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ON THE INCLUDING OF WELDED RAILWAY SWITCHES IN CONTINUOUS WELDED RAIL TRACK

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ABSTRACT
A welded railway switch is a railway switch without interior rail joints, but which has the rail joints at the ends. By the elimination of the rail joints at the ends of a railway switch using the aluminothermic welding method or flash butt welding method the welded railway switch is included in continuous welded rail track, and all discontinuities caused by presence of gap on the rail joints are eliminated. In this paper is presented some aspects about the computations which are needful to ensure a good operating of railway switches after the elimination of these end rail joints.
Keywords: welded railway switches; welding process; continuous welded rail track

1. INTRODUCTION
At the present day is impossible to talk about high-speed railway without taking in account the necessity of joints elimination. This principle is valid for the railway track and for the railway switches and crossings. In this paper is presented a Romanian technology used to include a new isolated standard turnout without interior rail joints in continuous welded rail (CWR) track, using the aluminothermic welding method or flash butt welding method. The main problems in this case are the computation of the computation of casting gap and the effect of weld cooling to ensure a good operating of railway switches after theirs integration in CWR track. In this paper is presented an original method to solve these problems.
The external (ended) rail joints are ones from the front of turnout and ones from rears of turnout.
For welded of isolated standard turnouts and theirs integration in CWR track are necessary to follow two phases:
- Phase I: The elimination of interior rail joints;
- Phase II: The elimination of external (ended) rail joints, including the welding of the joints from the buffer track panels fore to front of turnout and hind to rear of turnout for theirs integration in CWR track. It is important know that the works in this phase should be realized only into prescribed temperature range for decrease the risk of rail buckling and to ensure a good operating of turnout after including the welded turnout into the CWR track.

2. CONDITIONS FOR WELDING OF SWITCHES AND CROSSINGS
Turnouts that are to be included in CWR track shall comply with the following main conditions:
- they have to ensure the water drainage in turnout area;
- the track platform must respect the requirements about bearing capacity of the distribution sub-layer;
- crushed stone prism shall be complete, having the correct dimensions and must be stabilized;
- the elements of the turnouts (switch rail, stock rail, linking rails, wings, crossing) will be measured and checked using ultra - sound detector and ORE pattern, the ones that are not in a good state of repair shall be replaced before welding. These checking should be written down in a "test results

record sheet" for each turnout separately, where they have to mention the turnout geometry before welding and the geometry and the final fixing temperature after welding the turnout.
- the geometry of the turnout and the running channel should comply with regulations;
- the turnouts should be endowed with a device to block the relative displacement between switch rail and stock rail (device fork-tenon);
- position of the switch rail point as compared to the stock rail should be marked by a sign on the middle stock rail (kerner = punch-mark), corresponding to a neutral temperature established by the turnout manufactures (usually t=+20^{0}C). This mark sign is "the neutral point".
- the distance between the neutral point and the toe of the switch rail should correspond to the temperature difference between the neutral temperature and that when they weld the points. Otherwise, the position of the switch rail as compared to that of the stock rail has to be adjusted before welding;
- the fastening system of the compound parts of the turnouts on the sleepers should be elastic and strength;
- the moment of tightening of the fastening elements should correspond to the technical prescriptions for fastening;
- the turnouts have to be endowed will G.I.J. (Glued Insulated Joints);
- point machine and shunting and locking devices should work normally according to prescriptions in force;
- checking in locking stroke;
- checking in joints corner angels/square at the turnout point;
- checking the distance between the point fastening bolt and the middle of the distance between the two bolts on the case;
- the rails of buffer track panels must be in good conditions, without geometrical or mechanical faults;
- the turnout must be welded (with inner joints welded);
- sleepers inside the turnouts (condition, layout, and diagram) should comply with the plan showing their layout, and with the provisions in regulation;
The railway tracks adjacent to the welded turnouts must be welded before to the including of welded turnout in CWR tracks.
These conditions are not limitative, but they are the minimal conditions necessary to be respected for a good behavior of railway switches after the including of welded turnout in CWR track.

3. ABOUT THE TECHNOLOGICAL FLOW FOR INCLUDING OF WELDED TURNOUTS IN CONTINUOUS WELDED RAIL TRACK

Depends on the type of rail, the welded turnout is situated between one or two buffer track panels at their ends. The rail joints of the turnout and the buffer track panels should be eliminated using the aluminothermic welding method or flash butt welding method.
If the working temperature of rail is in prescribed temperature range it is possible to incorporate the welded turnout into CWR track in a definitive manner and if the working temperature of rail is out of prescribed temperature range the external joints of the welded turnout it will be halved with fish plates in a provisionally manner, and the welded turnout will be incorporate into CWR track in a definitive manner later, when the temperature of rail will be in prescribed temperature range.
The technological flow for including of welded turnouts in continuous welded rail track is similar with the technological flow for welding the inside joints of the single switch.
It is indicate to weld the external joints, in a first step, on the straight line, and after that, in a second step, it is welded the external joints on the divergent line, to respect **the symmetry principle**.
Before the welded the external rail the parts of welded turnout must be destressed on entire their length. Also, the adjacent track must be destressed on a length longer than the breathing zone if this track is a CWR track.
The breathing zone length of rail adjacent with the turnout witch must be destressed will be computed with relation:

$$l_r = \frac{\alpha EA(t_n - t_e) - R}{p} \quad \text{... (1)}$$

in which:

p is the value of longitudinal resistance;

R is the fishplates resistance;

α = 0,0000115 is thermal coefficient of expansion for rail steel;

$E = 2{,}1 \cdot 10^6\ daN / cm^2$ is Young's modulus for rail steel;

A is the area of rail cross section, which it depend of type of rail.

t_n is the neutral temperature of the adjacent track which must be destressed;

t_e is the extrem (maximum or minimum) temperature measured from the fixation of the adjacent track to the destressing phase.

The welding can be made one by one or simultaneously, but must be take into account that is not possible to make simultaneously welds at the same sleeper or along at the same rail.

The ordinary aluminothermic welding (OW) is the weld for which is not important the consuming of rail and the controlled aluminothermic welding (CW) is the weld for which take to obtain one part of turnout by two running rail parts of turnout with a desired length, so for CW is important the consuming of rail. CW is called, sometimes, the finish welding.

To assure the necessary gap Δ to make the aluminothermic welding and to take into account the effect of weld cooling, the length of the last rail part which will be welded must be the following:

a) when the both welds from ends of rail parts which will be welded are aluminothermic:

$$l_p = l + d_1 + d_2 + r_1 + r_2 - 2 \cdot (\Delta - \delta) \qquad \text{... (2)}$$

in which: l is the length of existing rail part, in mm, measured at the working temperature of rail when the joints are dismounted;

α = 0,0000115 is thermal coefficient of expansion for rail steel;

d_1, d_2 are the parts of rail which are eliminated by cut from the rail parts;

r_1, r_2 are the values of gaps, in mm, measured at the working temperature of rail when the joint are dismounted;

Δ is the value of the casting gap, in accordance with regulations of the Thermit provider;

δ is the effect of weld cooling (usually 2 mm for aluminothermic welding).

b) when the joints placed at one ends of the rail parts will be welded with aluminothermic welding method and the joints placed at the other ends of the rail parts will be welded with flash butt welding method:

$$l_p = l + d_1 + d_2 + r_1 + r_2 - (\Delta_{al} - \delta_{al}) + (t + x_1 + \Delta_{el} + \delta_{el}) \qquad \text{... (3)}$$

in which: l is the length of existing rail part, in mm, measured at the working temperature of rail when the joints are dismounted;

α = 0,0000115 is thermal coefficient of expansion for rail steel;

d_1, d_2 are the parts of rail which are eliminated by cut from the rail parts;

r_1, r_2 are the values of gaps, in mm, measured at the working temperature of rail when the joint are dismounted;

Δ_{al} is the value of the casting gap, in accordance with regulations of the Thermit provider;

δ_{al} is the effect of aluminothermic weld cooling (usually 2 mm for aluminothermic welding);

t is the error made at x_1 appraisal;

x_1 is the obliquity at the end rail cutting;

Δ_{el} is the value of rail consuming after activation of the automat welding process by flash butt welding method;

δ_{el} is the effect of flash butt weld cooling (usually 1,5 mm for flash butt welding).

So, for appraisal the position of cutting signs at the end of turnout parts out of running rail and making the cuts, the distance between the sign and the cutting end of the running rail should be equal with (Δ - δ) mm.

The time necessary for the complete cooling of the weld is circa three hours, whatever which of the both welding method is used. So, will be forbidden to run over the turnout earliest than three hours after the execution of the last weld.

The welded turnout must be measured according to "the test results record sheet" after the inclusion in the CWR track and the railway traffic can be restart after three hours from the achievement the last weld.

The buffer track panels will be connected with the ends of the welded turnouts by aluminothermic welding method. The buffer track panels will be connected each to others as well as the connection of the buffer track panels to the welded turnouts can be achieved either by aluminothermic welding method or by flash butt welding method.

The controlled welds (the finish weld) will be achieved by deformation (bending) in a vertical plane and lining on 5 m of the ends of rails.

After the execution of finish welding rails will be introduced in their definitive positions on the zone of remanent bending and the fastenings will be refixed after more than three minute from the completion of the welding process.

4. REFERENCES

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