained on the surface of the paper. Under the microscope, the particles were clearly visible bronze and steel. Furthermore been discovered hardly identifiable particles. They were subjected to analysis, see Fig. 5. And thus managed was discovered that due to the high contact pressure and temperature are formed in the oil abrasive particles containing mainly carbon and silicon. These elements form an abrasive material, which can cause wear and especially the noise source. Calcium comes from the backing paper. The measurement results are in Fig. 5. As it turns out, there is a minimum of sulfur, so the lubricating ability of the oil is very low.

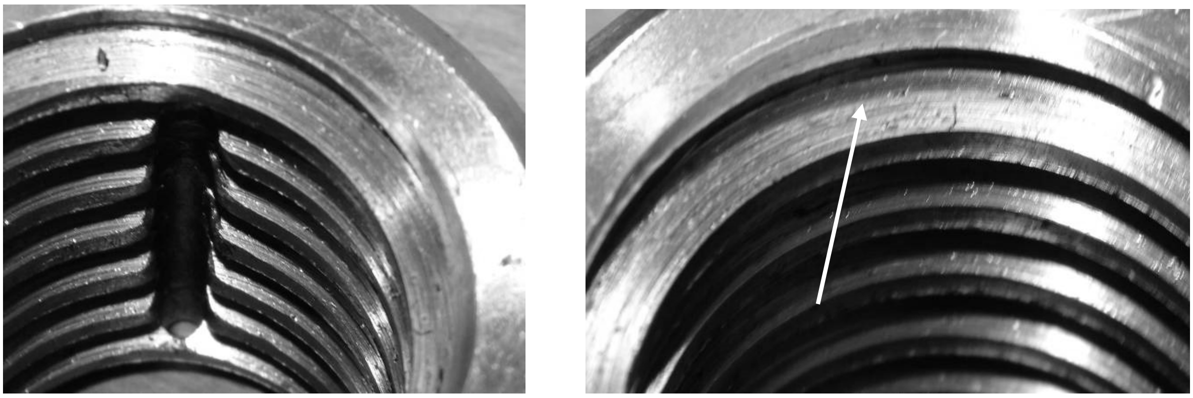

Fig. 4. Lubrication groove and worn cast down nut (left), visible impurities (right).

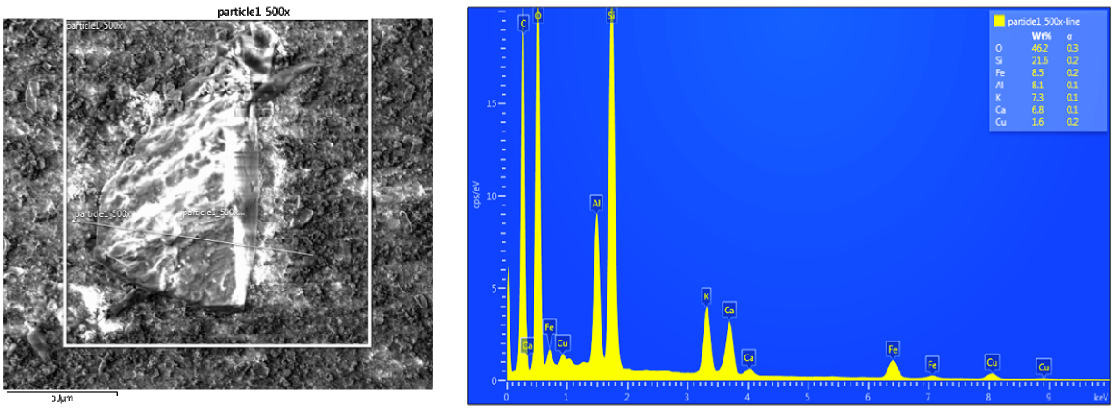

Fig. 5. Chemical analysis of solid particles: detail impurities (left), trace elements (right).

Numerical Analysis

To determine amount of strain and the size of the contact pressure between the screw and nut were compiled numerical analysis using the finite element method. The measured coefficient of friction was used in the FEM contact settings. In the program Ansys Workbench 14.5 contacts with friction were selected [2]. Ansys uses implicit algorithm for calculations [3 - 4], where individual states of the analyzed compression are updated gradually in time t to time t+dt according to Equation (1).

$$\delta u_{i+1} = u_{i+1}^{t+\Delta t} - u_i^{t+\Delta t} . \tag{1}$$

Where $u_i^{t+\Delta t}$ is vector of nodal displacements for ith iteration in the time $t+\Delta t$.

Contact pressure between the screw and nut were calculated and displayed about of the size 77.4 MPa (Fig. 6 left) and stress analyses (von Mises stress) had a size 79 MPa (Fig.4

right). The aim was to achieve the lowest values of internal forces in the device. Internal forces in the device made noise and vibration for different structural arrangement (Fig. 1).

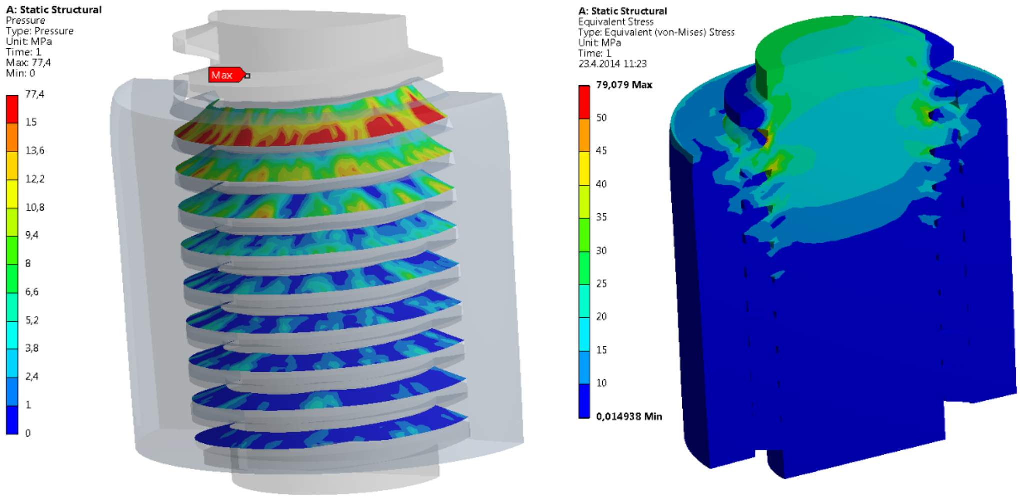

Fig. 6. Contact press between bolt and nut (right), von Mises stress of moving screw (left).

Summary

It would be necessary to achieve smooth surfaces between the nut and bolt. Surfaces should be smoothed slip and not be roughen. High loads, low rigidity frame structure, misalignment of the screw and nut leads to formation of micro-welds of the nut and screw. The resulting heat converts the oil to the abrasive particles. It is necessary to reduce the contact pressure between the nut and bolt to the maximum of 10 MPa with regard to the used transformer oil, to design flexible connectors to the nut and bolt and to make a stiffer frame of the instrument.

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References

[1] F. Zypman, J. Ferrante, M. Jansen, K. Scanlon, P. Abel, Evidence of self-organized criticality in dry sliding friction, Journal of Physics: Condensed Matter 15 (2003) L191-L196.

[2] F. Heslot, T. Baumberger, B. Perrin, B. Caroli, C. Caroli, Creep, stick-slip, and dry-friction dynamics: Experiments and a heuristic model, Physical Review E 49 (1994) 4973-4988.

[3] M. Petrů, O. Novák, P. Lepšík, Analysis and measurement of the charge intensity of the selected electrospinning electrodes, Applied Mechanics and Materials 486 (2014) 217-222.

[4] M. Petrů, O. Novák, L. Ševčík, P. Lepšík, Numerical and experimental research of design optimization of baths for production of nanofibers by the electrospinning, Applied Mechanics and Materials 486 (2014) 157-162.