DYNAMIC MEASUREMENTS OF PARAMETERS OF RAILWAY TOP STRUCTURE BY EDDY-CURRENT EQUIPMENT

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Abstract: Measuring of the parameters of the railway top structure, comprising width of rail track, lateral wear and rails clearance, nowadays is performed with the help of various NDT methods, various traveling speed of track measurement means.
At JSC MSIA "Spectrum" was developed the system PKRN-01 of dynamic contactless measurement of mentioned parameters of railways in which the initial information about condition of examined object is obtained by means of eddy-current transducers' modules positioned over the rails surface. The performed practical trails gave results of examination of parameters of rail tracks and butts at various traveling speed, helped to estimate the error and limitation of such a system implementation.

Introduction: Between the tasks solved with the help of means providing truck measurement on railway roads, one of the most urgent is the task of automated examination of the parameters of the railway top structure. Due to large extent of railway roads all over the world and in Russia as well, the measurement of the width of rail track, the lateral wear of rails and parameters of butt clearance (the clearance of butt and excess of one of the rail in the butt over the other) is better to carry out when the measuring unit of the track is traveling with high speed.
Existing automated inspection systems for examination of listed parameters used at the moment in most cases are implementing contact method of track shape measurements. Such systems comprise rollers that are pressed to the rail surface. The main advantage of such systems is type of obtained data as they present continuous profile of track shape; and the disadvantages – necessity periodically to provide lubrication of units, absence of information about butts, difficulty in obtaining of accurate data when the traveling speed of measuring system is increased above 30-40 km per hour.
Optical systems manufactured by a number of companies considered to be more promising in the field of development of means for measurement of parameters of rails top structure. Their indisputable advantage is that they provide contactless receiving of required data at high traveling speed but in case of satisfactory climatic conditions and good condition (clean rails) of the examined track. In case if any of the two above mentioned conditions will not be fulfilled it becomes rather difficult to perform measurements with the help of optic systems.

Results: For Russia with its huge extension of railway roads, server climatic conditions and tough conditions of rails operation one of the promising directions of development of systems for examination of rails top structure is use of equipment based on dynamic, contactless measurement of track width, parameters of wear and butt clearance with the help of contactless eddy-current transducers (ECTs), placed over the surface of each rail.

Discussion: At JSC MSIA "Spectrum" was developed the system PKRN-01 of dynamic contactless measurement of mentioned parameters of railways in which the initial information about condition of examined object is obtained by means of eddy-current transducers' modules positioned over the rails surface with gap of 10 mm that makes the contact between the rail and bottom part of the transducer surface impossible. The ECT block consists of three ECT modules mounted on one ruler (Fig. 1). Each of installed transducer is designed for measurement of certain parameter and practically is tolerant to changes of others. Unlike the eddy-current equipment of previous generation where were used the parametric ECTs mounted in common housing, in the system PKRN-01 the ECT of transformer type placed at some distance from each other are used, proposed construction eliminates the possibility of their interaction. The ECT block comprises a number of transducers for track width examination, which measures the distances between the rails top internal surfaces; the module of measurement of butt clearance, difference of height of rail edges in the butt and rail top wear as well as module of measuring of gap between the ECT and the rail. The last of listed modules is designed to avoid the disturbances necessary present during traveling of the system that cause deviations of clearance between the ECT and rail in the process of examination. The peculiarity of its construction is presence of two separate biased identical transducers displaced relative to the rail surface center, such installation in combination with special algorithm of signals processing allows to exclude the influence of changes of a clearance value on the results of parameters of the rail top structure examination.

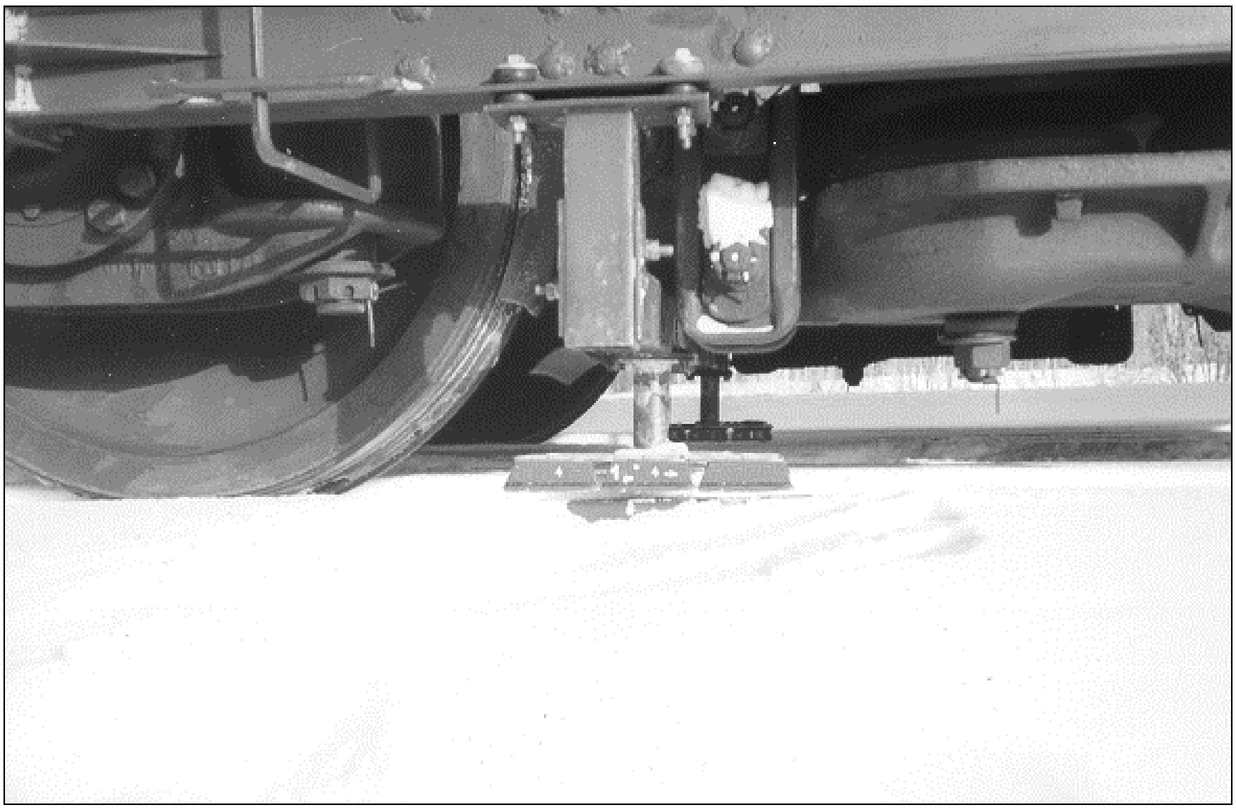

Fig. 1. Scheme of the ECT modules placement over the rail surface (winter time)

The processing of signals picked up from two ECT modules is carried out with the help of two separate electronic circuits in which the data obtained for each rail are detected and amplified by means of different transformations and filtrations. The data on the circuits' output are summarized through the ADC PCB in the PC where due to special program the calculations of the rail track and butt clearance are performed (Fig. 2-3).

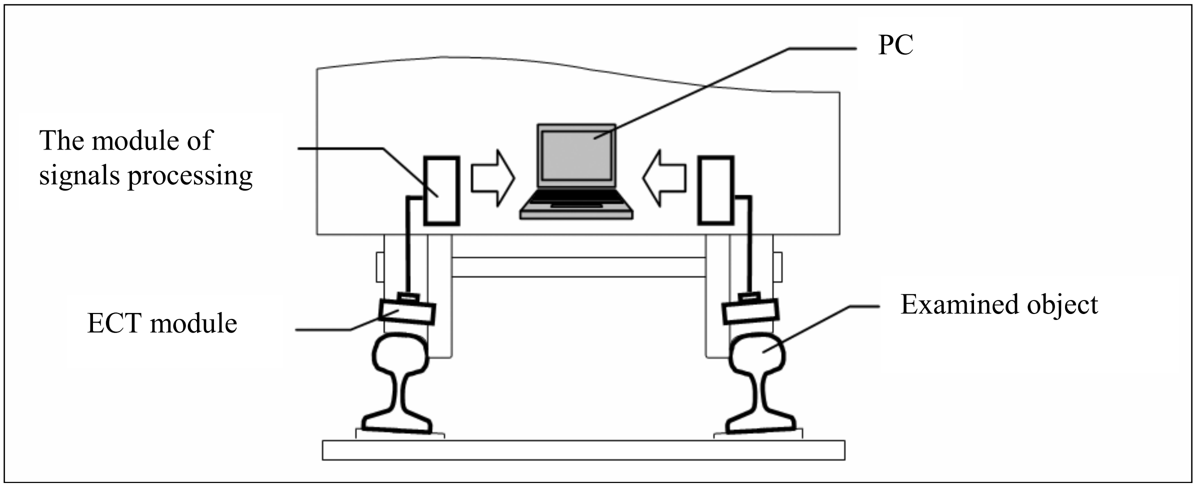

Fig. 2. The scheme of measuring system placement on the vehicle for the track measurement

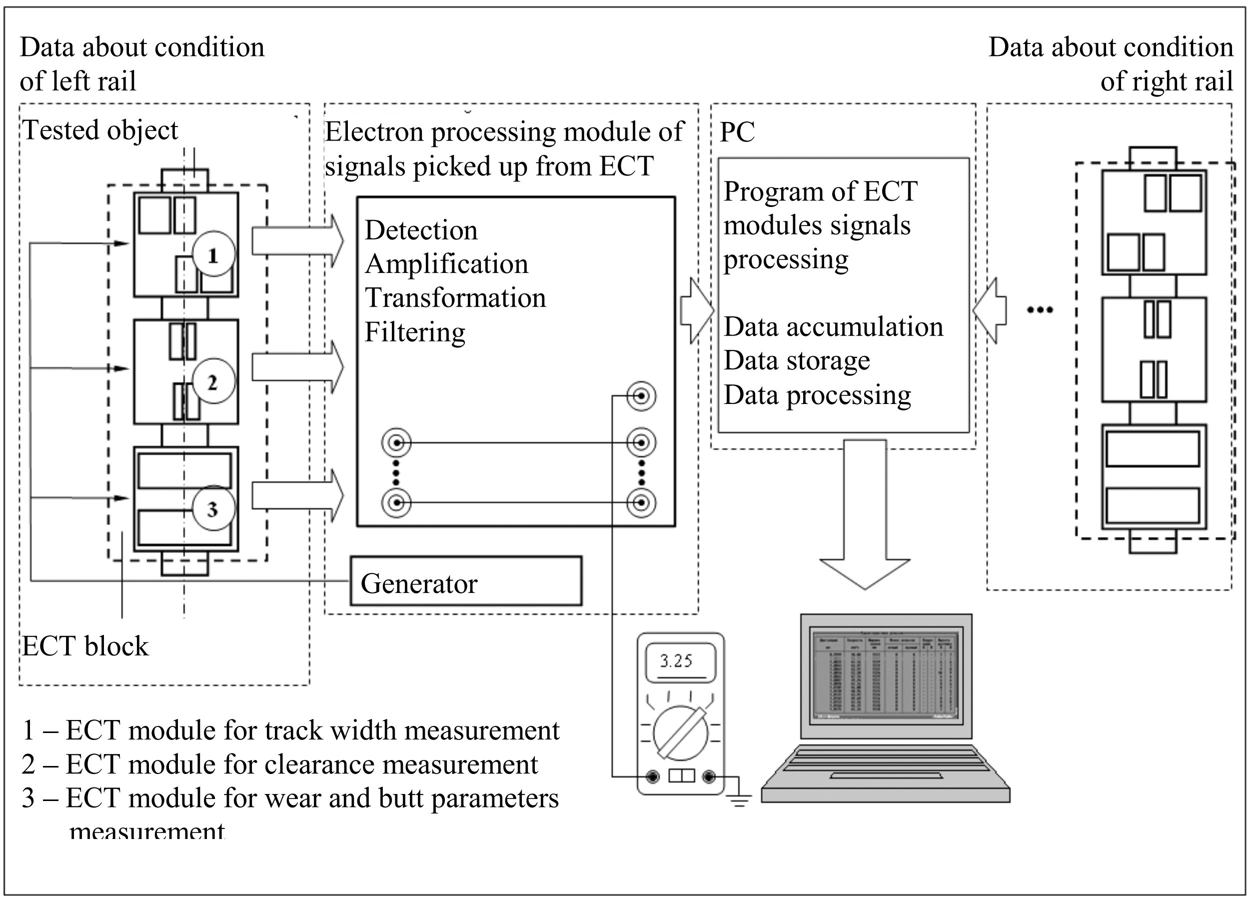

Fig. 3. General scheme of PKRN-01 system

The program of measurement data dynamic processing provides timely information about condition of the track, and when the measurements are completed it is possible to receive detailed analysis of data in various modes, i.e. when final results are presented in table (Fig. 4) or graphic modes (Fig. 5-6). During one run it is possible to have acquisition of parameters about condition of 200 km of railway track. It is possible to have information about each meter of the track width and rail wear and parameters about condition of each butt.

Характеристики стыков

Дистанция км	Скорость км/ч	левый рельс: превышение мм	левый рельс: зазор мм	правый рельс: превышение мм	правый рельс: зазор мм
0.0088	12.24			0	4
0.0088	12.24	-1	3		
0.0341	41.76	0	3		
0.0341	41.76			0	2
0.0594	65.88			0	3
0.0594	65.88	1	6		
0.0847	74.52	0	6		
0.0847	74.52			0	4
0.1111	86.04	0	6		
0.1111	86.04			0	2
0.1364	96.84	0	6		
0.1364	96.84			0	5
0.1485	92.52			-2	8
0.1485	92.52	-2	6		
0.1617	110.16	1	2		

Характеристики рельсов

Дистанция км	Скорость км/ч	Ширина колеи мм	Износ рельсов: левый	Износ рельсов: правый	Коррекция Л	Коррекция П	Высота датчика Л	Высота датчика П
0.9999	38.88	1517	0	0	–	–	7	7
1.0021	48.24	1517	0	0	–	–	6	6
1.0032	47.16	1519	0	0	–	–	6	6
1.0043	43.92	1519	0	0	–	–	7	7
1.0043	43.92	1522	0	0	–	–	9	8
1.0054	52.20	1524	0	0	–	–	10	9
1.0065	47.16	1519	0	0	–	–	6	6
1.0087	39.24	1517	0	0	–	–	6	6
1.0098	47.16	1515	0	0	–	–	8	6
1.0109	45.00	1515	0	0	–	–	8	7
1.0120	48.96	1515	0	0	–	–	7	6
1.0131	43.92	1516	0	0	–	–	7	7
1.0142	49.68	1516	0	0	–	–	8	6
1.0153	47.16	1515	0	0	–	–	8	8
1.0164	45.72	1518	0	0	–	–	8	7
1.0175	41.76	1518	0	0	–	–	7	7

Fig. 4. Presentation of measured track parameters in the form of tables.
The following parameters are displayed: Butt parameters: Distance, km; Traveling speed, km/h; Left (right) rail: edge' exceed height, mm; clearance, mm. Rails parameters: Distance, km; Traveling speed, km/h; Track width, mm; Rail wear: left, right; Correction (L, R); Transducer height (L, R)

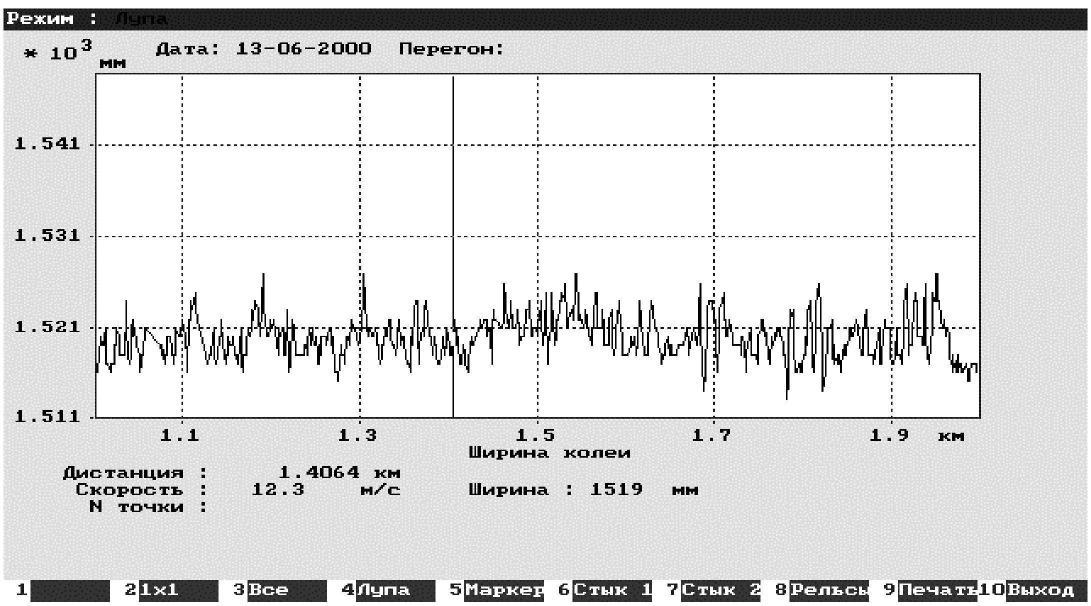

Fig. 5. Presentation of measured track parameters in the graphic mode: track width. The following parameters are displayed: Operating mode; Date; Run; Track width; Distance: km; Traveling speed: m/sec; Width: mm; Point #

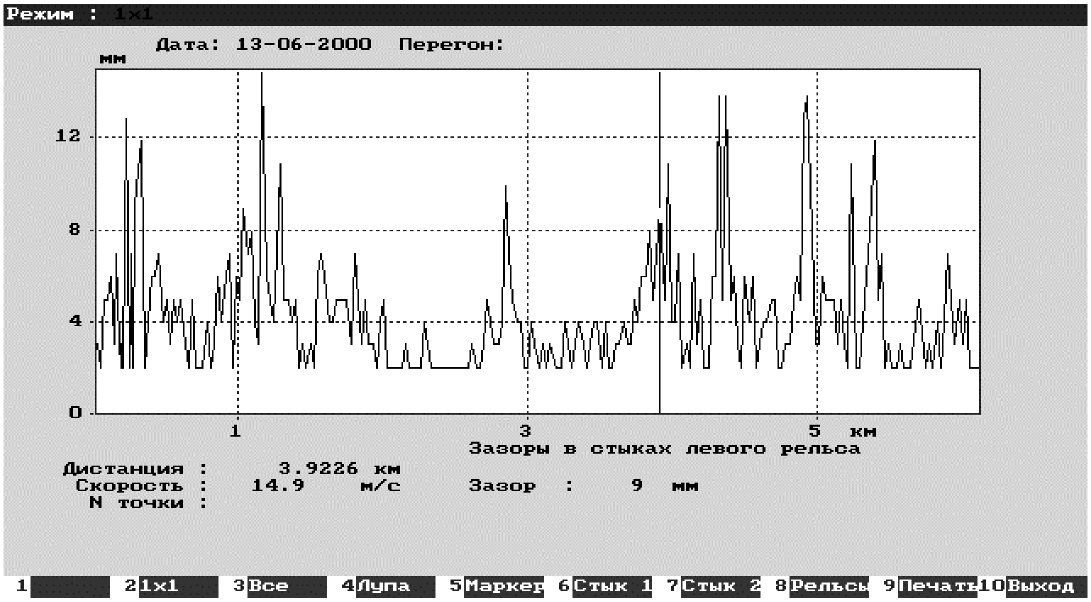

Fig. 6. Presentation of measured track parameters in the graphic mode: rail butt clearance.

The following parameters are displayed: Operating mode; Date; Run; Clearance in butts of left rail; Distance: km; Traveling speed: m/sec; Clearance: mm; Point #

There are some optional functions in the program, for example, continuous data recording or presenting on the screen of the signal present on the output of electron processing circuitry. In case of data recording or presentation on the screen it is possible to have access to the results of measurements for each channel, this helps to carry out system adjustment, introduction of required corrections and other studies (Fig. 7).

The transducers calibration is performed on the special three coordinate test bed comprising the parts of rails. With the help of the test bed it is possible to imitate various schemes of mutual placement of the ECTs and of examined object, to carry out studies of the transducer parameters including the recording in the dynamic adjusting mode of the ECT signal when the ECT block is interacting with butt clearance.

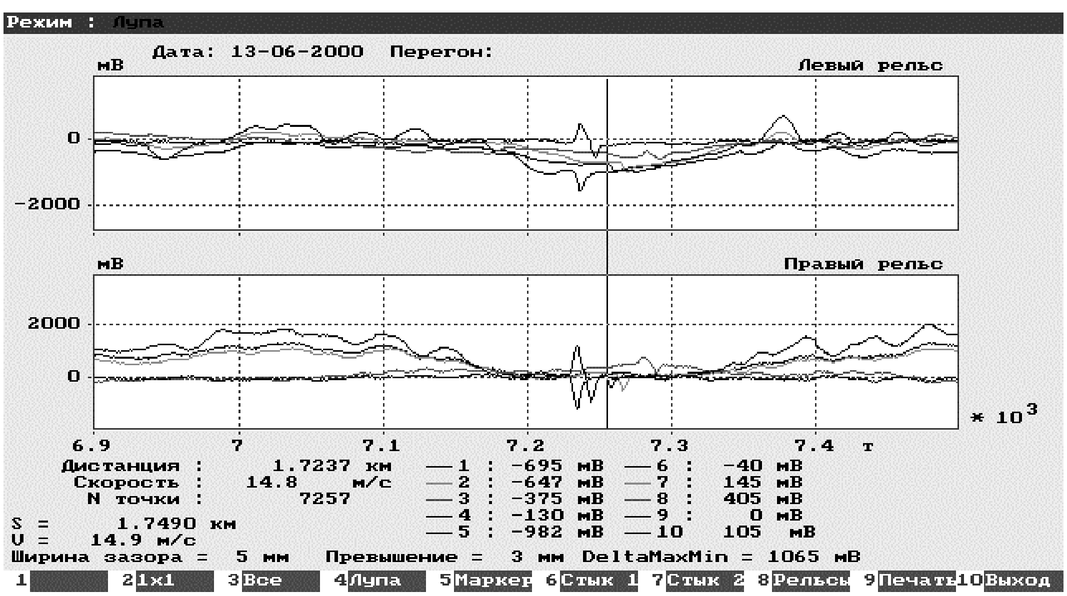

Fig. 7. The mode of ECT signal recording in the adjustment mode. The following parameters are displayed: Operating mode; Date; Run; For left rail and right rail; Distance: km; Traveling speed: m/sec; Clearance: mm; Point #; Clearance width = mm; Height exceed = mm.

To perform the integral evaluation of the rail track condition the final information is transmitted to the central PC of the laboratory providing track parameters measurements and is recorded in the data base "WAY (PUT') in which are stored all measured parameters of top and bottom rail structure and the condition of the contact system. In the mentioned data base in the form of tables, graphs and reports all collected data are available and can be used for reports printing out, for further data accumulation and statistical analysis, in particular, it is possible to prepare a report where the condition of the track is estimated in numbers.

Conclusions: The trails of developed system were carried out in test laboratory of JSC MSIA "Spectrum" and on testing ground of railway transport. During the trails and use of the presented system on Baikal branch of Russian railway roads it was proved that ECT can be successfully used for dynamic contactless examination of the railway tracks parameters, obtained results are satisfactory. Results were obtained for various measuring modes and different traveling speeds (20 - 90 km per hour). On the basis of these results the following conclusions can be made:

1. When performing measurement of rail track width and butt parameters of one and the same part of railway road the system provide obtaining of reliable and repeatable results independent on climatic and rails conditions. In laboratory conditions the error of track width and parameters of butt clearance measurement is ±1 mm. In accordance with existing regulating documents this is enough to provide evaluation of condition of railway track. It is necessary to underline that the track parameters are measured in dynamic mode and in presence of load and hence it is not possible to compare the accuracy of measurements by means of simple comparison of results of manual measurements performed on the track with the help of manual pattern.
2. When carrying out measurements of lateral rails wear with the help of presented scheme of the ECT it is possible to obtain only the summarized integral estimation without paying attention to its form. Wear measurements error is ±2 mm. The improvement of this error (i.e. its reduction) can be achieved due to further enhancement of the design of the existing eddy-current transducer and algorithm of signal processing.
3. In accordance with existing Russian norms the width of the rail track should be within the limits 1510 - 1545 mm and rated value is 1520 mm. However, actually measured value of track width due to the operation of railway road in severe climatic conditions, presence of overloads and irregular maintenance can be in more wide range (i.e. more than upper limit stated above) while the lateral wear of the rail top can reach 1560 mm. The preset distance between the ECT modules that measure parameters of left and right rails is equal to 1595 mm that corresponds to the track width of 1520 mm measured by means of manual pattern. The minimal error of track width and wear measurement is achieved when rail axis is displaced on ±25 mm relative to the position of the ECT module. For bigger displacement in given conditions the error increases due to reduction of sensitivity towards the displacement of the rail relative to the position of the ECT, this statement is especially evident in case of small clearance.
4. The measurements of the rail track parameters with required accuracy are possible only in case of correct positioning of the ECT module over examined object and absence of mistakes during performing of calibration procedure. The personnel using the system of such type should have proper qualification, be trained to understand the basic requirements imposed on assembling, adjustment and operation procedures of eddy-current equipment.