Influence of the Operating Damage on the Acoustic Parameters in the Railhead

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Abstract. The experimental study on changes in the structural noise level and on propagation velocity of surface waves in rail samples before and after operation is performed. The study describes the effect of accumulated damage in the railhead on the measured acoustic parameters.

Keywords: acoustic structurescopy, accumulated damage, rails

INTRODUCTION

In the process of rails operation on the railhead surface plastic deformation occurs as a result of multiple impact of a train load.

Consequently, it leads to the accumulation of microdefects which form serious large defects and ultimately lead to disasters.

To prevent the possible destruction of the rail, it is necessary to perform immediate non-destructive control of the structure in overlay of the tread surface.

Sensitive to the structural state changes acoustic methods are based on measurement of the structural noises level and the velocity of the Rayleigh surface waves. In this case the correlation between the ultrasonic wavelength and metal grain size is important. Properly chosen ultrasound frequency is sensitive to even small structural changes in metal.

The work is devoted to the effect of accumulated operating damage in the railhead surface on the measured acoustic structural noises and the propagation velocity of surface waves.

MEASUREMENT PROCEDURE OF STRUCTURAL NOISES

To assess diversity in structural state it was accomplished estimation experiment of the structural noise level for two rails: after operation 40 million gross tons (the old rail was fabricated in 1996 year) and without operation (the new rail was fabricated in 2013 year). The measurements were carried out on prepared tread surface of the headrail samples with a length of 300 mm.

The measurements were carried out by angle beam double-crystal transducer P122-5,0-65-8-M with a step of 5 mm from the edge of the rail slice.

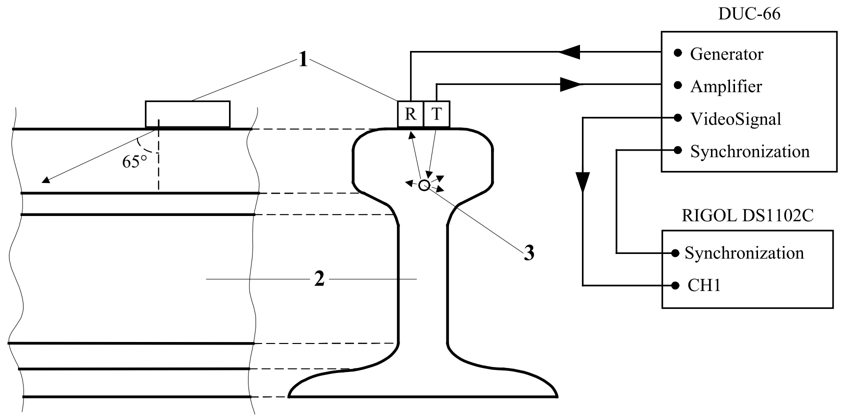

Figure 1. The schematic arrangement of measurement system: 1 – transducer, 2 – rail, 3 – grain structure

The ultrasonic defectoscope DUC-66 was used for excitation and reception of ultrasonic waves in the testing object. The digital oscilloscope RIGOL was connected to the output «Video Signal» of defectoscope by synchronization line for saving and the further processing of the electrical signal.

During installation of the transducer on the rail surface the oscilloscope digital screen displays the oscillogram (Fig. 2).

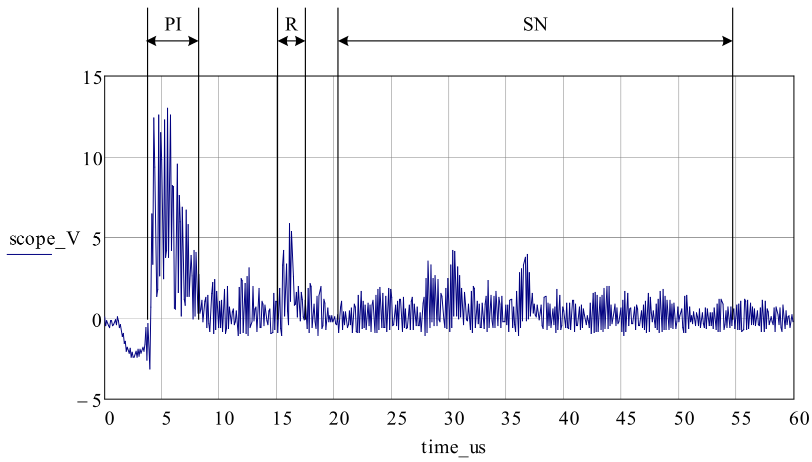

Figure 2. Oscillogram of the acoustic signal

As shown in Fig. 2, the waveform is divided into 3 areas:

- the first area corresponds to the probe pulse (PI);
- the second area corresponding to Rayleigh wave (R) appears in the double-crystal
- transducer protector [1];
- the third area corresponds to the zone of structural noise (SN).

The selected time period from 20 to 55 microseconds for the structural noise evaluating corresponds to the time of wave transmission from the headrail surface to the railhead bottom and back. Time domains contain interfering multipath ultrasonic waves from the fillet transition to the rail web.

To improve the accuracy of the dimension three measurements were taken from each of the 13 points on the rail. After that it was determined the average level of structural noise U_{SN} [1] and the Rayleigh wave level U_R for each dimension in the MathCAD program environment.

For the detuning from the quality of acoustic contact between ultrasonic transducer and rail surface it was calculated the ratio structural noise –Rayleigh wave U_{SN}/U_R.

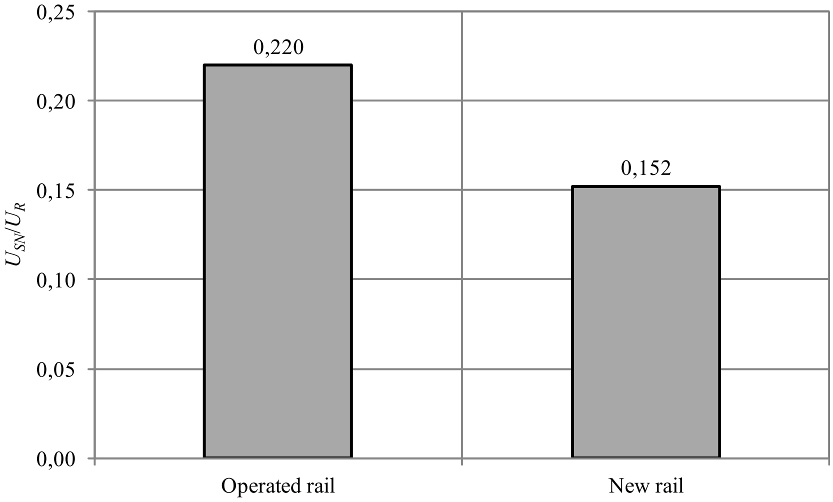

Figure 3. The level of structural noise in the old and new rails

Fig. 3 shows a chart demonstrating the difference in average levels of structural noise in the old and new rails. The data presented in Fig. 3 shows that the level of structural noise in the old rail exceeds the level of structural noise in the new rail by more than 40 %.

MEASUREMENT PROCEDURE OF THE SURFACE WAVES SPEED

Experimental assessment of the Rayleigh surface waves velocity in rail samples was performed by using electromagnetic acoustic structurescopy (SEA) and electromagnetic-acoustic (EA) transducer of surface waves at the frequency of 1.25 MHz.

EA transducer was mounted on surface in the middle part of the railhead. In this instance surface wave propagated along the rolled rail. Five measurements were taken on each rail. Fig. 4 shows the program window "the PRINCE VIII" displays the progress difference of surface waves in two rails.

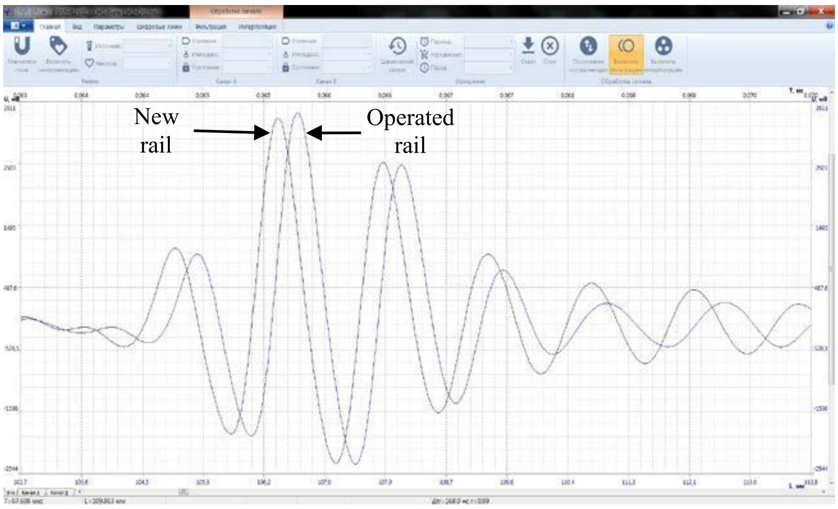

Figure 4. The program window "the PRINCE VIII"

The time difference of rays between two received signals of surface waves is $\Delta t_r = 168$ ns. This value approximately corresponds to the difference of the velocities of surface waves between the new and operated rail, which is 10.8 m/s. This fact can be explained by damage accumulation and work hardening [2–4]. The reduction of Rayleigh wave propagation speed on the rail wheel thread after operation is 0.3 %.

CONCLUSION

The analysis of experimental results shows the difference in the structural noise levels for the operated and new rails. This effect is due to the accumulated structural damage as a result of long exploitation.

Rayleigh waves, which are sensitive to the surface defects, confirm the presence of work hardening and the accumulated defects in the railhead surface after long time operating.

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