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Point Machines

A new approach to the measurement of setting forces in the electric points drives

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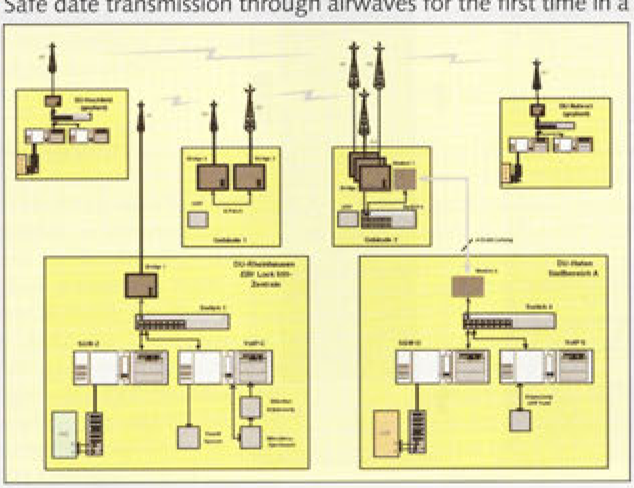
Zum Titelbild: Das Elektronische Rangierstellwerk von Tiefenbach im Bahnhofsteil Köln-Deutzerfeld umfasst den gesamten Bereich der ehemaligen Stellwerke Dtf, R2 und R3 und ermöglicht damit eine zentralisierte Betriebsführung auch in diesen Nebenbereichen.
(Foto: Tiefenbach GmbH)



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Inserentenverzeichnis

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Direct methods of measuring setting forces on electric point machines

Jerzy Mikulski / Aleksander Sladkowski / Jakub Młyńczak

The article presents a new approach to the measurement of setting forces in point drives. The measuring head was designed in such a way that the blade and stock rail curvatures are taken into account as well as strength parameters. The results of performed comparison tests show that the direct method features a very high replicability of results.

1 Introduction

The point drive serves the purpose of setting the blades, wing rails in the frogs or moving actual frog points. In these applications (and particularly when setting the blades in turnouts) the setting force is a very important parameter. This force is defined as the force exerted by the drive when setting the turnout blades. It is measured during the lost motion of clutch caused by an obstacle between the blade and the stock rail [1]. The approach used hitherto to measure setting forces was a gauge plunger method. The article presents the results of plunger instrument measurement using the finite elements method (FEM) as well as test results using finite elements with a new measurement instrument based on direct measurement.

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2 Plunger instruments

Presently in Poland (as in most European countries), plunger instruments are used for the purpose of measuring the setting forces in point drives. Their major feature is that the force is measured at the location of connection between the point rod of the point drive with the coupling bar constituting a part of the turnout (*Fig. 1*). The location of the plunger instrument in the measurement system is shown in *Fig. 1a*.

A large drawback of such a method is that in order to perform the measurement, the point drive system has to be disconnected, the tested point has to be temporarily out of control of the interlocking, and setting the turnout has to be tested. Moreover, the measurement has to be performed when the obstacle is located between the switch blade and the stock rail (*Fig. 1b*)

An equally important parameter is the time of measurement. The tests performed show that the average time taken to perform the measurement is 10 minutes. Assuming that the tested area contains a population of about 6000 point drives, where the majority, according to Polish regulations [2], have to be tested on average once every two months, the result is at the level of 6 x 10 x 6000 = 360000 minutes to perform the measurements (ca. 750 working days!) [3].

For the analyses performed using the finite elements method, an EZK plunger instrument was used (*Fig. 2*), because of its widespread application in Poland. There exist many more modern solutions (MMS-1, MEKS, μMoz-a), but the EZK instrument may be considered as their predecessor.

For the EZK type instrument a strength analysis was performed, using the finite elements method (FEM). For the analyses, Visual NASTRAN for Windows was used.

This model (*Fig. 3* and *4*) consisted of 29961 nodes and 15852 elements. The results of the analysis were disturbing, showing that when loading the plunger

Fig. 1a): Plunger measurement: plunger location (a white element on the point rod, between the point machine and rail)

Fig. 1b): Installation of plunger

Fig. 1c): Obstacle between a stock rail and switch blade

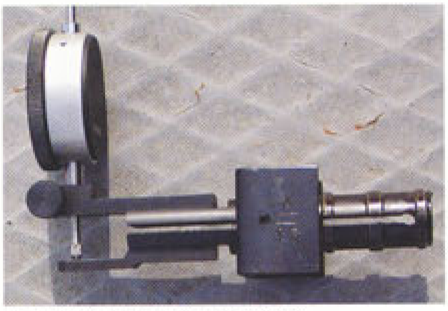

Fig. 2: Plunger instrument EZK

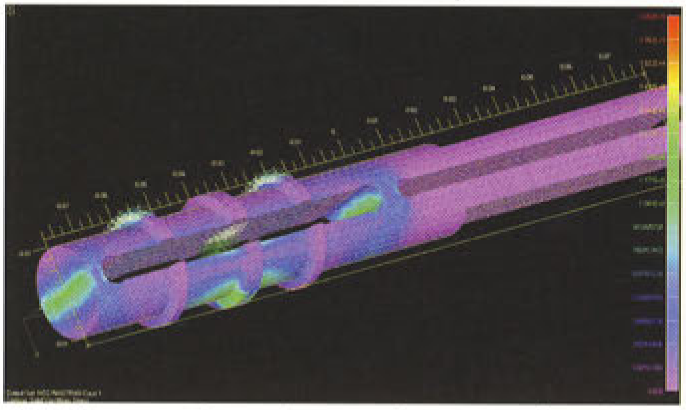

Fig. 3: Stress map of measuring gauge plunger EZK performed using the MSC/NASTRAN software

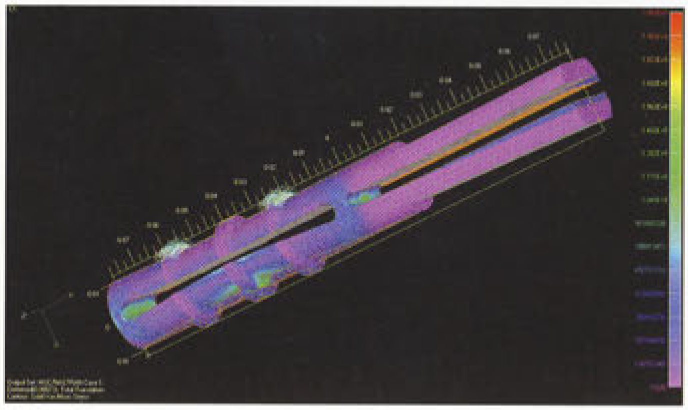

Fig.4: Stress map with the maximum dislocation of EZK gauge plunger elements performed using the MSC/NASTRAN software

with a force of about 10 kN (1000 kG), very high stresses appear, as determined by the Von Mises criterion (*Fig. 3*). At the indicated locations they reach the value of 1500 MPa, up to almost 2000 MPa. The upper load limit of this plunger was set to 10 kN, but it is also used for measurement of point drive holding forces, reaching 15 kN and more. Thus, it is highly probable that a majority of plungers remaining in use feature plastic deformations [4].
Figure 4 presents the total dislocation of EZK plunger elements. We may observe that the plunger undergoes large deformations during the measurement and at a certain threshold above its declared load-carrying capacity it will not only be deformed, but also may fail to measure the entire value of the force. Based upon this analysis we may state that the measurement plungers operate in very disadvantageous conditions and are prone to plastic deformations.

Fig. 5a): Measurement of setting forces using a direct method: measurement with an instrument

Fig. 5b): Measuring head during operation

3 Instrument for direct measurement method

In order to eliminate most of the errors that affect the plunger method, a concept of a new measurement method was developed along with a new design of measuring instrument. This concept consists measuring the setting force with an instrument (*Fig. 5a*) whose measuring head is located between the blade and the stock of a turnout at the location of the setting lock (*Fig. 5b*). The shape and size of the head result from geometric conditions.
In order to develop the method and raise its reliability the analyses were performed using the finite elements method and the MSC/NASTRAN software. The results obtained made it possible to optimize the measuring head parameters and to determine the values of measurement errors resulting from a poor adjustment of the instrument [5].
Calculations of deformation of the measuring head when loaded with setting forces were performed using MSC/NASTRAN. During the experiments, the extensometers were fixed to the middle part of the measurement head, made as a disk of small thickness depending on the load-bearing capacity of the instrument. For this purpose, the grid was generated separately for the central element (finer grid) and for the remaining part of the measuring head. These grids were generated in such a way as to provide for the possibility of their connection in common nodes. *Figure 6a* presents the generated grid. The 3D model obtained had 10745 nodes and 26050 elements.
For the module under consideration the preset boundary values were added by mounting in the area of one of the screws (shown in *Fig. 6a* to the right of the measuring head). The load was applied to the opposite side with separate node forces whose sum was equal to the setting force. The results showed that the central element of the head is the most heavily loaded (which was the objective during construction of the head), while the stress value in this element depends greatly on its thickness. The optimum disk thickness was selected taking into account the inadmissibility of plastic stresses. *Figure 6b* shows the distribution of equivalent deformation in the measuring element.
As shown on *Figure 6b* the greatest deformations of this element occur at an angle of ca. 10° to the X axis. This means that the angle has to be precisely found when attaching the extensometers and that the instrument has to be mounted in a proper direction. Such an approach may be used

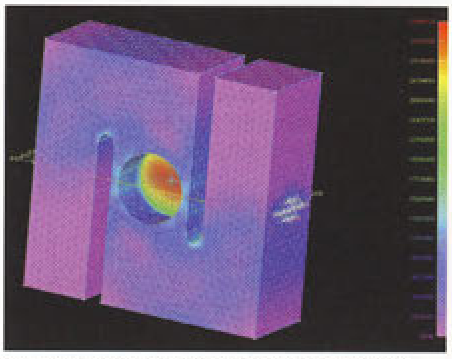

Fig. 6a): Map of deformations performed with the MSC/NASTRAN software: generated grid of finite elements

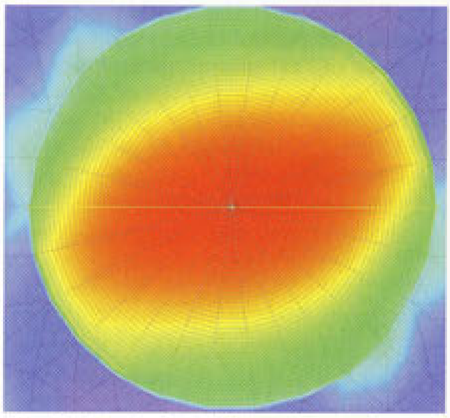

Fig. 6b): Equivalent deformations in the measuring element

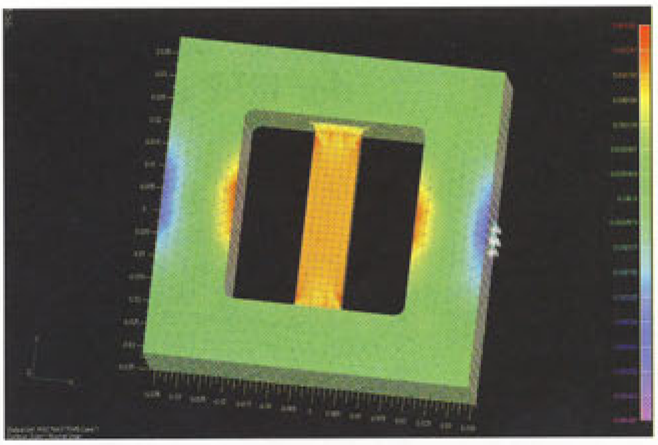

Fig. 7a): New measuring head: map of deformations of the entire head

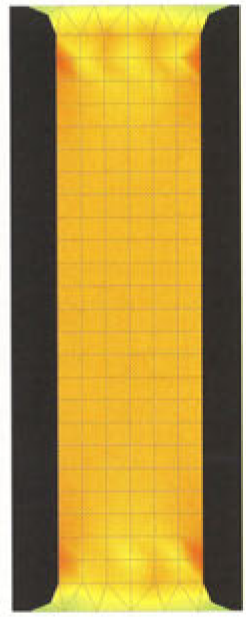

Fig. 7b): Equivalent deformations in the measuring element

for an individual production of the instrument taking into account the mandatory testing of each instrument. With a mass production of this measuring instrument such a method of positioning the extensometers is a considerable drawback.

The next step was to construct a measuring head not burdened with the faults of the present one. This head is shown in *Figure 7*.

The MSC/NASTERAN software was also used for calculation of stresses and deformations for the new measuring head. *Figure 7a* presents the distribution of normal deformations in the direction of Y axis (*Fig. 7b* – along the central measuring element). The obtained 3D model featured 5196 nodes and 18356 elements.

As we can see, the largest deformations and correspondingly the stresses occur in the direction of the Y axis, which makes it easier to attach the extensometers. The shape and dimensions of the new measuring head were also modified from the point of view of strength conditions and production technology.

4 Comparison of methods

The tests were also performed with a view to a comparison of the two methods to determine which one features higher accuracy and replicability of results. The article shows examples of such comparisons.

We have to emphasize that because of its structure, the measuring gauge plunger should be placed precisely in the connection point between the point rod and the coupling bar, so the forces are applied to the special bumps visible in *Figure 2*. This is very difficult to achieve, because in Poland there are many shapes of coupling bars and point rods. This means construction of many variants of plunger instruments, which is very expensive.

The measurement with a single type of plunger in many solutions of connection between the point rod and bar is burdened with considerable errors resulting from the fact that the force is not applied to the required measurement points.

Another measuring error is due to the fact that in the point drive – turnout system there exist initial forces that are not recorded by low-accuracy measurement instruments. It is possible to detect the initial force in the electronic plunger device; however, it has to be interpreted correctly. The characteristics shown in the article take into account the occurrence of these initial forces. The chart presenting these measurements is shown in *Figure 8*. We can see that the results obtained with a prototype instrument for direct method feature less scatter. This allows us to state (with the support of several tens of measurements) that the suggested measurement method is better than the plunger-based ones and that further work needs to be done in order to develop the instrument and the measurement method. We may note that the results obtained with the prototype device developed feature a low degree of scatter and oscillate around the average value [2].

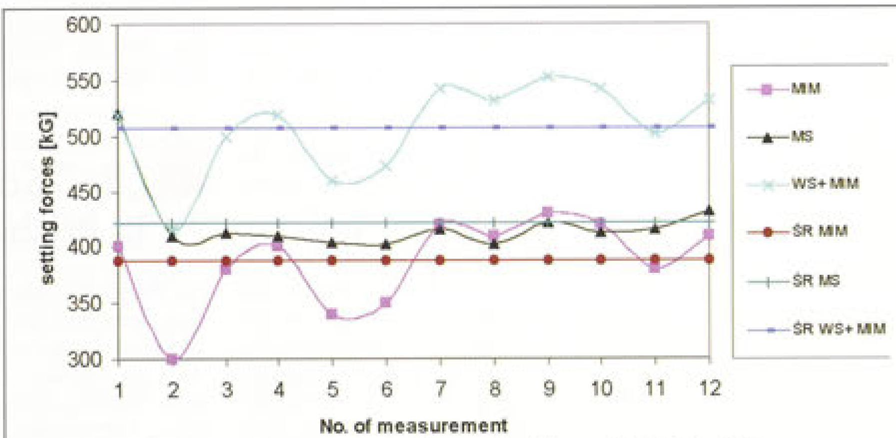

Fig. 8: Results of measurement series taken on a test turnout in Tychy station.
Designations of series: MIM – results obtained with device μMOZ-a; MS – direct measurement device; WS+MIM – μMOZ-a device with initial forces taken into account. Series designated as SR mean corresponding average results.

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ZUSAMMENFASSUNG

Methoden für die Messung der Stellkräfte von elektrischen Weichenantrieben

Der Beitrag beschreibt eine neue Vorgehensweise für die Messung der Stellkräfte von Weichenantrieben. Der Messkopf wurde so gestaltet, dass die Krümmungen von Weichenzunge und Backenschiene ebenso berücksichtigt wurden wie die Parameter der auftretenden Kräfte. Die durchgeführten Vergleichsmessungen zeigen eine sehr hohe Wiederholbarkeit der Ergebnisse.