RESEARCH IN PASSENGER CAR BOGIE CENTRAL SUSPENSION ROLLER AND ROD BASE METAL AND WELDED METAL STRUCTURE

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Abstract. In this article the urgent problem of improving the quality of repair of railway rolling stock main components and parts is considered; safety, life and health of passengers directly depend on these serviceable conditions. At the same time an important factor is a necessity of reduction of the cost of repairs. During periodic repair of cars often it becomes necessary to complete replacement of a particular unit or parts and procurement for this purpose of new very expensive, and in some cases no longer manufactured parts. Therefore, the restoration of parts by welding with further processing to drawing sizes allows to get cheaper and without reducing the strength characteristics the item practically identical to the new. The object of the research in this article selected the most important parts of the passenger car bogie – the roller and rod of the central spring suspension, in the operating process subjected to the greatest static and dynamic loads are considered. The existing requirements of normative-technical documentation for repairing the selected parts are considered. In this paper in steps the technology used on railroad car repair enterprises to repair parts with a description of the equipment used is described. For the research from the selected parts of metal samples are taken in the loaded areas. During the work sample preparation was carried out for further research using high-precision equipment of the RTU technical laboratory. Then, metallographic analysis of the roller and rod base metal and hardfaced metal was performed. The comparison of the standard requirements demanded to chemical composition of the base and the hardfaced metal to the actual chemical composition of the new parts and after surfacing was carried out with following graphical display of the results. Based on the results appropriate conclusions were written.

Keywords: passenger car bogie, central spring suspension roller, central spring suspension rod, steel, welding, welding wire, metallographic analysis, chemical composition, technological recommendation.

Introduction

The main goal of this study is to research the structure of the base metal and metal hardfaced to the roller and rod of the central spring suspension of passenger car bogie in the context of the analysis of the possibility of using the existing part repair technology and check it for compliance with the requirements of normative-technical documentation.

To achieve this goal the following tasks have been advanced: examine the recovery process by welding for the selected items; consider the requirements of normative-technical documentation; select part samples and prepare them for the research; conduct metallographic analysis of basic and weld metal of parts; compare these results with each other, as well as with standard values; to draw appropriate conclusions.

Faultless technical condition of passenger car bogie parts is a guarantee of railway safety. Part repairing by welding – one of the most widely used methods for the repair of rail transport products. Its advantage is that using the hardfacing method it is easy to obtain a large thickness layer. This is especially important in the repair of parts with big abrasion wear. Hardfacing allows modifying the physical and mechanical characteristics of the repaired surface in the necessary direction: to increase wear resistance, corrosion resistance, return the original configuration and dimensions of the worn parts. Mechanized electric arc hardfacing is the most widespread. Compared to manual arc welding it provides a high density of hardfaced metal, minimal content of oxygen and nitrogen. It is necessary to choose the added material so that the hardness and other properties of the weld metal are strictly complied with the requirements of normative-technical documentation for the restored part, just follow the instructions for welding and hardfacing on this product. For mechanized welding semi-automatic and automatic machines are applicable. In this case, the workstation is equipped with special and multipurpose hardfacing equipment, which includes: the source of the electric arc power, hardfacing installation, equipment automation and control hardfacing machine. The equipment set may include accessories, controls the process of welding and protective devices. Recently, for welding and welding in shielding gases in repair depot equipment from the company MIGATRONIC types of MIG is widely used, which is operating on AC and DC with HF ignition of the electric arc, has programmable input data of welding, forced cooled burner and other technological capabilities.

Materials and methods

In view of that this work describes the passenger car bogie, as the study objects parts of the central spring suspension were selected, namely the roller and rod respectively pos. 1 and 2 in Fig. 1 which are working together. As the scope of the research has been selected the hardfacing recovery process of these parts during the repairs on the Repair Company “L-Ekspresis” ltd, which in the Republic of Latvia is concerned in repair of passenger cars operated in long-distance.

Fig. 1. **Suspension parts:** 1 – roller; 2 – central suspension rod

Repair technology for the above-mentioned parts is the following, after demounting the roller goes to the repair position where it is measured, repaired and diagnosed for fault. At the roller measurement phase controls wear of bearing surfaces pos. 1 in Fig. 2 in the friction places of the rod bearings, and rollers central surface pos. 2 Fig. 2, on which the rod is suspended. Wear is monitored using the slide gauge by making measurement of the diameter in shown locations and comparing the results with the requirements for maintenance. Wear of roller bearing surfaces should not exceed 3 mm [1]. When it is up to 3 mm, it is allowed to repair the roller by welding, with followed turning to the drawing size. When it is more than 3 mm, the roller is subject to rejection.

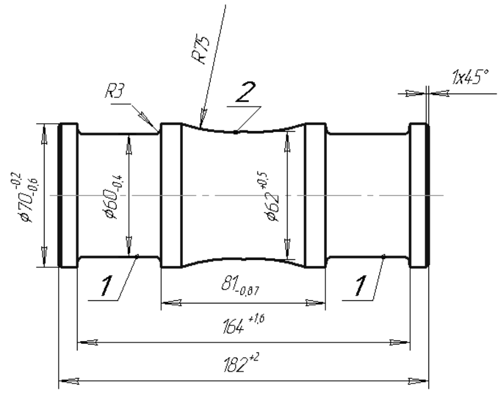

Fig. 2. **Roller:** 1 – roller bearing surface; 2 – roller central part

The requirements for rod repairing are the following. For all types of passenger car repair it is allowed to make hardfacing of rod opening wall worn, providing that the thickness of the upper bridge lug pos. a, Fig. 3 before hardfacing is not less than 35 mm. If the thickness remains less than 35 mm, the rod is rejected. Wear of the lower lug bushing pos. b, Fig. 3 should not exceed 0.5 mm, otherwise press in a new bushing is needed [1].

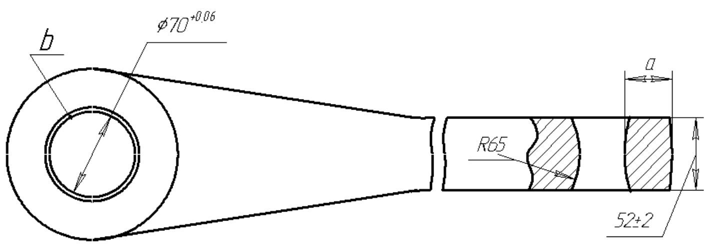

Fig. 3. **Central suspension rod:** a – upper bridge lug; b – lower lug bushing

Hardfacing of rollers is made in manual way at the welding and hardfacing compartment. Welding and hardfacing is dine by a welder, qualified and having the appropriate license model. For hardfacing industrial welding semiautomatic MIGATRONIC MIG 445 MK III is used, which for welding uses solid flux-cored wire.

Taking into account the technical requirements for the roller repairing and the requirements of the standard for the chemical composition of the steel wire, solid section brand HYUNDAI standard AWS 5.18 ER70S-4 with a diameter 0.8 mm is used. Before hardfacing, the roller and rod are heated in a furnace to 250-300 ºC. Hardfacing power is retained in the range 50-100 A with the wire releasing 8-15 mm. Comparative data of the base metal chemical composition and the metal of the wire are indicated in Table 1.

Table 1

Chemical composition of base metal and metal of wire

Steel grade, welding wire grade	C,%	Mn,%	Si, not more than,%	S, not more than,%	P, not more than,%	Ni, not more than,%	Cu, not more than,%	Cr, not more than,%
Ст5сп	0.28-0.37	0.5-0.8	0.15-0.3	0.05	0.04	0.3	0.3	0.3
AWS 5.18 ER70S-4	0.11-0.24	1.0-1.5	0.65-0.85	< 0.035	< 0.025	-	< 0.500	-

In the process of roller repair, the welder using the above equipment, puts hardfacing layers along the roller body at the same time turning it to the full perimeter of the circuit. The welder makes the thickness of the hardfacing layer up to 6-8 mm. Then the part is transferred to turning, where the turner grinds the roller to drawing sizes.

To conduct the research two central spring suspension rollers were selected – a new Fig. 4 pos. a and the repaired Fig. 4 pos. b, and two rods, with wear (the new rod has a greater value) Fig. 5 pos. a and the restored Fig. 5 pos. b.

a) b)

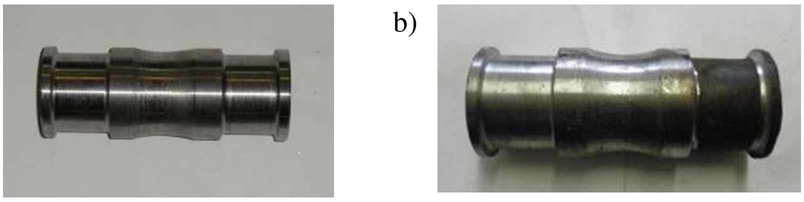

Fig. 4. **Roller:** a – new; b – repaired

a) b)

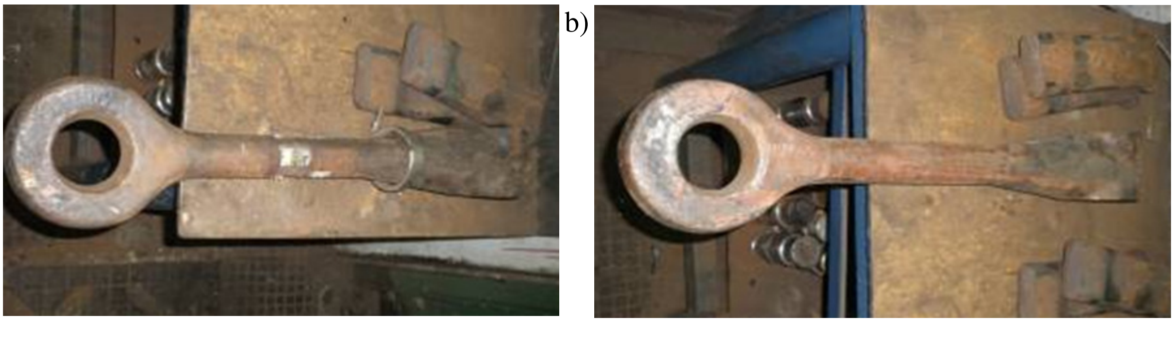

Fig.5. **Central suspension rod:** a – new; b – with wear

Then, in the mechanical workshop of car-repair enterprises using the band saw from the parts to be investigated, the samples were cut. The samples were cut in such a way that during further research in the laboratory the properties of both the base and hardfacing metal can be tested. To this in the roller was performed slices in sections 1 and 2 Fig. 6.

After cutting the surface of the samples in places were cut abraded and with roughness, what not enough to the research. To correct the defect, the samples were submitted to the turning and milling unit. The miller fulfilled grinding to the necessary surfaces on a precision surface grinding machine with a cross table and horizontal spindle, which is designed for high-precision machining of flat surfaces of various products.

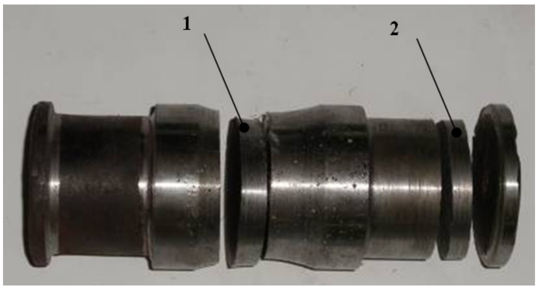

Fig. 6. **Roller:** 1 – cut in the cross section of the new roll;
2 – cut in a section of the repaired roller

In the rods cut has been executed in the most loaded section 3 Fig. 7.

Fig. 7. **Rod of the central spring suspension:** 3 – cross sectional slice of rod with wear (left);
3 – sectional slice of repaired rod (right)

The samples (hereinafter templets) were numbered. The corresponding numbering is represented in Table 2.

Table 2

Samples to research

Name of the original part	Roller with wear	Rod with wear	Repaired roller	Repaired rod
The assigned number of templet	2.1.	2.2.	2.3.	2.4.
Photo				

In the next research step for all samples metal chemical composition analysis was performed. To do this, using the optical emission analyzer ARC-MET 8000 Mobile Lab, working on the principle of local burning surface of the sample, followed by determination of the chemical composition and the conclusion of the data to the print device. Measurements were carried out in three different parts of each templet. The average results of the chemical composition analysis of the samples are given in Table 3.

Let us analyze the results of the templet base metal chemical composition analysis of the roller number. 2.1 and the rod number. 2.2 with steel standard, see Table. 1. To do this, we draw a graph Fig. 8 and compare the data.

Table 3

Templet chemical composition

Periodic table elements	Templet No. 2.1	Templet No. 2.2	Templet No. 2.3	Templet No. 2.4
Iron (Fe)	98.4 %	98.1 %	97.4 %	97.2 %
Carbon (C)	0.316 %	0.322 %	0.226 %	0.202 %
Silicon (Si)	0.291 %	0.334 %	0.809 %	0.796 %
Manganese (Mn)	0.580 %	0.695 %	1.30 %	1.19 %
Phosphorus (P)	<0.0050 %	<0.0050 %	<0.0050 %	<0.0050 %
Sulfur (S)	<0.0050 %	<0.0050 %	<0.0050 %	<0.0050 %
Chromium (Cr)	0.134 %	0.196 %	0.0322 %	0.0309 %
Molybdenum (Mo)	0.0112 %	<0.0030 %	<0.0030 %	<0.0030 %
Nickel (Ni)	0.0533 %	0.133 %	<0.0050 %	<0.0050 %
Aluminium (Al)	0.0050 %	0.0170 %	0.0080 %	0.0072 %
Cobalt (Co)	0.0126 %	0.0081 %	0.0073 %	0.0073 %
Copper (Cu)	0.108 %	0.162 %	0.167 %	0.166 %
Niobium (Nb)	<0.0030 %	<0.0030 %	<0.0030 %	<0.0030 %
Titanium (Ti)	<0.0020 %	<0.0020 %	<0.0020 %	<0.0020 %
Vanadium (V)	<0.0020 %	<0.0020 %	0.0030 %	0.0030 %
Tungsten (W)	<0.0250 %	<0.0250 %	<0.0250 %	<0.0250 %
Lead (Pb)	<0.0100 %	<0.0100 %	<0.010 %	<0.010 %
Zirconium (Zr)	<0.0030 %	<0.0030 %	<0.0030 %	<0.0030 %

Red color in Fig. 8 shows the tolerance limit of the standard steel. As can be seen from the graph, the concentration of all elements is within the rated values, except the silicon value for the templet number 2.2 (rod, base metal), where there is excess to 0.034 %. This may be the result of the templet insufficient degreasing or compliance technology at manufacturing of the rod, which is unlikely. Silicon in steel increases its strength. In this case, the rod base metal is stronger than the roller base metal, which accelerates wear of the roller during operation in the bogie.

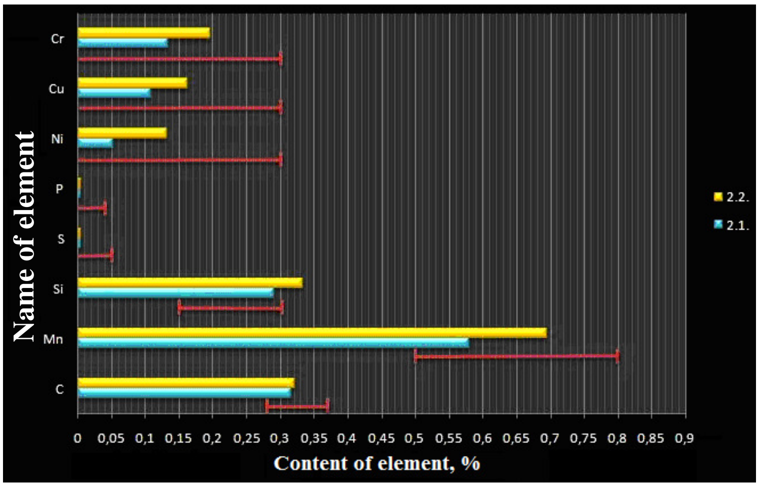

Fig. 8. **Graphical representation of the results of the samples 2.1., 2.2 chemical analyses**

Then, the templet of the roller No. 2.3 and rod No. 2.4 hardfacing metal analyses are compared with the welding wire standard data. Also we build a graph and analyze it. The resulting graph in Fig. 9 shows a similar situation. But in this case the mass fractions of the elements do not contradict the requirements of the wire standard.

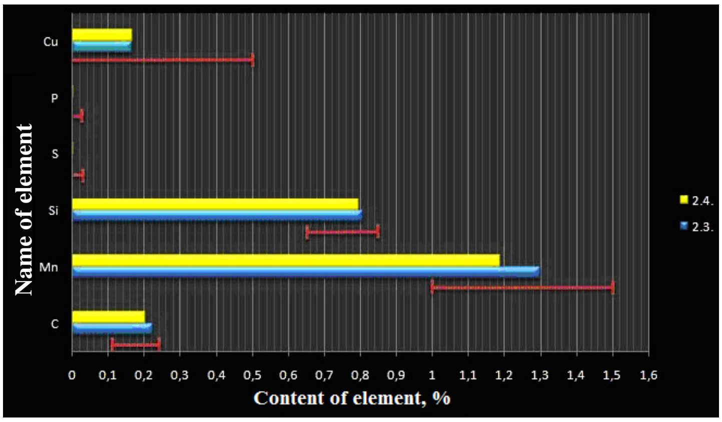

Fig. 9. **Graphical representation of the results of the samples 2.3., 2.4 chemical analyses**

Results and discussion

The conducted research enables us to determine the chemical composition of steel, determine the mass fraction of the metal elements that can give an answer to the question, for example, in the case when an important part was broken. It should be noted that the content of manganese (Mn) and silicon (Si) in the hardfaced samples is twice greater than in the base metal templets. As it is known, manganese and silicon increase the strength of steel, and here is the aim to improve reliability of the researched parts in operating conditions [2].

Conclusions

1. During the implementation of this work the main goal has been achieved – to research the structure of the base metal and metal hardfaced to the roller and rod of the central spring suspension of passenger car bogie in the context of the analysis of the possibility of using the existing part repair technology and check it for compliance with the requirements of normative-technical documentation.
2. All advanced tasks have been completed.
3. The research has shown that the main elements of the chemical composition of the samples are within acceptable limits and comply with the requirements of normative-technical documentation, except for silicon content index (Si) in the rod base metal, where there was a slight excess 0.034 %, which, according to the authors, may be a consequence of insufficient quality sample preparation to the research and does not affect the properties of the material.
4. The results showed that in hardfaced samples the content of such chemical elements as manganese (Mn) and silicon (Si) is 2 times higher than in the base metal. Since silicon and manganese increase the strength of steel, it can be concluded that in this case it increases the part resistance to abrasion.
5. The applied technology permits qualitatively and at lower cost to increase the safety factor for wagon parts and significantly extend their service life.

References

1. ПКБ. Методика выполнения измерения при деповском ремонте тележек пассажирских вагонов. (Passenger car bogie measurement methodology during depo repair (type of passenger car repair)). Project and Constructing Bureau. RD 32 CL 011-89. Moscow, 1989, 37 p. (in Russian).
2. Гуляев А.П. Металловедение. Учебник для вузов. (Metal science. Textbook for high schools). “Metallurgy”, Moscow, 1986, 544 p. (in Russian).
3. Богомолова Н.А. Практическая металлография. (Practical metallography). “High school”. Moscow, 1982, 272 p. (in Russian).
4. Полухин П.И. Технология металлов и сварка. (Technology of metals and welding. Textbook for high schools.) “High school”. Moscow, 1977, 464 p. (in Russian).
5. Болховитинов Н.Ф. Металловедение и термическая обработка. (Metal science and thermal treatment). “Mechanical engineering”, 1965, 503 p. (in Russian).