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AN APPROACH TO MEASUREMENT OF AXLE SETS OF TRAIN IN MOTION

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ABSTRACT
The paper presents final results of research on measurement stand model for geometrical properties of axle sets of railway vehicles in motion. Three different measuring methods were investigated under project. We use contact and non-contact sensors. The paper presents the range of application of the methods in the point of view of possibility of obtaining sensitivity of measurement, what means possibility of identification of minimum difference between theoretical and real diameter and shape deformation. This is also description of whole project witch was started few years ago. Main goal of the research is develop a method for identification worn out wheels diameter with is one of the criteria to qualify the axle set to regeneration process.
Keywords: monitoring, diagnostics, measurement, wheel sets, axle sets, railway, circular errors

1. INTRODUCTION
Research on the method of identification of railway vehicle wheel diameter is made in Department of Machine Technology. Main goal of the research is develop a method for identification worn out wheels diameter with is one of the criteria to qualify the axle set to regeneration process. Regeneration is made by machining. We are make assumption, that proposed method could be used in the industrial environment.

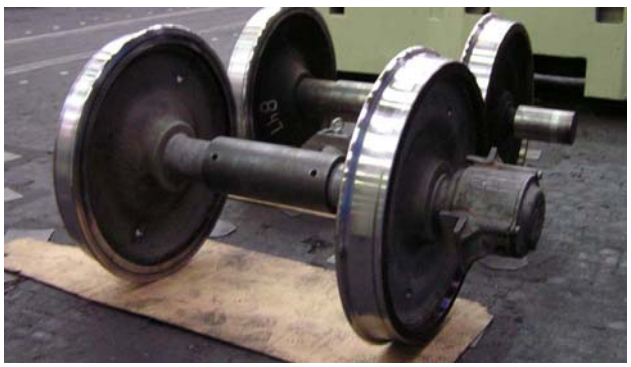

Figure 1. View of axle sets

Wear type can vary in a wide range of patterns, e.g. flat places of high local hardness may occur during breaking skid. It can be stated that the natural wheel wear invokes various shape errors of a wheel, called circular errors. In the example of rail tracks, circular errors can cause additional dynamic forces to occur at contact area between rails and wheels. It causes the increase in both noise and vibrations, what leads to uncomfortable transportation.

As we know natural wear of wheel's tracks in use is one of most important phenomena of rail transportation. Wear process is very complex and more or less intensive, depending on many factors, i.e. rail curves, breaking conditions, start-up conditions of trucks, truck velocity and loading etc.
Circular errors and differences of diameter in axle set wheels are criteria to qualify the axle set to regeneration process. Regeneration process of worn wheels of a truck performs on special machine tools.
The axle sets very often need to be disassembled before machining begins. The disassembly process is not only very expensive but also time-consuming as the worn wheels are excluded from use for a long time period. Thus, the decision about axle set regeneration is very important. If it's taken prematurely, it can be unprofitable, from the other side if it's undertaken too late, it can be simply dangerous. The best criterion for the problem of decision-making is to identify the actual state of a wheel track.
We decided to build the model of the stand that permits measure geometrical state of wheel while train is in motion. In past works we presented results of method that prove suitability of inductive contact sensors for measurement with required accuracy. Significant sensitivity on construction parameters of measuring stand makes difficult to apply one in the industrial environments.
Presented approach is continuation of work began by A.Kolka [2]. Compare of three method of identification of diameter is main goal of research. Proposed method using:
- inductive non-contact sensors
- encoders,
- laser triangular measuring units.

2. MEASURING STAND

Measuring stand (fig.2) is built in form of pair of rails. In both rails are mounted different measuring units. At the right one are mechanical measuring modules equipped in two kinds of sensors and at the left one are used laser sensors.

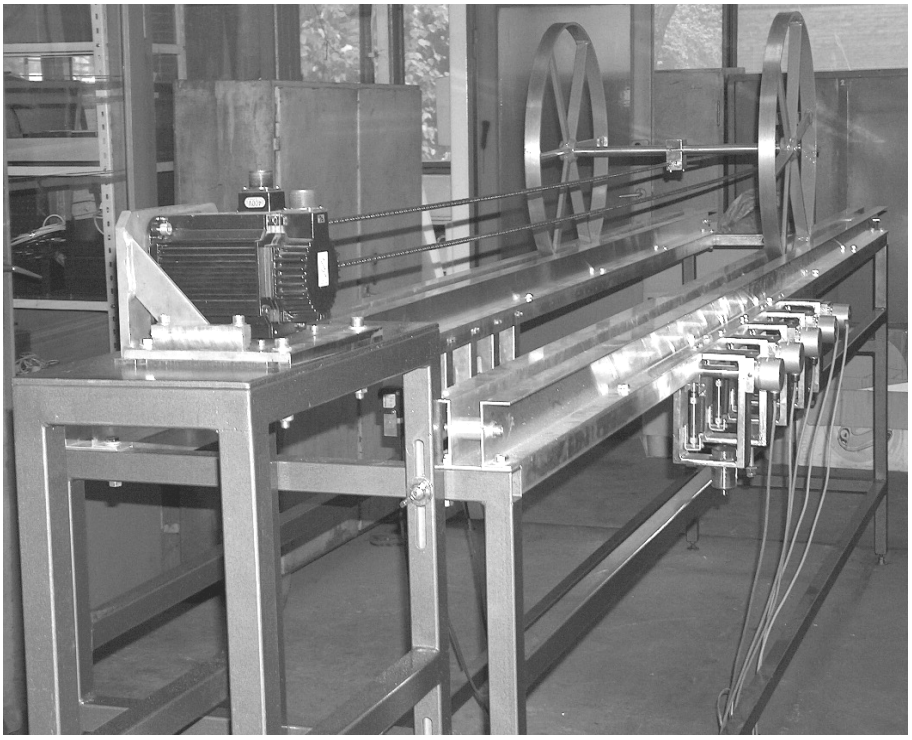

Figure 2. Rail of measure stand with assembled measuring units

Mechanical measuring unit is presented in the figure 2 and 3. In the one we are using to kind of sensors operating with mechanical parts. One is encoder and second non-contact inductive sensor. Mechanical part with rotating lever equipped with roller (1) staying in the contact with the axle wheel passing measuring stand. In the axis of rotation (3) of lever are set encoder and cam cooperating witch

non-contact inductive sensor. Shaft of encoder is connected with shaft of lever. Under sector cam, on the bottom of unit is set non-contact inductive sensor. When railway car passing the stand axle wheel pushing lever by roll and lever rotation force rotation of encoder shaft and simultaneously sector cam. Encoder measuring angle position of shaft and non-contact inductive sensor measures distance between sector cam surface and sensor surface. Registered signals are represents complete change of angle of lever during contact with the wheel registered on two ways at the same time.
Second approach using non-contact laser heads (fig.4) that measuring direct distance between rail and wheel. In this case depends on mounting distance two or three sensors are in measuring range at the same moment when wheel passing the stand.

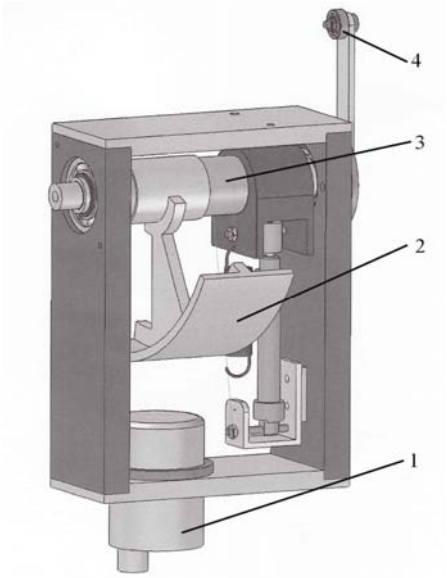

Figure 3. Model of diameter measuring unit: 1 –non-contact inductive sensor, 2 – cam, 3 – shaft, 4 – lever with roller

Figure 4. View of row of laser heads at left rail

3. DATA ACQUISTION AND PROCESSING

Complete acquisition and processing are automated by special software developed in LabVIEW environment. User-friendly interface gives access to options of signal sampling and wide range of processing of signals. One of most important procedure is adjustment of measuring units. It is possible to select one or two acquisition method. Different algorithms for signal processing are used. Algorithms for diameter estimation are built in. If number of measuring units is enough kind of circularity deformation is recognized. Results can be presented in the report and format as data for numerical control of machine tool for regeneration of axle set if it is necessary.
Software is made as modular system, it can be extended for industrial purposes in the future. There are applied modules for control A/D converters. In the future any hardware made by well-known National Instruments can be used with this software.
Example result plots obtained during acquisition are presented below. Last step in signal processing is estimation of diameter of wheel that is represented as mean value of obtained values (fig.7). Additionally algorithm based on FFT is applied for circular deformation classification. But this option works only in case of use number of measuring units enough to cover complete circumference.

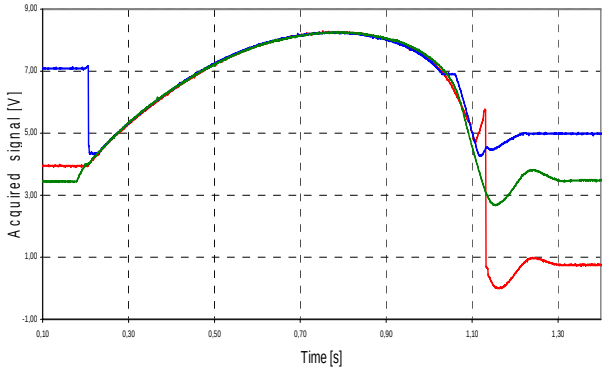

Figure 5. Example plot of acquired signals form rotary encoder

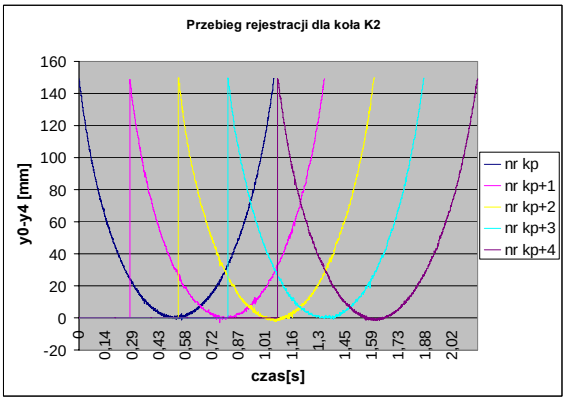

Figure 6. Example plot of acquired signals form laser sensors

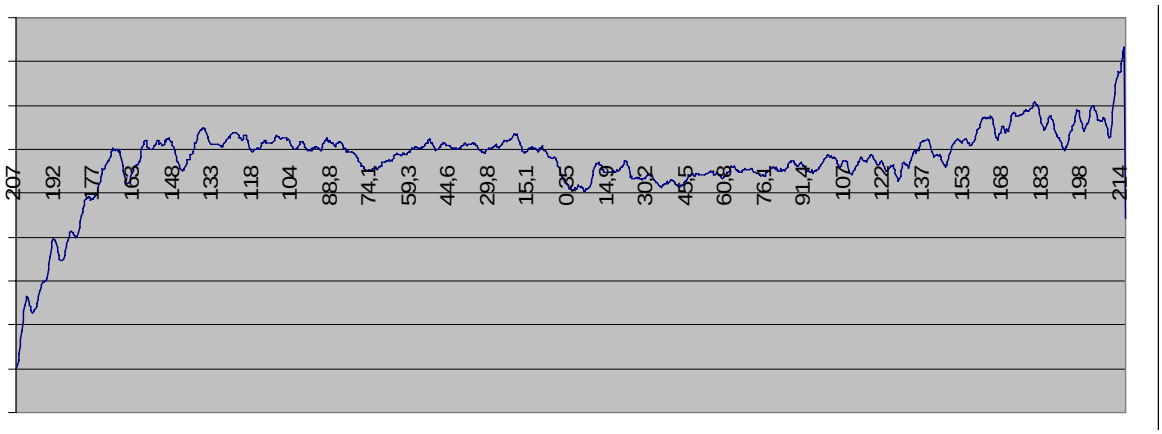

Figure 7. Example plot of estimated diameter of wheel

4. CONCLUSIONS

Main goal of research is to compare few methods of measuring taking under consideration accuracy, and usefulness of application. Now a day we can answer, that easiest to application are laser measuring units, but signals significantly depends on measured surface quality. From the second hand mechanical units needs using rotary encoder with bigger accuracy to improve results. Third approach witch cam elements are not satisfactory.

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