# System for determining state of continuous welded track

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**Abstract.** The article considers the main disadvantages of the existing method of examining the lashes of a jointless path, in which a pedestrian bypass of the sections of the canvas and their visual control is performed. A system for monitoring the temperature stresses of jointless rail lashes laid in the path is proposed, which allows monitoring the longitudinal displacement of the track throughout the entire life cycle: from the moment the rails are welded into long-length lashes, including their laying, and throughout further operation. The system makes it possible to monitor compliance with the optimal fixing temperature of rail lashes during their laying, welding and fixing, based on data obtained with the help of sensors, to determine the actual fixing temperature in the lashes of a jointless track; to control the optimal fixing temperature of rail lashes in areas of restoration of their integrity.

## 1 Introduction

In the construction high-speed railways, most modern railways use the continuous welded rail. The lack of control over the condition of the welded lashes creates a problem for the safety of train traffic, due to thermal stresses in the rails, a bend in hot weather or a fracture of the rail lash in cold weather may occur. Such deformations can occur when the ambient air temperature is high and because of this, large stresses appear in the lashes of the jointless path, which eventually makes the path unstable to external influences. In order to monitor the current state of the lashes of the jointless track, it is necessary to develop a monitoring system to ensure the safety of train traffic [1-8].

The most progressive and popular design of the upper structure of the track is a jointless track. In the developed countries of the world, in particular in France, Germany, Spain, Japan, China, Russia, great attention is paid to expanding the range of its application and is one of the priorities for researchers and railway transport workers. However, despite the many indisputable advantages over the link, the joinless path has a feature that limits the polygon of its expansion. This is the occurrence of significant longitudinal forces in the rail lashes when the temperature of the rails changes relative to the fixing temperature. If the clamping force of the intermediate rail fasteners is insufficient, the theft of rail lashes may occur. Its standard value should be at least 10 kN. At smaller values, longitudinal movements of rails can occur under the action of rolling stock, in other words, track hijacking. The hijacking of rails leads to a change in their stress-strain state, which can

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cause the ejection of the track when the temperature rises and the rupture of joints when it decreases [9]. The hijacking of the track leads to the displacement and distortion of sleepers, the loss of under-rail gaskets. Elimination of the consequences of rail theft is associated with the performance of complex and time-consuming work on the adjustment of gaps and discharge of temperature stresses in rail lashes. Therefore, in order to further expand the joint-free track landfill, it is necessary to introduce a set of diagnostic tools that allow monitoring the condition of intermediate rail fasteners, improve train safety, stability of the joint-free track and reduce the cost of its current maintenance [10].

Train speeds are increasing on the railways of the world. In order to switch to high speeds, it is necessary to modernize the existing railway tracks and the entire infrastructure.

When the temperature changes, longitudinal forces arise in the rail lashes of the jointless track, which is the main danger in the operation of the jointless tracks [11]. When the temperature of the rail-jointed lashes increases (in relation to the temperature of fixing in them when they are laid in the way), the rail-jointed lashes elongate, and in the pinched state, longitudinal forces arise, which can create a danger of ejection of the track [12, 13]. When the temperature decreases in the rails, forces may occur, which can lead to the rupture of the rail lash due to the cut of the butt bolts, while creating a gap dangerous for train traffic. From the moment of fixing the rail lashes during laying, constant control (monitoring) should be organized over the force of pressing the sole of the rail to the sleeper and over the longitudinal movements (hijacking) of the rail-free lashes [9-11]. Stealing lashes due to the violation of the technology of fastening, wear rubber cushioning strips that directly affect the clamping force applied to the foot rail to the sleeper, by weakening the torque applied bonding, which causes the violation of the established temperature-busy mode of operation and can lead to dangerous concentrations whips tensile or compressive stresses [12, 13].

## 2 Objects and methods of research

At present, in order to detect the longitudinal displacement of the rail lashes in a timely manner, in accordance with industry regulations, a walking tour of the sections of the track and their visual control is carried out [9].

Visual inspection should be carried out on the control sections (lighthouse sleepers), which are located near the picket post at a distance of 100 m from each other [10]. Longitudinal displacement of rail lashes (hijack) show traces of terminals on the sole of the rails (Fig. 1), the displacement of the pads on the tracks (Fig. 2), loose fit of ballast to the side faces of the sleepers and their bias.


**Fig. 1.** Traces of the terminal on the sole of the rail at the longitudinal displacement of the lashes.

With the current maintenance of the joint-less track, it is necessary to eliminate shortcomings in order to ensure proper pressing of the rail to the sleeper and the position of the track in the plan and profile according to regulatory documents [11]. During operation, the control sections of the rail lash are shifted relative to the "beacon" sleepers and, accordingly, it becomes impossible to accurately determine the possible theft of the rail track without connecting it [12-17].

**Fig. 2.** Displacement of the under-rail linings along the sleepers.

Until that time, there were no other ways to control the longitudinal movement of jointless rail lashes.

The main disadvantages of this method is that you need:

- make calculations of the lengthening of the rail lash;
- make marks with chalk or oil paint on the sole of the rail and the lining to monitor the movement;
- paint the sleepers with oil paint (fig. 3);
- constantly make visual observation [18].

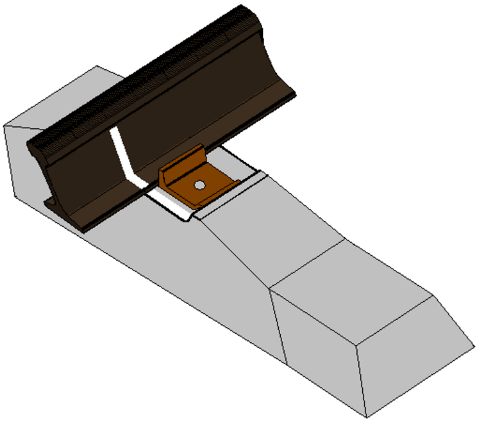

**Fig. 3.** Marking of the control section on the lash and the" beacon " sleeper to control the hijacking of the track for the fasteners.

In addition, with this method:

- possible mechanical displacement of track equipment "lighthouse" sleepers relative to the cross-sections applied to the sole of the rail;
- it is not possible to restore the original data obtained during the laying of the jointless rail lash;
- it is not possible to accurately measure the theft of a non-jointed rail lash, since the sections are applied with a large error, and the "beacon" sleepers are displaced due to strong vibration when passing trains [19].

When laying with an eyelash alignment device up to 800 m long connected to a rail, it was possible to dissolve the eyelash and fix it again at the optimal temperature when the initial fixation temperature is lost. Today, when the length of the eyelash attached to the rail reaches 74 km or more, it is almost impossible to do this: you need to cut the eyelash into dimensional fragments, loosen them, fix them and weld them to the eyelash again. This is a very time-consuming job that requires long breaks in the movement of trains and significant economic costs.

There are a number of organizational measures [20] aimed at preventing changes in the position of the joint-free path in the plan or profile, but none of them guarantees the elimination and absence of stress concentration zones on the joint-free lash. Increasing the speed of trains requires a good technical condition of the road, as well as the replacement of manual labor with high-performance vehicles, reducing the number of workers working on the road, and visual inspection of the condition of the high road structure, roadbed and structures.

To ensure strict adherence to the schedule of busy trains, it is necessary to monitor the condition of the track, predict the chaos on the track and eliminate it in time. Until now, information about changes in longitudinal movements in railway eyelashes could only be recorded in the absence of traffic on the highway. A system is proposed to monitor the temperature tension of the joint-free rail weaves laid on the track, which makes it possible to observe the process from the moment the rails are welded to long nets during the entire life cycle, including their laying and subsequent operation [21-23].

## 3 Results and discussion

The. ba.sis of the. syste.m is a. wire.le.ss me.a.suring se.nsor (SKBP-2009) with a.n e.le.ctronic unit mounte.d on a. ra.il. It a.llows you to me.a.sure. the. de.gre.e. of te.nsion, compre.ssion a.nd the. ma.gnitude. of the. re.sulting stre.sse.s of the. ra.il whe.n the. a.mbie.nt te.mpe.ra.ture. cha.nge.s. Such wire.le.ss me.a.suring de.vice.s a.re. de.signe.d to me.a.sure. a.nd control the. inte.rna.l stre.sse.s in the. ra.il la.she.s tha.t occur unde.r the. influe.nce. of te.mpe.ra.ture. cha.nge.s a.nd othe.r e.xte.rna.l influe.nce.s on the. ra.il-sle.e.pe.r grid.

The. sche.ma.tic dia.gra.m of the. de.vice. for monitoring the. sta.te. of the. jointle.ss ra.il la.she.s la.id in the. wa.y, during the.ir ope.ra.tion, is shown in Fig. 4.

Me.a.suring te.mpe.ra.ture. a.nd re.fe.re.nce. te.mpe.ra.ture. se.nsors e.quippe.d with a.n e.le.ctronic unit monitor the. stre.sse.s tha.t occur during the. ope.ra.tion of a. non-jointe.d ra.il tra.ck.

A.ccording to the. re.a.dings of the. e.le.ctrica.l signa.l of the. se.nsor, da.ta. on the. te.mpe.ra.ture. a.nd the. conditiona.l fixing te.mpe.ra.ture. corre.sponding to the. inte.rna.l stre.sse.s occurring in the. ra.il a.re. ta.ke.n. This informa.tion is de.te.rmine.d by the. re.sults of ca.lcula.tions pe.rforme.d on the. ba.sis of the. da.ta. of the. e.le.ctronic unit.

The. se.nsor is a.tta.che.d to the. ra.il ne.ck by a. spe.cia.lly de.ve.lope.d me.thod - by spot we.lding it to a. pre.-sa.nde.d se.ction of the. ra.il ne.ck surfa.ce.. A. prote.ctive. housing is insta.lle.d on the. se.nsor, which is a.tta.che.d to the. cla.mp. The. se.nsors with the. e.le.ctronic unit a.re. se.lf-conta.ine.d, se.a.le.d, va.nda.l-proof a.nd ha.ve. a. built-in powe.r supply. The. informa.tion from the. se.nsors is tra.nsmitte.d wire.le.ssly to the. ba.se. sta.tion, a.nd from it goe.s to the. se.rve.r.

The. se.rve.r pe.rforms long-te.rm stora.ge., proce.ssing of the. re.ce.ive.d informa.tion a.nd its displa.y on the. we.b inte.rfa.ce.. Ba.se.d on da.ta. on the. va.lue. of the. re.sista.nce. of compa.cte.d ba.lla.st she.a.r sle.e.pe.rs, friction be.twe.e.n the. ra.il a.nd unde.r ra.il cushioning ga.ske.t (de.pe.nding on the. bond), the. da.ta. on the. pla.n a.nd profile., the. wa.y a. na.tive. of the. rolling stock syste.m a.llows you to a.na.lyze. a.nd compa.re. the. growth of opposing force.s tha.t a.rise. due. to stre.ss conce.ntra.tion, a.nd to a.nticipa.te. a. possible. cha.nge. in the. position be.stima.ge. pa.th in pla.n a.nd profile.

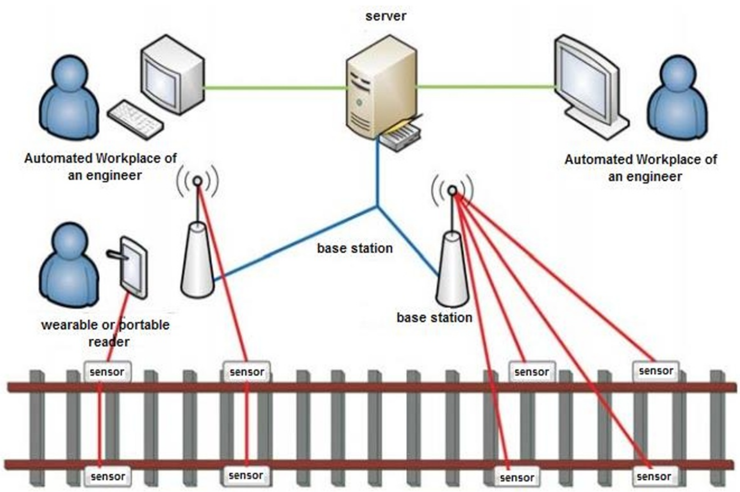


**Fig. 4.** Schematic diagram of the device for monitoring the temperature stresses of jointless rail lashes laid in the path during their operation.

The system for monitoring the temperature stresses of the rail linkless track has successfully passed laboratory tests (Fig. 5).

**Fig. 5.** Base station with antenna and solar battery

VNIIZhT has developed a test program with the creation of artificial faults on a closed section of the track.

During the. work, the. se.nsor re.a.dings we.re. re.corde.d, a.nd cha.nge.s in the. stre.ss sta.te. of the. ra.il we.a.ve.s we.re. de.te.rmine.d by the.ir move.me.nts re.la.tive. to the. sa.she.s, "lighthouse." sle.e.pe.rs, a.ccording to the. indica.tions of the. me.cha.nica.l stra.in ga.uge. MT-200. The. te.mpe.ra.ture. of the. ra.ils wa.s me.a.sure.d by the. IT-2 te.mpe.ra.ture. indica.tors. The. a.na.lysis of the. da.ta. obta.ine.d with the. he.lp of me.a.suring instrume.nts (SKBP-2009 se.nsors with a.n e.le.ctronic unit of dome.stic production a.nd a.dditiona.l me.a.suring instrume.nts liste.d a.bove.) showe.d tha.t the. re.sults a.re. within the. a.ccura.cy of the. me.a.sure.me.nts a.nd on a.ve.ra.ge. do not e.xce.e.d 0.6-2.5 %.

Figure 6 shows examples of how the proposed monitoring system displays information related to some indicators.

The economic feasibility of the proposed development is as follows: only the border changes, in accordance with the instruction of the Central Law No. 2022r of 01.10.2009 "On the establishment of temporary standards for the operation of a non-jointed track", will allow achieving an economic effect of about 1 billion sum on the network of JSC "Uzbekistan Railways". sum per year.

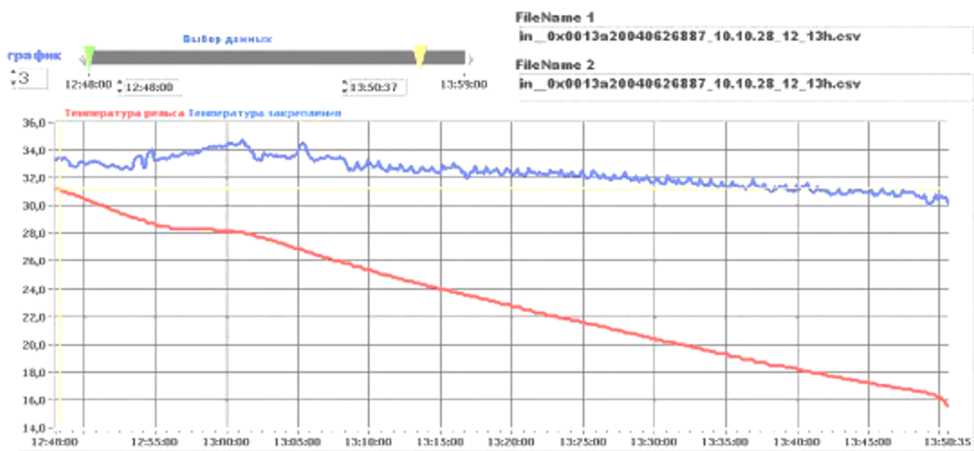


**Fig. 6.** Graph of partial loss of the optimal fixing temperature during forced heating of the whip and then its cooling after fixing.

## 4 Conclusion

Thus, the. monitoring syste.m of te.mpe.ra.ture. stre.ss sta.te. ra.il se.a.mle.ss wa.y a.llows monitoring of the. a.re.a. of ra.ilwa.y tra.ck whe.n its dista.nce. from the. workpla.ce., to a.na.lyze. the. work of the. scourge. a.t a.ny time., including pre.vious re.que.ste.d inte.rva.ls. This ma.ke.s it possible. to pre.dict the. de.ve.lopme.nt of ma.lfunctions, a.nd in critica.l situa.tions, turn on the. re.d signa.l of the. tra.ffic light to stop the. tra.in, pre.ve.nting the. de.pa.rture. of the. rolling stock. With the. he.lp of sta.tiona.ry a.nd ma.nua.l re.a.ding de.vice.s, the. syste.m ke.e.ps e.le.ctronic re.cords a.nd controls the. pe.rforma.nce. of work a.t the. initia.l sta.ge. of la.ying a. non-jointe.d tra.ck a.nd in the. future. a.t a.ny time..

In a.ddition, the. syste.m provide.s the. a.bility to:

to monitor complia.nce. with the. optima.l te.mpe.ra.ture. of the. fixing ra.il la.she.s whe.n insta.lling, we.lding a.nd consolida.tion on the. ba.sis of da.ta. obta.ine.d by se.nsors (SKBP-2009); obse.rve. the. cha.nge. of stre.sse.s in the. whips se.a.mle.ss wa.y for the. e.ntire. life. cycle., including cha.nge.s in the. curing te.mpe.ra.ture. mid-te.rm re.pa.irs; to e.xclude. the.

huma.n fa.ctor in the. fina.l gra.de.;

de.te.rmine. the. a.ctua.l te.mpe.ra.ture. of fa.ste.ning in the. la.she.s of a. non-jointe.d tra.ck; control the. optima.l te.mpe.ra.ture. of fixing the. ra.il la.she.s in the. a.re.a.s of re.storing the.ir inte.grity;

ide.ntify se.ctions of tra.ck whe.re. the. inte.gra.te.d e.mission ha.za.rd ind e.x (S) e.xce.e.ds the. ha.za.rd le.ve.l; this is ne.ce.ssa.ry for pla.nning work on the. curre.nt ma.inte.na.nce. of non-jointe.d tra.cks during ma.chine. ope.ra.tion (trouble.shooting in the. pla.n a.nd profile.).

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