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INDUCTION DEVICE FOR HEAT TREATMENT OF WELDED JOINTS OF RAILWAY RAILS

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The paper studies the design peculiarities of induction device for heat treatment of welded joints of railway rails and gives the results of its testing. The device uses the inductors with magnetic cores and matching transformers, developed and manufactured at PWI. The inductors are located opposite one another from rail sides. Inductive wire of the inductor is divided for two parallel conductors, which follow the shape of rail surface, surround part of running surface, inner edge of rail head, rail web and part of rail flange with increased air gaps in area of rail web and blades. The magnetic cores are located over rail head running surface, inner edges of head, web and lower surface of rail flange. Testing of induction device at 2.4 kHz current frequency showed uniform distribution of temperature field in rail section and absence of overheating of rail blades. Heating of rail zone of 50–55 mm width to 850–910 °C temperature took 140 s. Nominal power of supply source is 90 kW. 7 Ref., 4 Figures 4.

Keywords: *rails, rail welded joints, heat treatment, induction heating, inductor*

Heat treatment of the welded joints of railway rails, produced with resistance butt welding, is used for providing structural zonal homogeneity after welding, balance of hardness of metal of rails head, elimination of unfavorable diagram of internal residual stresses of welded joint metal [1, 2]. A process of heat treatment includes heating of welded joint zone and further quenching of running surface of rail head by means of forced cooling with air-water mixture or compressed air. Currently, heat treatment of the welded joints of rails is carried out, mainly, using induction units of UIN-001 type of different modification. The main elements of the unit are a system of inductors, control block, quenching block and high-frequency power source of 100 kW power and current frequency 8.0–16.0 kHz. The system of inductors includes two similar electrically connected multirun inductors without magnetic cores. The heating temperature for heat treatment of welded joints of rails of R65 type at UIN-001 unit makes 850–950 °C, heating time is 240 s from welding heat and 360 s from workshop temperature [3, 4].

One of the ways to increase efficiency of induction heating equipment for heat treatment of the welded joints of rails is improvement of inductor design. A task of the inductors is to reduce the of time of welded joints heating in order to increase efficiency of rail bar production lines, provide uniform distribution of temperature field along rail section and eliminate rail elements overheating.

It is known that the magnetic cores [5, 6] promote increase of level of electromagnetic coupling of current in the inductors with eddy-currents being inducted in the heated part, and, respectively, rise of efficiency and coefficient of power of inductor-part induction system. Application of the magnetic cores in the inductors allows distributing power delivered to the welded joint taking into account difference in mass of metal of head, web and flange of the rail as well as solving the problem of head center heating and place of transfer of the rail flange into the web due to the peculiarities of heating of complex shape parts with high frequency currents.

Present work describes the peculiarities of inductor design and gives the results of testing of the induction device for heat treatment of the welded joints of railway rails. The inductors with magnetic cores and matching transformers, developed and manufactured

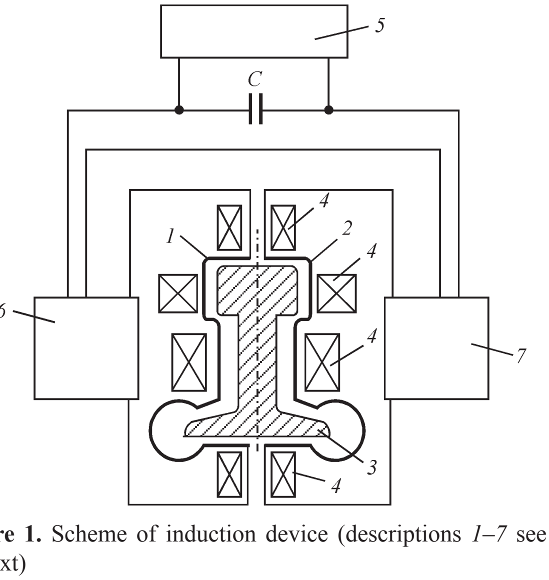

Figure 1. Scheme of induction device (descriptions *1–7* see in the text)

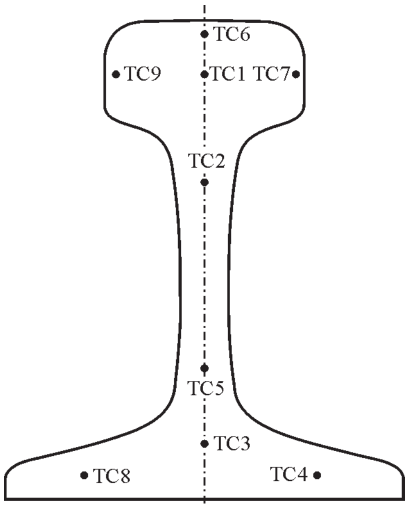

Figure 2. Scheme of location of thermal-electric converters TC1–TC9 in rail section (see designations in the text)

at PWI, are used in the device. Nominal frequency of current is 2.4 kHz.

Induction device (Figure 1) consists of inductors *1* and *2* of similar design. The inductors are located opposite one another from rail *3* side surfaces. Inductive wire of the inductor is divided for two parallel conductors, follow the shape of rail surface, surround part of running surface, inner edge of rail head, rail web and part of rail flange with increased air gaps in area of rail web and blades. Conduct buses of the inductors over the head running surface are equipped with the channels for passing a pyrometer beam. The different length magnetic cores *4* are installed over the head running surface, inner edges of rail head, web and lower surface of rail flange [7]. Matching transformers *6* and *7* are used for connection of inductors to thyristor frequency converter *5*.

Efficiency of the induction device was investigated in heating of zone of R65 type rail. Infrared pyrometer Optris CSLT15 was used for measurement of temperature on running surface of rail head. A distance from pyrometer to running surface makes 130 mm. Temperature of metal in rail section was controlled with chromel-alumel thermal-electric converters TC1–TC9 (TC1 — along symmetry axis at 20 mm

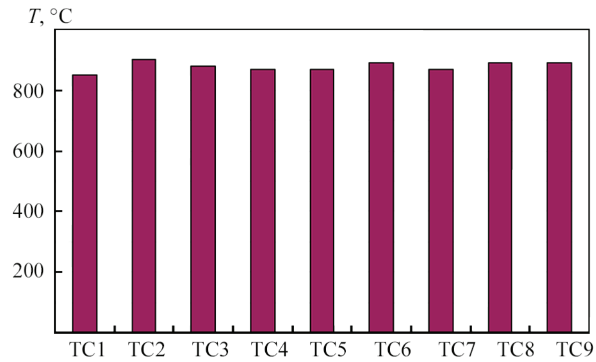

Figure 4. Histogram of temperature in points of rail section during 140 s heating time

depth from running surface; TC2, TC3, TC5 — along symmetry axis at 120, 20 and 50 mm distance, respectively, from flange lower surface; TC4 and TC8 — at 10 mm depth from flange lower surface and 32 mm from blade edges; TC6 — along symmetry axis at 3 mm depth from running surface; TC7, TC9 — in center of inner edges at 3 mm depth) (Figure 2).

Tests of the induction device showed that heating of rail zone from 20 °C temperature to temperature on head running surface 850 °C (Figure 3, *a*) was carried out for 60 s. The nominal power of frequency converter is 90 kW. Width of heat affect zone makes 50–55 mm. The rate of heating of head running surface to temperature of magnetic transformation point makes around 17.5 °C/s. The rate of heating on head running surface reduces to 1 °C/s with metal loss of magnetic properties and rise of depth of current penetration. The time of heating reduces to 40 s in heating of rail zone from 250 °C temperature to temperature on head running surface 850 °C/s (Figure 3, *b*) and nominal power of frequency converter 90 kW. Heating of rail zone from 250 °C temperature was simulated by a process of heat treatment of the welded joints of rails from welding heat in process lines of rail bar production.

Distribution of the temperature field in rail section in heating of rail zone from 20 °C during 140 s are reflected by dependencies, given in Figure 4. Temperature of head inner edges is 870–890 °C (TC7,

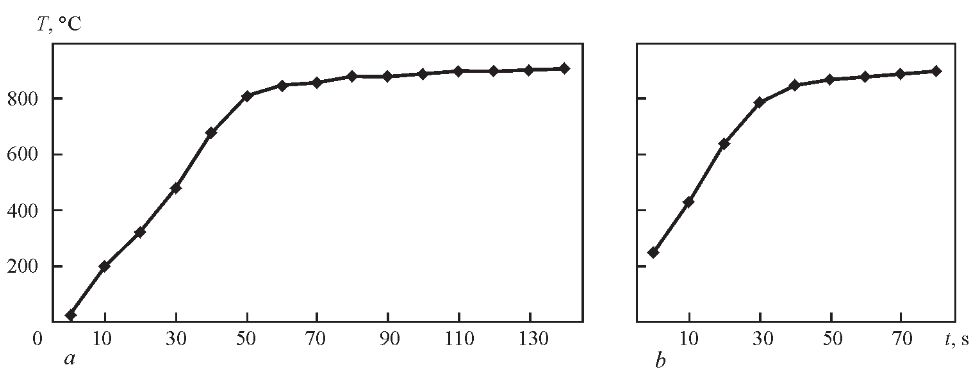

Figure 3. Time dependencies of temperature on running surface of rail head in heating of rail zone from 20 (*a*) and from 250 °C (*b*)

TC9), that of web makes 870–890 °C (TC2, TC5), it is 880 °C (TC3) at 20 mm depth from lower surface of flange along rail symmetry axis and 870–890 °C for rail flange (TC4, TC8). Time of holding of head running surface at temperature more than 850 °C is around 80 s. A temperature difference between running surface (Figure 3, *a*) and center of head (TC1, Figure 1) is not more than 50–60 °C. No overheating of rail blades is present. The temperature in place of flange to rail web transfer is 880–890 °C (TC3, TC5).

Conclusions

1. The induction device for heat treatment of the rail welded joints includes the inductors with magnetic cores and matching transformers, developed and manufactured at PWI. The inductors differ by design of inductive wire and location of magnetic core relatively to rail elements.

2. Uniform distribution of the temperature field in rail section and absence of rail blades overheating were reached in process of testing of the induction device at current frequency 2.4 kHz. Heating of the rail zone of 50–55 mm width to 850–910 °C temperature was performed for 140 s. Nominal power of supply source is 90 kW. It is necessary to note a reduction of time of heating in comparison with ITTZ-250/2.4 and UIN-001 units, which are used for heat treatment of the welded joints of rails under track and workshop conditions.

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