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IMPROVEMENT OF THE ULTRASONIC DIAGNOSING OF AXES OF THE WHEELED PAIRS OF ROLLING STOCK OF RAILWAYS

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Summary. A mathematical vehicle for computation and construction of diagrams amplitude-distance-diameter is presented, application of which allows to promote authenticity of results of diagnosing of axes of the wheeled pairs of rolling stock of railways by an ultrasonic method.

Key words: rolling stock of railways, technical diagnosing, ultrasonic impulsive echo-method, defect.

INTRODUCTION

In connection with the necessity of more than complete satisfaction of necessities in transportations of loads and passengers, in particular increases of carrying capacity and speed of transportations in XXI age, with the special sharpness there is the problem of comprehensive perfection of work of railway transport. The successful decision of this task on the ferrous road relies on the technical state of rolling stock to a great extent [Gavriluk, Rjabec 2007].

One of the most responsible systems of rolling stock is carriage part. Maintenance at the high level of the technical state of elements of carriage part is the inalienable condition of providing of safety of motion on the railways.

In the process of making and exploitation the elements of carriage part are exposed to the technical diagnosing in order to avoid the origin of production and operating refusals. The great number of control operations enters in the complement of the technical diagnosing, including nondestructive control of elements of carriage part on absence of internal defects.

One of the most responsible elements of carriage part of rolling stock is the axis of the wheeled pair. The fracture of axis, because of presence in her internal defects, can result in a serious failure on the ferrous road. On the fig. 1 the example of fracture of carriage axis, which the tails of freight carriage on the direct area of rail way happened because of, is presented.

Fig. 1. Place of fracture of middle part of carriage axis

RESEARCH OBJECT

The axes of the wheeled pairs in the process of making are exposed to the ultrasonic control on absence of internal defects in axial and radial directions.

In the case of violation of technology of making, in axes there can be the production defects located in central part of axis. Such defects most complete to come to light as a result of ultrasonic control in radial direction.

At the control of axes of the wheeled pairs in radial direction is used ultrasonic impulsive echo-method.

Determination of admission of defect is carried out by comparison of amplitude of echo-signal from a defect with amplitude of echo-signal from an artificial reflector in the standard sample of enterprise (SSE). Make SSE from the axis of the wheeled pair, as artificial reflectors, opening with the flat bottom oriented athwart to the axis of cylinder are used. The layout chart of artificial reflectors in the standard sample of enterprise is presented on the fig. 2.

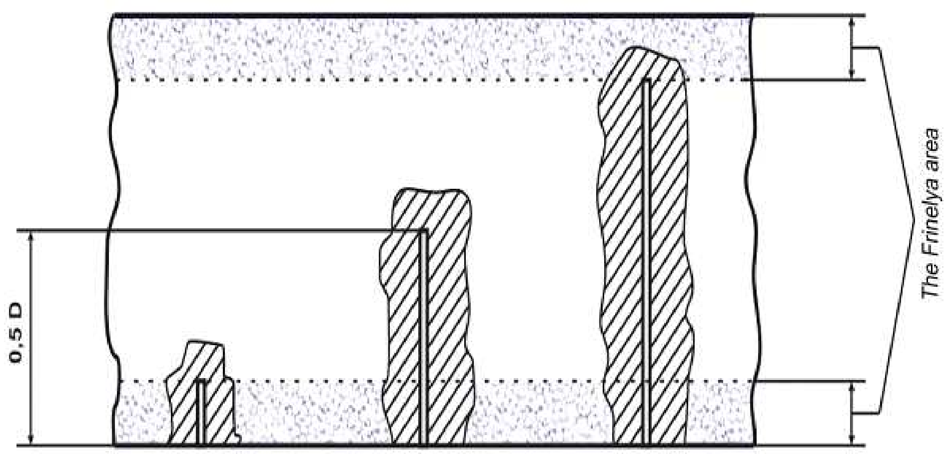

Fig. 2. Layout chart of artificial reflectors in SSE

Making is the SSE expensive and technologically difficult process. As a result of influencing of great number of factors (inaccuracy of instrument, technological equipment, performer and etc.) in standard samples there can be the following disparities to the technical requirements:

- absence of parallel of flat bottom of artificial reflector and tangent plane to the point of input of central ray of ultrasonic transformer (fig. 3, a), what a reflected from the flat-bottomed opening ultrasonic wave leaves because of aside and not fully gets on transformer;
- deviation from the plane of bottom of artificial reflector (fig. 3, b), what a reflected from the flat-bottomed opening ultrasonic wave leaves because of aside and not fully gets on transformer;
- high roughness of surface of flat bottom of artificial reflector (fig. 3, c), what an ultrasonic wave disperses because of on the surface of reflector;
- because of technological inaccuracy of the SSE making there can be other disparities to the technical requirements which diminish amplitude of accepted by an ultrasonic transformer echo-signal.

Also the large value on the decline of authenticity of diagnostic operation of ultrasonic control of axes of the wheeled pairs is played by a difference in fading of ultrasonic wave at its passing in the controlled axis and in the standard sample of enterprise.

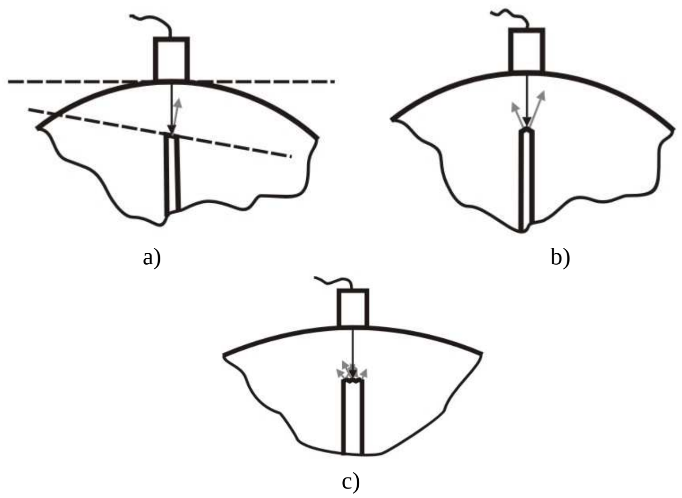

Fig. 3. Possible disparities to the technical requirements at making SSE

RESULTS OF EXPERIMENTAL RESEARCH

To get rid of from the listed above lacks of existent method of determination of admission of defects, at the ultrasonic control of axes of the wheeled pairs in radial direction allows transition to the method, without a standard, based on the study of law, describing communication between amplitude of ultrasonic echo-signal from a defect and his sizes, depth of bedding and parameters of the controlled object.

Amplitude of echo-signal from a reflector in dB is described by dependence:

$$A = 20\lg\frac{S_a S_b}{\lambda^2 x^2}, \qquad (1)$$

where: A – amplitude of echo-signal from a reflector, dB; S_a – area of transformer, mm^2; S_b – area of reflector, mm^2; λ – length of ultrasonic wave, mm; x – distance to the reflector, mm.

At passing of ultrasonic wave through the object of control, its intensity diminishes. It is conditioned by fading of ultrasonic wave in the object of control, which in same queue, it is conditioned by absorption (by transition of energy of mechanical vibrations in thermal) and dispersion (by the reflection of part of ultrasonic wave in transition of border of corns of metal). Besides fading, at the ultrasonic control of axes of the wheeled pairs in radial direction, intensity of ultrasonic wave goes down due to the input of ultrasonic wave through a protuberant cylindrical surface. A protuberant cylindrical surface acts part of anti focusing lens for an ultrasonic wave [Basov, Markov, Kireev, Volkova 2004].

For consideration of the above enumerated factors sub logarithmic expression from dependence (1) is multiplied on $e^{-2\delta x}$, where δ – the coefficient of weakening of ultrasonic wave, and dependence of signs, is a kind:

$$A = 20\left(\lg \frac{S_a S_b}{\lambda^2 x^2} e^{-2\delta \cdot x} \right). \tag{2}$$

For computation of amplitude of the ground echo-signal in an axis in radial direction the dependence is used:

$$A_d = 20\lg\left(\frac{S_a}{2\lambda D} e^{-2\delta \cdot x} \right), \tag{3}$$

where: A_d – amplitude of the ground echo-signal;
D – diameter of the controlled area of axis.

From expression (3) we find:

$$\delta = -\frac{\ln\left(\dfrac{10^{\frac{A_d}{20}} 2\lambda D}{S_a} \right)}{2D}. \tag{4}$$

From expressions (2), (4) we find dependence for computation of peak description of echo-signal from a reflector:

$$A = 20\lg\left(\frac{S_a S_b}{\lambda^2 x^2} K_\delta \right). \tag{5}$$

where: $K_\delta = e^{2\frac{\ln\left(\frac{10^{\frac{A_d}{20}} 2\lambda D}{S_a} \right)}{2D} x}$.

How evidently from expression (5) for computation of amplitude of echo-signal from a reflector it is necessary to know amplitude of the ground echo-signal on the controlled area of axis which is measured directly on the diagnosed axis

As artificial reflectors at the control of axis of the wheeled pair in radial direction the flat-bottomed cylindrical opening are used by a diameter 3 and 5 mm:

- 5 mm - as a threshold rejection value at determination of admission of defect by peak recommendation of echo-signal;
- 3 mm - as a threshold control value at determination of admission of defect on an extent.

On results measuring of amplitude of the ground echo-signal in the controlled area of axis, takes advantage of analytical dependence (5) a diagram amplitude-distance-diameter (ADD-diagram) is built for the diameter of artificial reflector 3 and 5 mm.

On fig. 4 the ADD-diagram for the area of locomotive axis is presented by a diameter 235 mm, A_d = -32 dB (on an area without a defect).

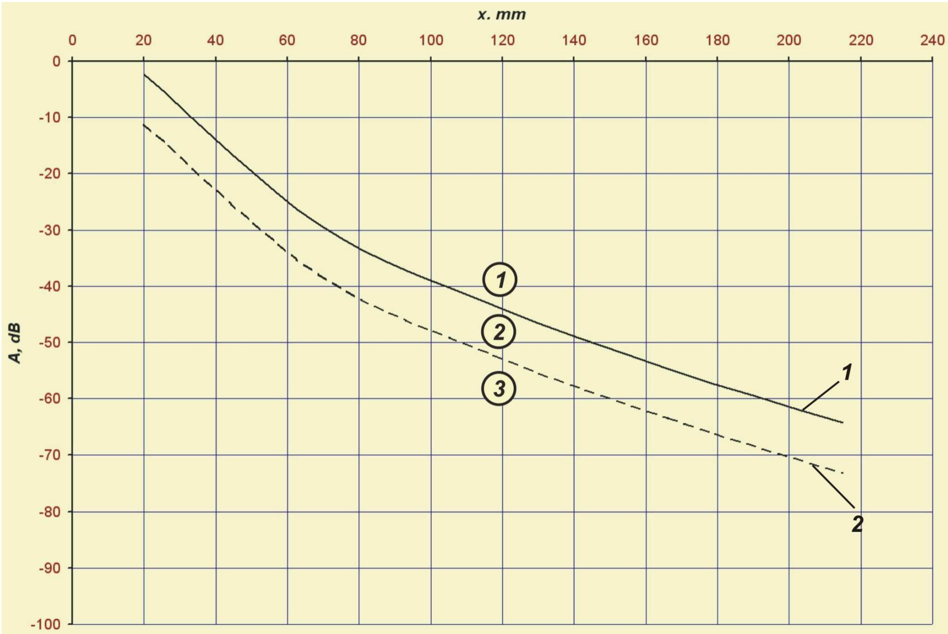

Fig. 4. Diagram amplitude-distance-diameter
1 – at the diameter of reflector 5 mm; 2 – at the diameter of reflector 3 mm

At estimation of found out a defect, in the case of hit of value of peak description of echo-signal from a defect in the region 1 diagram, a defect is classified as impermissible; in the case of hit of value of peak description of echo-signal from a defect in a region 2 diagram or on a curve 1, the conditional extent of defect is measured (if less or equally 40 mm – a defect is possible, if more than 40 mm – a defect is classified as impermissible); in the case of hit of value of peak description of echo-signal from a defect in a region 3 diagrams or on a curve 2, a defect is classified as possible.

CONCLUSIONS

For providing of safety of motion on the railways of axis of the wheeled pairs of rolling stock are exposed to the technical diagnosing in order to avoid the origin of production and operating refusals. For the search of production defects of axis of the wheeled pairs are exposed to diagnostic operation of ultrasonic control in radial direction by an impulsive echo-method.

The existent method of the ultrasonic diagnosing has failing which lower authenticity of results of diagnosing.

The developed method of classification of defects at the ultrasonic diagnosing of axes of the wheeled pairs of rolling stock of railways allows to get rid of from the lacks of existent method and promote authenticity of results of diagnosing.

The developed method is in wide positions of automation of operation of diagnosing of axes of the wheeled pairs.

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УСОВЕРШЕНСТВОВАНИЕ УЛЬТРАЗВУКОВОГО ДИАГНОСТИРОВАНИЯ ОСЕЙ КОЛЕСНЫХ ПАР ПОДВИЖНОГО СОСТАВА ЖЕЛЕЗНЫХ ДОРОГ

Басов Г.Г., Киреев А.Н., Киреева М.А.

Аннотация. Представлен математический аппарат для расчета и построения диаграмм амплитуда-расстояние-диаметр, применение которых позволяет повысить достоверность результатов диагностирования осей колесных пар подвижного состава железных дорог ультразвуковым методом.

Ключевые слова: подвижной состав железных дорог, техническое диагностирование, ультразвуковой импульсный эхо-метод, дефект.