Research of Estimate's Possibility of Thermal Stresses in Rails

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Abstract. The article discusses the possibility of assessing the thermal stress in the rail service. To assess stress method is used on the basis of phenomena acoustoelasticity. The results of the control of residual stresses in the rail at the site jointless track.

Keywords: acoustoelasticity, electromagnetic-acoustic conversion, residual stresses, rails

INTRODUCTION

The occurrence of longitudinal compressing stresses and tensile strengths in the rails is explained by thermal action, first of all, that creates high loads, which can become the cause of rail's blowout or its deflection. Rail breakage and changing of rail's shape are the prime causes of train delay and derailing. The consequences of rail's deformation is considerable for safety, reliability and efficiency of rail transportation, especially at service of a high-speed passenger traffic.

Stresses in the rails can be measured by using strain gauges, thereby strain-gauge sensor must be securely fixed with an object surface [1, 2]. Measurements of strains are performed only in the process of their change, so value of zero reading is necessary. The account of temperature influence is also necessary, because resistance of the strain-gauge sensor depends not only from the strains, but also from the temperature.

Making of gauges of internal stresses in rails is important a nondestructive testing stage. Using of portable gauges of stresses in rails will allow railway's service to check jointless track sites of a railway. There aren't practical methods of such gauging of stresses level in rails now. The most suitable method for the solution of this problem is the hypersonic method based on the phenomenon of acoustoelasticity [3, 4]. The operation purpose is the exploration of control's possibility of internal stresses in rails while in service.

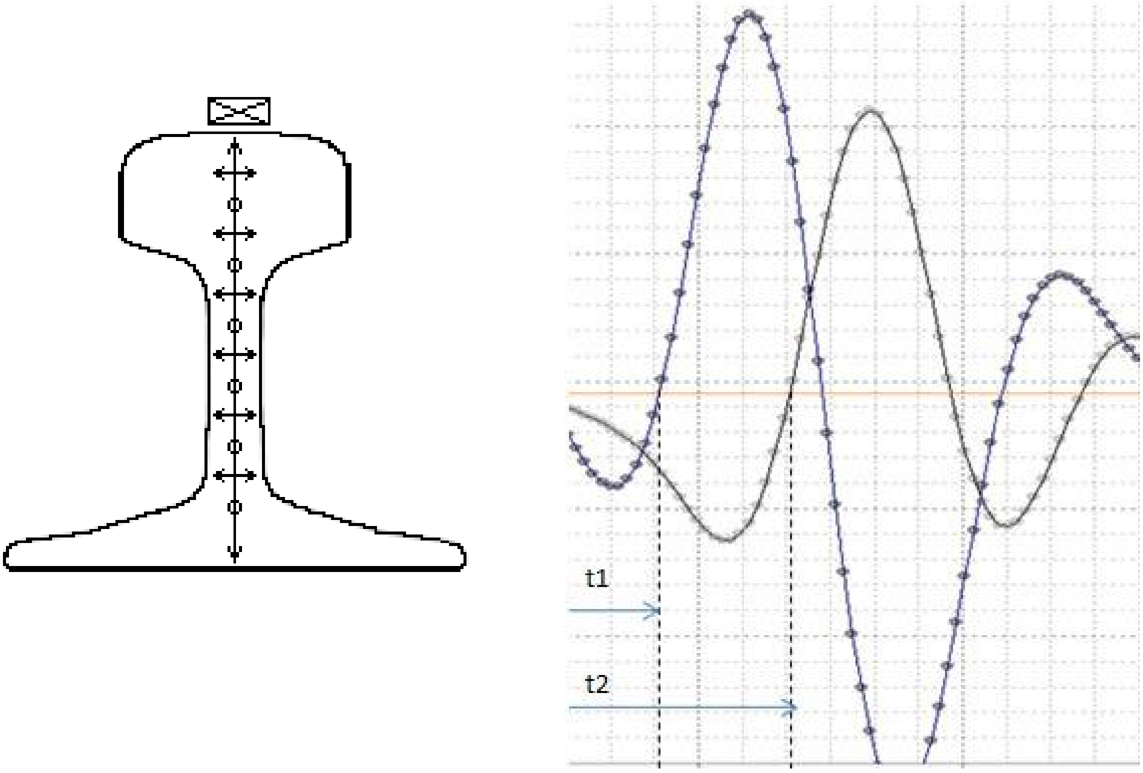
MEASUREMENT TECHNIQUE

The basis of rail's stresses measurement technique is the known procedure of control of the stress-strain state in railway sprockets [5].

The acoustoelasticity method is based on the dependence of ultrasonic waves propagation velocity on mechanical stresses in a solid body taking into account coefficients of acoustoelasticity [3, 4]. For ultrasound excitation and receiving the SEMA structurescope (Fig. 1a) equipped with the noncontact electromagnetic-acoustic (EMA) transducer (Fig. 1b) is used [5]. The SEMA structurescope was designed in the «Department of Devices and Methods for Measurement, Control, Diagnostics» of Izhevsk State Technical University (Izhevsk, Russian Federation).

(a) (b)

Figure 1. The experimental equipment: entire view of structurescope SEMA (a), the EMA transducer (b)



(a) (b)

Figure 2. Plan of the rail scanning (a), the accepted signals (b)

The plan of rail scanning is presented on Fig. 2a. The EMA transducer is installed on a rail head; two pulses of orthogonally polarized transverse waves are excited from a rail head and received after reflection from a rail base by the same EMA transducer. The received signals (Fig. 2b) are then handled by specialized software called “Sensitive” which allows to measure amplitudes and arrival times discrepancy of two received echo-pulses.

The discrepancy in propagation time of the impulse signals, which are polarized lengthwise and perpendicularly rail axes, is proportional to residual stresses value. Values of propagation time of transverse waves t_1 and t_2 in one section of a rail, are used for the calculation of residual stresses σ by the formula [5]:

$$\sigma = D\left(\frac{t_1}{t_2} - 1\right), \tag{1}$$

where D – coefficient of elastic-acoustic linkage for the explored material, spotted experimentally and equal to 145 GPa.

RESEARCH RESULTS

Studies have been conducted on the site of continuous welded rail track Yuski – Ludzy haul of Agryz – Izhevsk section of Gorky Railways. Residual stresses were determined on a region of 400 m in length in several places, at a distance of 50 m from each other in the same locations and at different ambient temperatures and respectively rail: 4 °C, 24 °C and 32 °C. The research results for various temperatures are shown in Fig. 3. The lengthening of the rails occurs during heating, so the temperature rise must increase the compressive stresses in the fixedly secured rail. It is known that the rails fixed to the sleepers twice a year for use in summer and in winter.

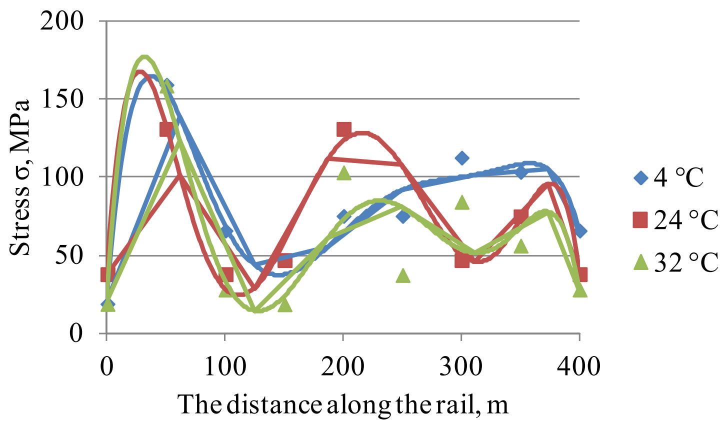


Figure 3. The stress distribution in the rail at different test temperatures

The rails are laid at a temperature of 20 °C (the initial "neutral temperature"), designed for summer operation. The stresses occur from the present temperature and the thermal expansion coefficient of the rail, if the neutral temperature is known, therefore, stress redistribution conditions are predictable. During processing results of research the temperature of 24 °C was selected as the neutral temperature of rail lying. The stress distributions in the rail taking into account the neutral temperature are shown in Fig. 4. Reducing the stress occurs with increase temperature, since the rail expands and undergoes compressive loads, as can be seen from the diagram.

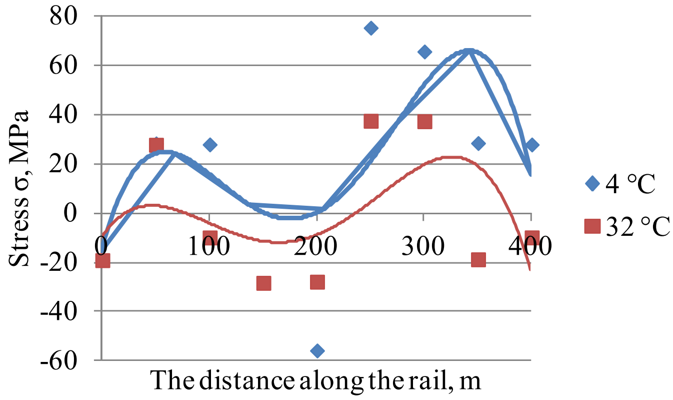


Figure 4. The stress distribution in the rail at different test temperatures compared with stress-free temperature

Unfortunately, the neutral temperature can be changed after laying the rails associated with locomotive traction and braking. Cross-section of a rail bar was selected to investigate the influence of a load moving train on the stress level. Stress at the point was 103 MPa at a distance of 300 mm from the beginning, before the passage of electric train ED9M with 4 cars, after passing train the stress increased to 113 MPa.

A series of measurements was carried out at two points at a distance of 20 cm from each other, to take account of the influence of errors. The results are shown in Table 1.

Table 1. Results of measurement errors

The number measurement	Stresses in the section 1, MPa	Stresses in the section 2, MPa
1	38	28
2	28	28
3	28	19
4	28	19
5	38	28
σ_{avg}	32	24
$\Delta\sigma$	5	5

Changing the stress after the passage of a train is in the range of error and can be not taken into account when evaluating thermal stresses.

Conclusion

The tried control technology compression-tensile thermal stress in the rails allows measurements in any section of the rail and provides highly accurate results. However, indefinite stress variation with temperature change of the rail requires additional studies evaluating residual stresses in the rails during the production and accumulation of residual stresses during operation.

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