Reconditioning of the Railways through Welding

Gabriel Gârleanu, Delia Gârleanu, Claudia Borda

Abstract— These instructions give The article presents a new technology of mechanized reconditioning through the welding of the driveways, with or without channel, used for the transportation of passengers/goods or in the industry for the technological bridges. The loading technology is based on a welding facility with a mechanical detector. The loading can be achieved both on the driving horizontal surface but also on the lateral guiding surface. The welding process chosen is of MAG type with tubular wire with/ without protection gas. The value of the hardness of the deposited material and in the head affected area is within the imposed limits. From the metallographic items included in the article it can be noted the depth of penetration at the loading of the horizontal surface and the appearance of the railways' side area before and after loading. There have been used 3 types of fillers, 2 manganese steels, 1 loe steel alloyed with Cr. The advantages of this technology are given by the possibility of local loading of the driveways, as well as the increase of the service life of approximately 2-3 times.

Index Terms— increase of the service life, mechanized loading through welding, Metal Active Gas welding.

1 INTRODUCTION

The railways are steel bars laminated after a certain profile, used as a driveway for a wheeled vehicle: train, tram, technological bridges or guiding driveways for certain mobile parts in a technical plant.

The composition and mechanical properties of the railway are different and are selected depending on the place of use. For economic reasons, the rails are made of unalloyed or low-alloy carbon steel with a high content of carbon from 0.6 to 0.9%, thermally treated or not. The hardness value is about 300-400 HB. Certain parts of the driveway, such as: point rails, frogs, etc., are made of manganese steels, highly alloyed with Cr, Mn and Ni.

From the point of view of the cross-section, the following types of railway are highlighted:

- railway with channel – are rails with a rolling head (rail end), a guiding head (tet), in between them being found the channel of the railway, and which have in the component of their profile a core and a sole - are used in general for: trams, cranes' driveways;
- railway without channel – are rails which have only a rolling head (rail end), core and soleare used in general for the driveways of bridges, of cranes or in CFR (Romanian Railways).

In this paper work the railways without channel are treated, the loading being made on the driveway.

The railways are subject to different kinds of mechanical stress, such as: compression, tension, friction, shock, bending, weariness, etc. Due to these stresses, after a period of use, it appears a quite pronounced wear and the rail must be replaced or reconditioned through loading by welding.

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Generally, depending on the stress manner, the following types of wear may occur which can be reconditioned through the loading by welding:
- side/ lateral wear;
- vertical wear.

In general, the rolling bridges/ the cranes have a quite large load (weight) on the wheel in between 5-50 tones per wheel.

This leads to a very high value of the contact pressure (compressive impact load) of wheel/ rail. In these circumstances, on the rolling/ running surface of the rail and of the wheel wear and deformation may be observed, occurring the phenomenon of material flow, phenomenon which may be observed by the appearance of the side burr, see Figure 1 and 2. This burr is cut by the lateral rollers of the rolling bridge (lateral guiding wheel of the bridge) when passing from one direction to another.

Fig.1.Railway without channel .

Fig. 2. The wear of the driveway with the flowing phenomenon.

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Besides the flowing phenomenon, it was also noticed a reduction of the contact surface between the wheel and the rail, this contact surface being reduced to 25% (visible as a shiny surface) thus increasing the crushing phenomenon, see fig. 3.

Fig. 3.Railway without channel – the contact surface is only the shiny one.

In Figure 4 are shown 2 rails with channel worn in a different way, namely one shows wear on the thin side, "Tet" (Fig. 4 a) and the other shows wear on the wreath (Fig. 4 b). This type of rail is usually used for the trams' railways. The biggest wear and which appear quickly are those in areas of rail curvature, where the tram must change its travelling direction with an angle of minimum 90 degrees. On a normal traffic, these railways must be changed or reconditioned once every 2 years.

a) b) c)

Fig. 4 a) Railway with channel Side wear of Tet; 4 b) Railway with channel – side wear of wreath; 4 c) Reconditioned railway.

The phenomenon is even more intense in the joints area where one rail ends and the other begins, where in addition to the static stress there is also a high enough shock stress, leading in time to the occurrence of basins (rail depressions).

All these processes occur continuously, leading in time to the pronounced wear of the driveway, to the decrease of the rail's height or of its width in the case of the rail with channel. In order to solve these problems the rail can be replaced or reconditioned through the loading by welding. The solution with the lowest costs is the loading by welding, for there are no longer performed infrastructure works. The loading is made with manganese steel and thus the service life increases of approximately 2-3 times.

2 Current Condition

Detailed Currently, this reconditioning is done through the loading by welding by the processes: S.M.E.I. welding with coated electrode or MIG / MAG, with full/ tubular wire, in case of semi-mechanized welding being possible the use of some devices running the loading by welding but on relatively small lengths (1-2 m).

The disadvantages of the current technology are:

- low productivity;
- being a manual loading process, the quality of the work is subject to the qualification and the physical and psychic condition of the welder. Very high probability of occurrence of some defects specific to the process;
- the surface resulted after reconditioning has many geometrical discontinuities thus requiring extensive grinding works in order to obtain the appropriate geometrical configuration;
- high level of physical stress of the workers, welders and locksmiths, due to the uncomfortable working position, the railway being at ground level;
- additional measures to maintain the qualities of the filler material in the case of interventions through the SMEI process (calcinations of electrodes, maintaining in cabinet dryers, using the waterproofing jackets, etc.).

Tractors are known for linear or circular welding seams, the adjustment of the parameters being done from a control desk. The driveway of these tractors for welding is independent from the loading rail; see Figure 5 a) and b). Because of this, the positioning and fixing of the driveway is made with difficulty, and during welding are required multiple adjustments on at least 2 axes. The operator is always present, performing continuous adjustments in order to maintain a constant position of the torch gun from the piece, as it can be seen in Figure 5 a) and b).

If the adjustment is made late or it is not appropriate, the welding lacks quality and may have various defects, such as: lack of fusion, pores, side burning etc. Another problem is the misuse of the type of wire for the MAG welding.

a) b)

Fig.5 a) Railtrac - automated welding solutions for the repair of rail track components - ESAB; 5 b) Tramtrac™ II – for the repair of embedded city tramway rails - ESAB [3].

Most often it is welded with full wire, being absolutely necessary to use a protection gas. In terms of using the facility in the open, very often due to the air currents, the protection gas is diverted not being able to ensure an adequate protection of the metallic bath. This will automatically lead to the development of some welding defects in the strap, those respective areas being then repaired by the SMEI process.

3 Modernized Reconditioning Technology

The technical problem solved by this new reconditioning technology through welding is the use of an automatic facility and of an auto-protection tubular wire.The welding process proposed is MAG. The driveway used for the movement of the welding facility is actually the rail to be reconditioned. In this way, the length of the welding strap is practically unlimited. The welding straps are positioned dependent on the modification of the geometric configuration due to a mechanical detector, in the form of a copper flange.

The filler material used is from the manganese steels group. The MAG welding head is fastened to a positioning device, see Figure 6, which allows its positioning on several directions. The welding device is mounted on a mobile cart/ bogie, see Figure 7, which moves on the drive rails by means of an actuator. Onto the mobile cart/ bogie there are mounted the following: an electronic device for the automatic adjustment of the working parameters, the welding equipment, including the filler material.

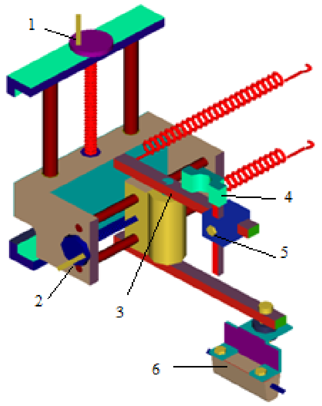


Fig. 6. Positioning device:
1 – vertical positioning screw;
2 - horizontal positioning screw;
3 – upper arm for the fastening of the welding head; 4 – copper flange coupling; 5 - fastening screw; 6- mechanical detector.

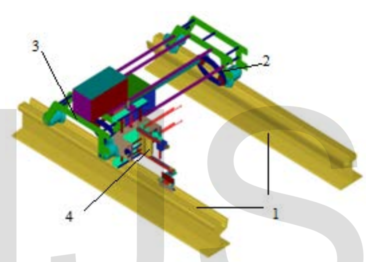
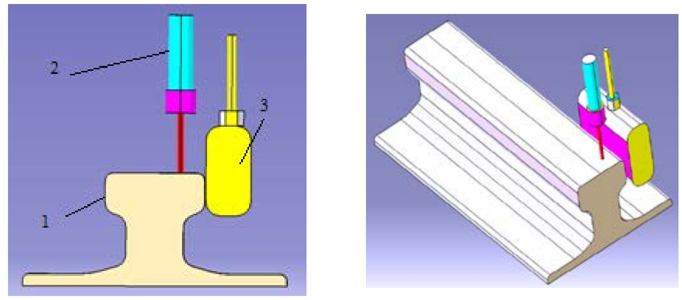


Figure7 – Mobile cart/ bogie:
1- rail; 2- mobile cart/ bogie;
3 - welding equipment; 4-welding device.

The positioning device comprises a mechanical positioning system on 2 axes and a cylinder - fork which supports two arms, the upper and the lower one. The mechanical positioning system allows the adjustment of the distance of the torch gunfrom the vertical rail by triggering screw "1" and from the horizontal one by triggering screw "2". On the upper arm "3", the welding torch gun is fixed into couple no. 4.

This coupling allows the positioning of the head on other two directions, vertically and along the rail. Screw 5 has a fastening purpose. On the lower arm the mechanical sensor (detector) is mounted, a flange 6 to support the bath of molten metal and to track the rolling rail subject to reconditioning. This also ensures the continuous positioning of the welding head (see Figure 8) without the operator's intervention. The adjustment of the welding torch gun is made only at the beginning of the welding process.



a) b)
Fig. 8: a) front view; b) isometric view; 1- rail; 2- welding head; 3 -skid.

In this article it is shown the loading by welding of some rails of Burbach A65 type, on a length of 400 m using the welding facility/ installation presented above. The width of the rolling surface is of 65 mm. Through welding there have been deposited 7 rows with a single layer, using 3 types of wire, namely:

1) Lincore 33, low alloyed steel, see Figure 9 a:
- the chemical composition is the closest to the rails' composition, 0.2%C; 2.1%Mn; 0.7%Si; + 1.3% Cr and 1.8%Al;
- the hardness obtained after welding was in between 28 – 30 HRC;
- hardness after cold-straining 30 – 34 HR;
- the super-elevation is uneven;

2) Lincore M, manganese steel, see Figure 9b:
- the chemical composition 0.6% C; 0.4%Si; + 13%Mn and 5%Cr;
- the hardness obtained after welding 30 – 32 HRC;
- after cold-straining 40 – 45 HRC.

3) Lincore 15CrMn,manganese steel, see Figure 9c:
- the chemical composition 0.4% C; 0.3%Si; + 15% Mn and 16%Cr;
- the hardness obtained after welding 26 – 28 HRC;
- after cold-straining 38 – 42 HRC.

The parameters of the welding conditions were Is = 290 – 300 A, Us = 28 – 30 V, Welding speed = 40 – 45 cm/min.

It can be observed in the macroscopic images (Figure 9) the thickness of the deposited layer and area of thermal influence.

a) b) c)
Fig.9. a)welding with Lincore 33; b) welding with Lincore M; c)welding with Lincore 15CrMn

Analyzing the 3 samples, the following have been observed:
1) in terms of metallographic structures, version 1 is the best and cheapest but with the lowest hardness value, thus with low endurance;

2) in terms of endurance, version 3 is the best but it is the most expensive;
3) the version which best suits the analysis criteria, ensuring the best endurance/ cost price/ metallographic structure is version 2.

The welding technology and the installation proposed for use has the following advantages:

- very high productivity, the process being limited only by the depositing rate of the filler material and by the process used;
- the execution quality does not depend on the workmanship or of the physical - psychic condition of the welder;
- in case of reconditioning the side wear, by using a flange to support the bath it is ensured a geometry appropriate to the reconditioned area, being necessary only a superficial finishing polishing;
- high efficiency of use of the filler material;
- the possibility of reconditioning on long lengths;
- being a fully automated process, the monitoring by the welder is made intermittently not being done any adjustment during the welding process, thereby decreasing the welder's demands;
- the number of risks from the point of view of occupational and labor safety are greatly diminished;
- the machine is achieved in a sturdy construction, its movement being made only on the rails being reconditioned, practically not being any risks of shock occurrence that may affect its proper functioning;
- it decreases the risk of occupational and labor illness due to the intermittent monitoring of the process, the operator being at an appropriate distance from potential hazards;
- the possibility of automatic adjustment of theparameters of the welding regime depending on thevariation of the value of the existing wearon the length of the rail, thus obtaining an appropriate geometric configuration and an important increase in productivity.

The samples reconditioned were tested in a certified laboratory and the results were above expectations, thus achieving a special quality of the rails of the driveways, with metallographic structures which behave well to the wear of metal on metal and do not show defects (pores, cracking or lack of fusion).

4 Conclusions

The new technology of mechanized loading by welding allows the reconditioning of the driveways, with or without channel, used for the transportation of passengers/ goods or in the industry for the technological bridges.

The loading technology is based on a welding facility/ installation with mechanical detector, onto which the loading can be achieved both on the horizontal rolling surface and also on the side surface, the guiding one. The welding process chosen is of MAG type with tubular wire with/ without protection gas using 3 types of filler materials, 2 manganese steels, 1 low steel alloyed with Cr. The advantages of this technology are given by the possibility of local loading of the driveways, as well as the increase of the service life of approximately 2-3 times.

The technology presented above can be applied to any type of rail at low costs and with very good results; with this new facility, the rails may be very easily reconditioned in curves or in straight line, making a cost reduction of 25-40% in comparison with the usual technologies or the costs related to their replacement.

The metal layer deposited is more resistant than the base material. The service life of a rail may increase 2 to 3 times after a process of reconditioning, this reconditioning process being able to take place several times.

The loading material must be a self-protection wire and it is chosen depending on the chemical composition of the rail to be reconditioned. The grinding of the loaded area is not always necessary. However, if necessary, the grinding can be made using an oval stone.

The productivity obtained after the modification of the technology is very high due to the use of the mechanized welding facility/ installation with mechanical detector, the length of the strap no longer being limited.

Using this reconditioning technology of loading by welding, in the recent years,there has been reconditioned over 400 km of railways, thus observing an increase of the service life of approximately 2-3 times.

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