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METHOD OF DIRECT MEASUREMENT OF SETTING FORCE IN THE POINTS DRIVES

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1. INTRODUCTION

The electric drives transfer the rotational moment to the setting slide through controlled couplings [1,2]. Amount of setting force depends then directly of the type of motor employed and coupling regulation. In the case when the turnout setting resistances exceed the setting force amount, the coupling should skid. However, setting the coupling to an unallowable value of setting force may impair the safety of passengers and condition of the points drive. In the case of two points drive types used in Poland, the oversetting of the coupling may yield various effects, however, harmful in both cases. In the case of points drive JEA29 when the setting force is too high and there is an obstacle between the blade and the saver, the drive moves towards the motor. Direction of drive's moving depends of the direction of setting slide movement direction:

- During pulling of slide the drive moves upwards;
- During pushing of slide the drive moves downwards.

The move results in change of the setting rod lengths in this drive, and thus drive position control in spite of the blade being offset.

In the EEA-4 type points drive, the oversetting of coupling involves other hazard. The correct process of moving the turnout-drive system consists in the fact that after covering the gaps, the motor performs its work of turnout setting already during startup. During this time the speeds of subsequent rotating masses grow very quickly. After completion of setting, in spite of motor being switched off, the rotating masses – due to their inertia – are still moving. This movement is damped by a small skidding of overload coupling. If the coupling is set incorrectly (especially if it's set on the setting force higher than acceptable), then damping of inertia of the rotating masses thorough the skidding of the overload coupling will not take place. Such case may result in a reverse phenomenon in the drive, consisting in the gear's forcing a certain rotation of the motor in the inverse direction. Consequence of this is change of the contacts position in the control and regulation device. Such change may take place directly after the process of turnout setting or after passing of the rolling stock. The second situation is of much more importance as these changes take place during train passing, and make themselves apparent as a false turnout splitting. Moreover in the EEA-4 drive, there may take place a phenomenon of non-jamming the rolls in the self-energizing brake, entailing failure to ensure appropriate force of drive holding. This phenomenon may be dangerous as may lead to the automatic turnout moving under the passing train as a result of dynamic action of turnout to the points drive.

Another important parameter is the time of measurement. Employing the hitherto rod methods the measurement time amounted to 10-15 minutes. Taking into consideration that these measurements should be performed in average every 2 months [3,4] this process is very time-consuming. For instance within the former infrastructure management of Katowice there exists ca. 6000 points drives, which means $6 \bullet 10 \bullet 6000 = 360000$ minutes to perform the measurements (ca 750 working days!).

The aspects mentioned above have enforced a need to establish a new method of measurement of setting forces. This method should be immune to the systematic errors appearing in the presently used measurement methods.

2. THE HITHERTO USED METHOD

Presently on PKP (Polish State Railways) for the measurement of setting force the gauge method is used, based upon a measurement plunger located at the connection between setting slide and the setting rod [5]. The gauge plunger is made in several flavors: as a mechanical system with data readout on the clock sensor measuring the shift of part of the plunger under the force applied or as a system with built-in extensometers with a readout on an electronic display. However, the plunger measurements are burdened with various systematic errors. All plunger devices are made based upon the design presented on Fig. 1.

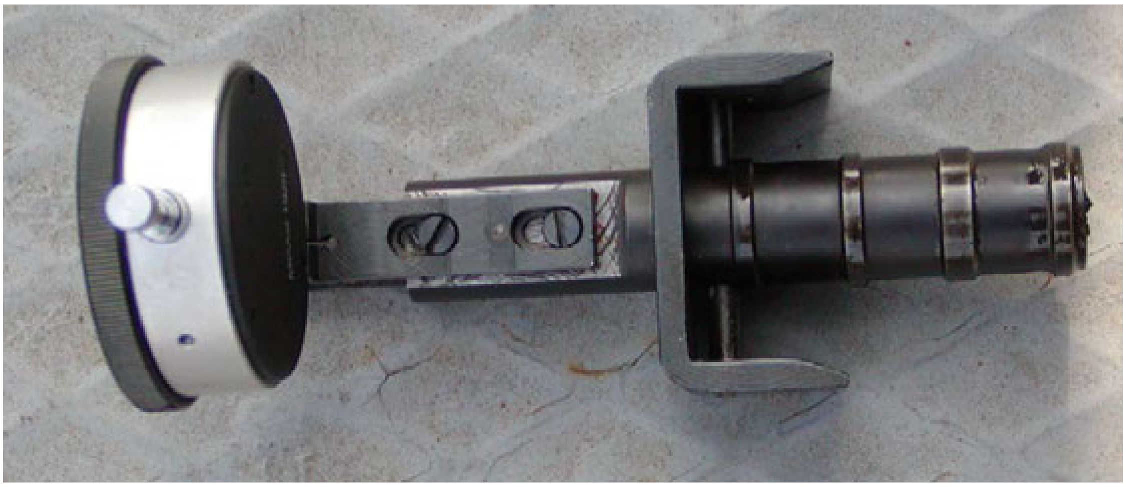


Fig. 1. Plunger gauge EZK

Methods of mounting the plunger gauges in the drive-turnout system is presented on Fig. 2. Because of its design the gauge plunger should be put precisely into the connection point of setting slide and setting rod, so that the forces are applied to the special bumps shown on Fig. 1. This is quite difficult to achieve because in Poland there are many shapes of setting rods and settling slides. This means that there is also many solutions for gauge plunger meters. This is however a costly process.

Measurement with one plunger in a several solutions of setting slide connection with the setting rod is charged with a quite large error, resulting from the fact that the force is not applied to the required measurement points.

Another measurement error is that there are initial forces in the system points drive-turnout that are non-recordable by the low-accuracy plunger devices (Fig. 1, 2a). In the electronic plunger gauges the initial force may be detected but its interpretation should be correct.

a) b) c)

Fig. 2. Plunger method of setting force measurements: a) measurement with EZK plunger; b) measurement with μMOZ-a plunger; c) view of the entire measurement system

3. CONCEPT OF NEW METHOD AND NEW MEASUREMENT DEVICE

In order to eliminate many errors that are brought about by the plunger methods, a new measurement method and new measurement device concepts were developed. The concept consists in the fact that the setting force is measured using a device (Fig. 3a) with measuring head located between the blade and the saver of the turnout at the level of setting closure (Fig. 3b). In order to develop the method and enhance its reliability the analyses were performed using FEM and MSC/NASTRAN software. The results of analyses obtained allowed the optimization of measurement head and enabled determination of values of measurement errors resulting from poor setting of the device.

a) b)

Fig. 3. Measurement of setting forces with MS450 device: a) measurement with MS450 device; b) MS450 measurement head during operation

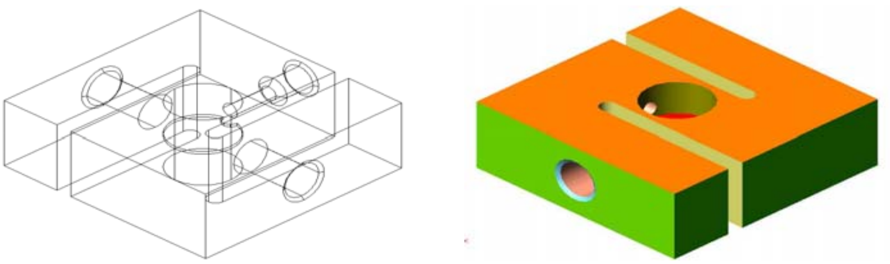
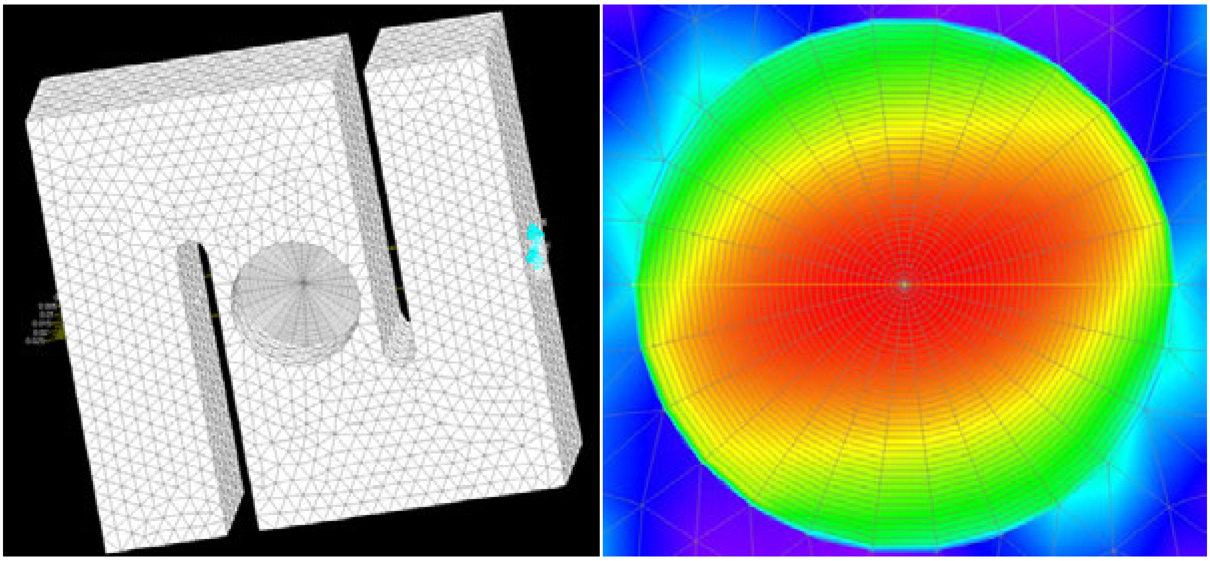


Fig. 4. 3D model of measuring head of the MS450 device made in the AutoCAD program

Fig. 4 presents a 3D model of the primary measurement head made in AutoCAD program. In order to calculate the measurement head deformation during its loading with setting forces the

MSC/NASTRAN software was used, realizing the finite elements method (FEM). During experimental testing, the extensometers have been glued to the middle part of measuring head made as a disk of comparatively low thickness. For this element it was necessary to determine the deformation and stress level. For this purpose, a grid was generated, separately for the central element (finer grid) and remaining part of measurement head . These grids have been generated so that there existed a possibility to connect them through a common nodes The fig. 5a shows the generated grid. The obtained space model had 10745 and 26050 elements.

For the model under consideration the boundary values were set as a mounting in the area of one of tappings (Fig. 5a shows it at the right side of measurement head). The load with node forces was applied to the opposite side and the total of these forces was equal to the setting force. As a result of tests it was established that the central element of the measurement head is subject to the highest loads, while the value of stresses in this element depends largely of its thickness. The disk thickness was adjusted to take into account the inadmissibility of plastic stresses. Fig. 5b shows the distribution of equivalent deformations in the measurement element.



a) b)

Fig. 5. Deformation map made in the MSC/NASTRAN software:
a) generated finite element network; b) equivalent deformations in the measurement element

As it is shown on Fig 5b the largest deformations of this element appear at the angle of 30° in relation to the X axis. This means that when gluing the extensometers it is necessary to determine this angle precisely and fix the extensometer to the appropriate direction. Such an approach may be used for individual production of each device, taking into account the obligatory testing of each device. During mass production of this measurement device such a method of fixing extensometers is quite a disadvantage.

For this reason, a new solution of measurement head was proposed, and its 3D and geometric model was obtained in the AutoCAD software (Fig. 6)

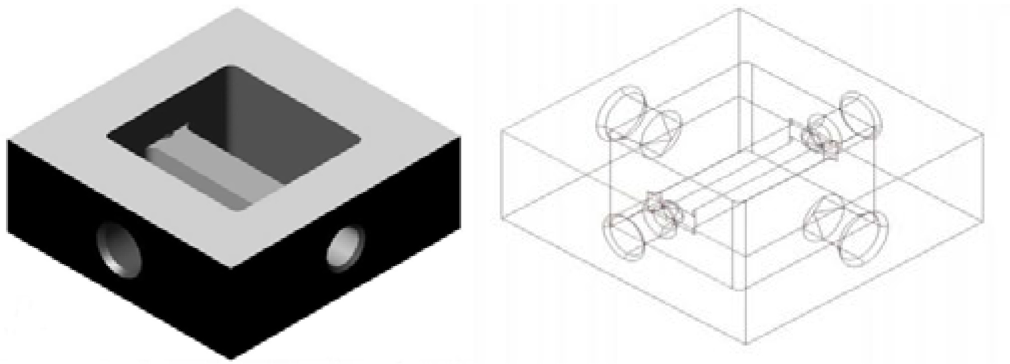


Fig. 6. 3D model of measuring head of the MS450 device made in the AutoCAD program (concept)

The software MSC/NASTRAN was also used to the calculation of stresses and deformations of the new measurement head. Fig. 7a shows the distribution of normal defirmation in the direction of Y axis (Fig. 7b – along the central measurement element).

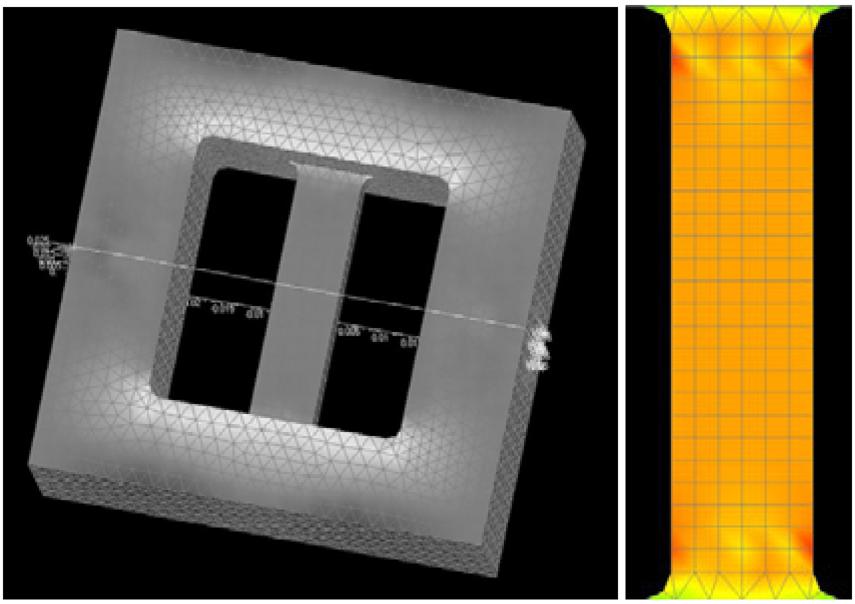


Fig. 7. The map of deformations made in the MSC/NASTRAN software: a) map of deformations of the entire head; b) equivalent deformations in the measurement element

As we see, the largest deformations and respective stresses appear in this direction which makes easier fixing of extensometers. Also shapes and dimensions of the new measurement heads were selected with regard to the strength conditions and production technology.

5. SUMMARY

The paper shows a concept of new device for measurement of setting forces in the railway turnouts. In the further progress of research, after optimization of shape of the measurement head and determination of influence of incorrect setting of the head during measurements to the results, the final shape of measurement head and the device itself will be developed. Perfection of the measurement device will enable verification of its accuracy and further specification of measurement method details. The further stage will be validation of measurement method and device.

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