IMPORTANT ASPECTS IN WELDED OF RAILWAY SWITCHES

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Abstract: In this paper are presented some important aspects about a Romanian technology used for elimination of interior rail joints in a new isolated standard turnout by aluminothermic welding method and for include this 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 length closure rails, the computation of casting gap and the effect of weld cooling to ensure a good operating of railway switches after the elimination of interior rail joints and after theirs integration in CWR track. In this paper is presented, also, an original method to solve these problems.

Key words: welded railway switches, welding process, rail joints, 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 [5].

Because the rail joints have gaps, impacts occur when a railway wheel encounters these discontinuities. In case of railway switches the vertical interaction forces between wheels and rails are amplified by presence of major discontinuities in frog of switch area. These large impact forces may cause damage to wheel, track and vehicle. A modern solution to clear up this problem is to eliminate the interior rail joints included in railway turnout using aluminothermic welding method and to include this isolated standard turnout without interior rail joints, in continuous welded rail (CWR) track, using the aluminothermic welding method or flash butt welding method [1].

A welded railway switch is a railway switch without inner (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 the continuous welded rail track, and all discontinuities caused by presence of gap on the rail joints are eliminated [3].

In Romania, the elimination of interior rail joints can be carry out only for a range of temperature into rails between 0°C and +40°C.

The behavior of inner rails of welded turnout are like a breathing zone of continuous welded rail track (with displacements) and the behavior of outer rails of welded turnout are like a central zone of continuous welded rail track (without displacements). Because the displacements of switch blade and stock rail are different and because exist device fork-tenon appear the danger to produce the buckling of the rails in front of turnout area, if the welds are not make in a correct manner.

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 [2]:

- *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 to know that the works in this phase should be realized only into prescribed temperature range for decrease the risk of rail track buckling and to ensure a good operating of turnout after including the welded turnout into the CWR track.

In Romania, this prescribed temperature range is between +17°C and +27°C temperature into rails [1].

2. **ON WELDING INNER (INTERIOR) RAIL JOINTS AND THE INCLUDING OF WELDED RAILWAY SWITCHES IN CONTINUOUS WELDED RAIL TRACK**

Turnouts that are to be welded shall comply with the following main conditions [2]:

1. they have to ensure the water drainage in turnout area;

2. the track platform must respect the requirements about bearing capacity of the distribution sub-layer;

3. crushed stone prism shall be complete, having the correct dimensions and must be stabilized;

4. 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.

5. the geometry of the turnout and the running channel should comply with regulations;

6. the turnouts should be endowed with a device to block the relative displacement between switch rail and stock rail (device fork-tenon);

7. 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°C). This mark sign is "the neutral point".

8. 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;

9. the fastening system of the compound parts of the turnouts on the sleepers should be elastic and strength;

10. the moment of tightening of the fastening elements should correspond to the technical prescriptions for fastening;
11. the turnouts have to be endowed with G.I.J. (Glued Insulated Joints);
12. point machine and shunting and locking devices should work normally according to prescriptions in force;
13. checking in locking stroke;
14. checking in joints corner angels/square at the turnout point;
15. checking the distance between the point fastening bolt and the middle of the distance between the two bolts on the case;
16. sleepers inside the turnouts (condition, layout, and diagram) should comply with the plan showing their layout, and with the provisions in regulation.

Turnouts that are to be included in CWR track shall comply with the same conditions like turnouts that are to be welded and following supplementary conditions:

17. the rails of buffer track panels must be in good conditions, without geometrical or mechanical faults;
18. the turnout must be welded (with inner joints welded);
19. 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 turnouts after the elimination of interior rail joints and after the including of welded turnout in CWR track, respectively.

3. TECHNOLOGICAL FLOWS AND COMPUTATIONS

3.1 The inside joints welding of the single turnout

The successions of technological operation are the following [3, 4, 5]:

- The circulation of the trains is restricted;
- The preparing of the turnout for the elimination of interior rail joints:

- checking the geometry of turnout by all points of view (gauge, level, running channel dimensions, gaps, lengths of all turnout parts, etc.);
- the "test results record sheet" will be filled;
- checking if the clamp lock working;
- checking of the neutral point, corresponding to neutral temperature established by the turnout manufactures;
- the replacement of the elements of the turnouts that are not in a good state should be repaired before welding works.

- The dismounting of all internal (inner) joints, from 1 to 8 (fig. 1);
- The dismounting of the fastenings placed along of the switch blades, stock rails and closure rails to allow the displacements of switch blades;
- The aluminothermic weldings of inner joints will be prepared and worked out using ***the symmetry principle*** as follow:

- The closure rail and runway rail from the outer curve of the turnout are cut to assure the gap necessary to made the ordinary aluminothermic welding OW8, taking in account the effect of the weld cooling;
- The closure rails are moved so that to assure the necessary gaps Δ to made the ordinary aluminothermic weldings OW1 and OW8;
- The inner joints 1 and 8 from the outer parts of the turnout are eliminated by the ordinary aluminothermic weldings OW1 and OW8 (fig. 2);
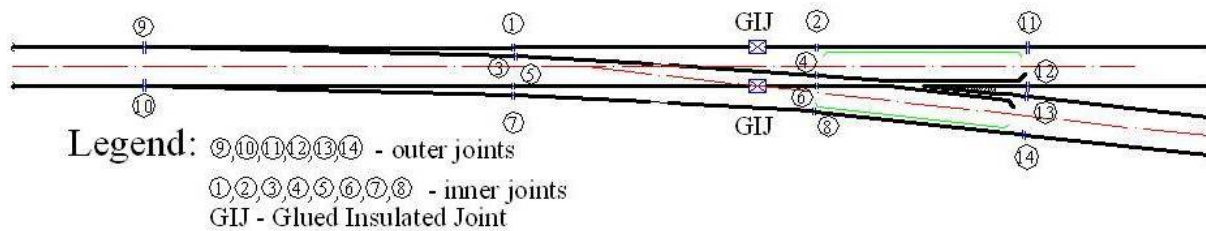
Fig. 1 The turnout before to be welded

- The closure rail and curved stock rail are cut to assure the gap necessary to made the controlled aluminothermic welding CW7, taking in account the effect of the weld cooling;
- The closure rail and runway rail from the outer right part of the turnout are cut to assure the gap necessary to made the controlled aluminothermic welding CW2, taking in account the effect of the weld cooling;
- The closure rail which is in the extension of the part made of right closure rail and stock rail are moved so that to assure the necessary gaps Δ to made the controlled aluminothermic welding CW2;
- The part made of the closure rail and runway rail which are in the extension of the curved stock rail are moved so that to assure the necessary gaps Δ to made the controlled aluminothermic welding CW7;
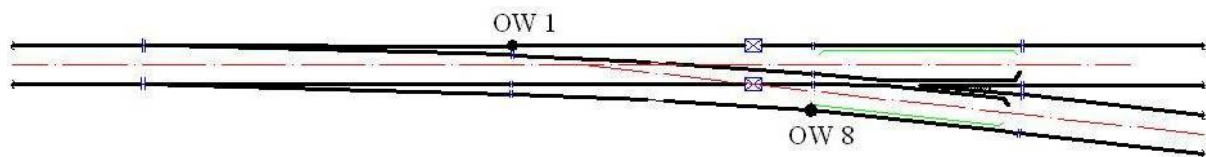

Fig. 2 The turnout after first two ordinary welds

- The inner joints 2 and 7 from the outer parts of the turnout are eliminated by the controlled aluminothermic weldings CW2 and CW7 (fig. 3);
- The right switch blade, the closure rail which are in the extension of the right switch blade and the wing rail which are in the extension of the right switch blade are cut to assure the gaps necessary to made the ordinary aluminothermic welding OW5 and the controlled aluminothermic welding CW6, taking in account the effect of the weld cooling;
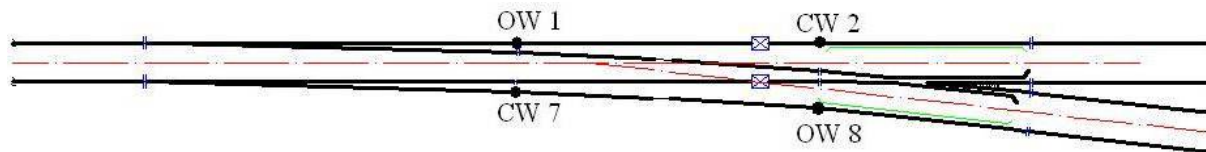

Fig. 3 The turnout after first two controlled welds

- The curved switch blade, the closure rail which are in the extension of the curved switch blade and the wing rail which are in the extension of the curved switch blade are cut to assure the gaps necessary to made the ordinary aluminothermic welding OW4 and the controlled aluminothermic welding CW3, taking in account the effect of the weld cooling;
- The closure rail which is in the extension of the right switch blade is moved so that to assure the necessary gaps Δ to made the ordinary aluminothermic welding OW5;
- The closure rail which is in the extension of the curved switch blade is moved so that to assure the necessary gaps Δ to made the ordinary aluminothermic welding OW4;

- The inner joints 2 and 7 from the inner parts of the turnout are eliminated by the ordinary aluminothermic weldings OW4 and OW5 (fig. 4);
- The curved switch blade is moved so that to assure the necessary gaps Δ to made the controlled aluminothermic welding CW3;
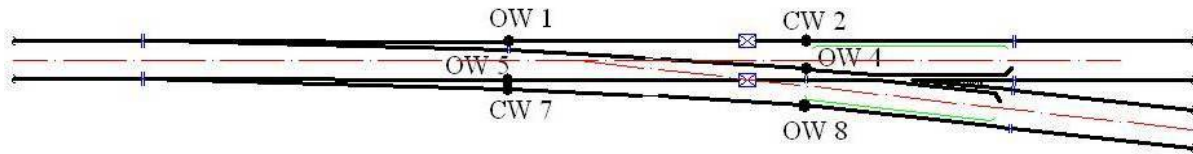

Fig. 4 - The turnout after last two ordinary welds

- The part made of the curved switch blade and the closure rail which are in the extension of the curved switch blade are moved so that to assure the necessary gaps Δ between this welded part of turnout and the wing rail which are in the extension of its made the controlled aluminothermic welding CW6;
- The inner joints 3 and 6 from the inner parts of the turnout are eliminated by the ordinary aluminothermic weldings OW3 and OW6 (fig. 5);
    - The re-fixed of the fastenings;
    - The cast seams are removed and the welds are grinded on the running rail surfaces and gauge face of rails;
    - The turnout is measured and checked again and the results are written down in the "test results record sheet";
    - The circulation of trains will be opened at three hours after the finish of last weld.
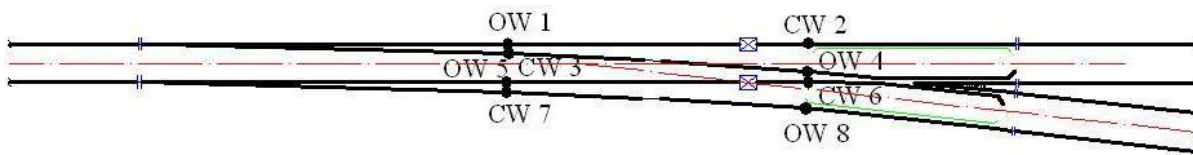   -

Fig. 5 The turnout after last controlled welds (after elimination of all inner rail joints)

To assure the necessary gap Δ to make the aluminothermic welding and to take into account the effect of weld cooling, the length of closure rail should be the following [2]:

$$l_p = l + d_1 + d_2 + r_1 + r_2 - 2 \cdot (\Delta - \delta) \qquad (1)$$

in which:
- l is the length of existing closure rail, in mm, measured at the working temperature of rail when the joint are dismounted;
- $\alpha = 0.0000115$ is the thermal coefficient of expansion for the steel of rail;
- d_1, d_2 are the parts of rail which are eliminated by cut from the running parts of the turnout;
- 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).

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.

3.2 About the 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 [5].

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 turnout.

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*.

The parts of welded turnout must be destressed on entire their length before the welded the external rail. 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 which must be destressed will be computed with relation [2]:

$$l_r = \frac{\alpha EA(t_n - t_e) - R}{p} \tag{2}$$

in which:
- p is the value of longitudinal resistance;
- R is the fishplates resistance;
- α = 0.0000115 is the thermal coefficient of expansion for the steel of rail;
- $E = 2{,}1 \cdot 10^6 \ daN/cm^2$ is Young's modulus for the steel of rail
- A is the area of rail cross section, which is depending of type of rail.
- t_n is the neutral temperature of the adjacent track which must be destressed;

- t_e is the extreme (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.

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) if the both welds from ends of rail parts which will be welded are aluminothermic shall be used the relation (1), with some differences:

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

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

b) if 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 [2]:

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

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 the thermal coefficient of expansion for the steel of rail;

- 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 appraisal of the x_1;

- x_1 is the obliquity at the cutting of the end rail;

- 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 $(\Delta - \delta)$ mm.

The time necessary for the complete cooling of the weld is about three hours, whatever which of the both welding method is used. So, it 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 residual bending and the fastenings will be re-fixed after more than three minute from the completion of the welding process.

4. CONCLUSIONS

For welded of isolated standard turnouts and theirs integration in CWR track shall be respected the symmetry principle.

It shall be in account the computation of length closure rails, the computation of casting gap and the effect of weld cooling in both welding methods (the aluminothermic welding method or flash butt welding method) using above-mentioned formulae.

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