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NEW REQUIREMENTS FOR THE QUALITY OF STEEL RAILS

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Abstract

Rails are an important part of the railway infrastructure. Quality of rails have directly affect the functionality of the railway traffic. Increasing speed of trains, high frequency of traffic and axle load wagons and locomotives is directly related to the quality of rails. The characteristic quality tracks are prescribed standards of the International Union Railway (published UIC and EN 13674).

In order to increase the competitiveness of rail transport compared to other forms of transport and establishment of interoperable railway system of the European Union, is obligate to establish system management quality in according to ISO 9001. Also new standard EN 13674 establish other types steels of rails (seven types pearlite steels) and introduces a new philosophy in the micro and macro composition of steel for rails.
Key words: rails, steel quality, standards

Introduction

The railway infrastructure is a tracks with all the appropriate facilities plants and other devices, which are in function at the railway traffic.

Rails as an important part of the railway infrastructure have exactly level of quality. In Europe, the quality of rails is prescribed by international standards, the European Union of Railways UIC 860 and EN13674.

In other vital parts of railway infrastructure in order to: increase the speed of trains, increasing the axles loads of trains and locomotives traction and increasing the density of traffic and increase resistance to harmful influences of the environment (environmental aspects), required and improve the quality of rails.

The European Union standards for railways (UIC) have agreed national standards of different countries.

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In Serbia, the quality of tracks, measures and tolerances are prescribed standards SRPS.C.K1.020 and SRPS.C.K1.021.

These standards clarify in detail the most important components of quality tracks, production of steel for rails, and to control the final delivery of new rails.

Depending on load rails in service are set levels of quality tracks, with the aspect tensile strength and ductile properties. Depending on the degree exploitation load rails, rails are divided into two main groups, namely:

- rail and normal quality
- wear resistant rails (rails with high resistance to abrasion).

Demands for quality rails, metal-in during production steel rails, emphasis given to the following adjustment in the production of rails:

- Increased the mass of the rail due to the meter 45 to 77 kg / m. Now the most used rails with a mass 60 (Fig. 1) the prescribed weight of 60,34 kg / m, represented by former rail profile 49 kg / m prescribed weight 49,43 kg / m (Fig. 2).
- Increase the value of tensile strength from 700 to 1300 MPa.
- Increasing the purity of steel especially sulfur and phosphorus from the previous maximum of 0,050 to 0,030%.

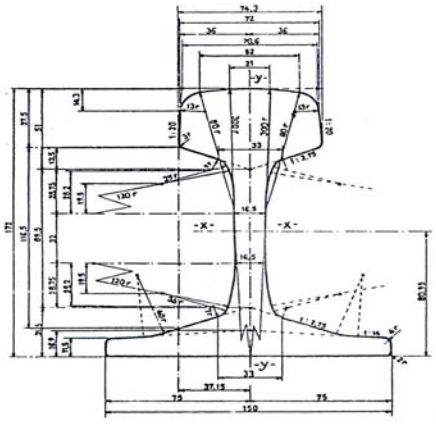

Fig. 1 The form and extent of cross-section rails 60 kg / m

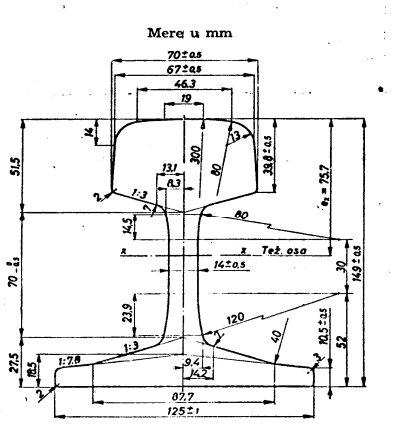

Fig. 2 The shape and extent of cross-section rails 49 kg / m

Production of long rails up to 120 m in length (decreasing the number of welded joints and dilatation spaces). [1], [4]

Macrostructure i. e. the consistency of the material is checked by Baumann test.

For Baumann test can be seen the level of expressed macro segregation, which is in direct correlation with low soluble micro constituents layout (Fig 3).

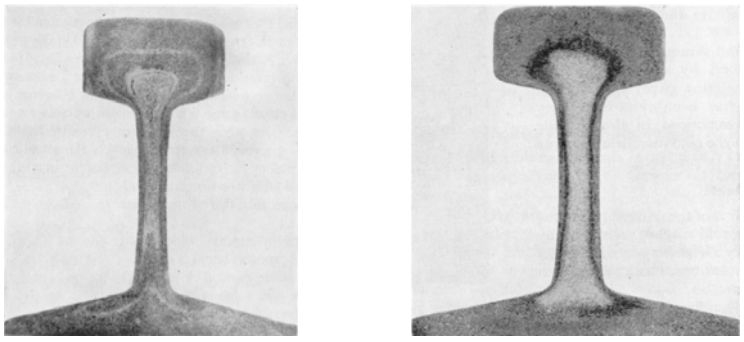

Fig. 3 Strong segregation block at the intersection of rails

Prescribed properties for steel of rails

Requirements of UIC 860 V

For a selection of different types of rails, the corresponding chemical composition and mechanical property requirements are presented in (Table 1) according to standard UlC 860 - 1.

From the Table it is obvious that, in the case of wear - resistant rails, increased carbon (C) and manganese (Mn) content is responsible for the improved mechanical properties. The increase in wear resistance is based on a theory of the mutual influence of certain elements. Carbon influences the mechanical properties through the volume fraction of cementite and the content of pearlite. Manganese influences the temperature decrease of the eutectoidal reaction and the fineness of pearlite lamellae, that is, the reduction in the interlamellar distance. As an illustration of the influence of alloying elements, such as carbon, manganese and silicon, on wear speed for a pearlite structure, the following equation is given:

$$W = 0.1427 \left(C + \frac{Mn}{4.72} + \frac{Si}{10} \right) \qquad (1)$$

where:

W - represents the speed of wear expressed as volume loss per unit of path over which sliding occurs, C, Mn, Si - represent the percentage contents of carbon, manganese and silicon respectively.

For all rail types, the appropriate values of mechanical properties are also laid down and controlled by the Standard (Table 1).

In pearlitic steels, the structure of which is depicted in (Fig. 4). The mechanical properties are largely governed by the distance between the cementite (Fe_3C) lamellae, their thickness and by the grain size. The influence of the interlamellar spacing on yield point, tensile strength and reduction of area is demonstrated by the structures shown in (Fig. 5). These examples display microstructures of the same steel subjected to different

cooling rates. The same effect can be achieved by controlling the diffusion rate via the alloying contents. [1]

Table 1 Rail characteristics according to UlC 860 - 1

Steel grade	Chemical composition, %						Rm N/mm^2	A_5 min %
	C	Si	Mn	Cr	P_{max}	S_{max}		
700	0,40-0,06	0,05-0,35	0,80-1,25	-	0,05	0,05	680-830	14
900 A	0,60-0,80	0,10-0,50	0,80-1,30	-	0,04	0,04	min. 880	10
900 B	0,55-0,75	0,10-0,50	1,30-1,70	-	0,04	0,04	800-1030	10
1100	0,60-0,82	0,30-0,90	0,90-1,30	0,80-1,30	0,04	0,03	min. 1080	9

Requirements of EN 13674

The new European standard EN 13674, which deals with issues of quality rail, takes into account the increasing demands for safety and economy of railway traffic. European standard EN 13674 includes symmetrical rails with wide rate of mass ≥46 kg/m.

This standard was developed by the European Committee for Standardization CEN (European Committee for Standardization) of the National Committee of the 19 countries. This standard has built a modern approach to the issue of quality tracks with the recommendation that manufacturers should be required tracks have introduced quality management system in accordance with the requirements of ISO 9001 standards.

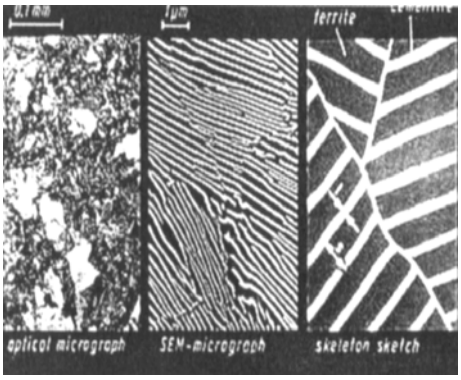

Fig. 4 Microstructure of pearlite

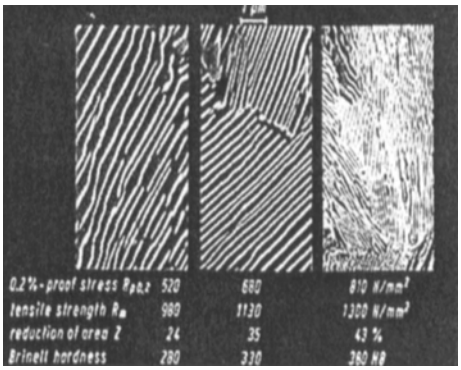

Fig. 5 Scanning electron micrographs of pearlite

Standard EN 13674 - 1:2003 consists of two main parts:

- qualification test and
- acceptance tests

Qualification tests are some other tests that were previously carried out, as for example, fracture toughness. Acceptance tests characterize the properties of the prescribed tests, which ensure production of high quality rails, and testing requirements of railway administration (Table 2) and (Table 3).

Quality of rails is based on measured values of hardness, by which they introduced new labels for steel rails.

Qualifying tests

Qualification testing must be conducted at least one in five years and the major changes in technology, production rails. Additional testing residual stresses are carried out on all types of steel rails every two years maximum, provided that the longitudinal strain rate in the rails can amount to up to 250 MPa.

The prescribed qualifying examination is the following:

- fracture toughness
- fatigue crack growth rate
- fatigue testing
- residual stress in rail foot
- variation of centre line
- tensile strength and elongation
- segregation
- other qualification requirements

Acceptance tests

Within acceptance testing is carried out a series of laboratory tests such as:

- chemical composition (the maximum content of the following elements: H, O, Al, V, N and oligoelements)
- microstructure (increasing x 500)
- degree of decarburizing charred layer (allowed up to 0.25 mm)
- purity of steel (especially the presence of oxide)
- macrostructure (Baumann test)
- hardness
- tensile strength

Other acceptance testing rails are:

- dimension tolerances
- criteria (control template)
- inspection requirements / tolerances for to internal quality and surface quality

Internal state is examined ultrasound in a continuous process control, and includes at least 70% of the head and at least 60% web.

Table 2. Chemical composition/mechanical properties (according to the standards EN 13674-1:2003)

Steel sample grade		% By mass									10^{-4} % ppm max. by mass		Rm min.	min. elong A	Centre line
		C	Si	Mn	P max	running surfice	Cr	Al max.	V max.	N max.	O	H	MPa	%	
R200	Liquid	0,40/0,60	0,15/0,58	0,70/1,20	0,035	0,008/0,035	0,15 max	0,004	0,030	0,009	20	3,0	680	14	200/240
	Solid	0,38/0,62	0,13/0,60	0,65/1,25	0,040	0,008/0,040	0,15 max	0,004	0,030	0,010	20	3,0			
R220	Liquid	0,50/0,60	0,20/0,60	1,00/1,25	0,025	0,008/0,025	0,15 max	0,004	0,030	0,008	20	3,0	770	12	220/260
	Solid	0,50/0,60	0,20/0,60	1,00/1,25	0,025	0,008/0,025	0,15 max	0,004	0,030	0,008	20	3,0			
R260	Liquid	0,62/0,80	0,15/0,58	0,70/1,20	0,025	0,008/0,025	0,15 max	0,004	0,030	0,009	20	2,5	880	10	260/300
	Solid	0,60/0,82	0,13/0,60	0,65/1,25	0,030	0,008/0,030	0,15 max	0,004	0,030	0,010	20	2,5			
R260 Mn	Liquid	0,55/0,75	0,15/0,60	1,30/1,70	0,025	0,008/0,025	0,15 max	0,004	0,030	0,009	20	2,5	880	10	260/300
	Solid	0,53/0,77	0,13/0,62	1,25/1,75	0,030	0,008/0,030	0,15 max	0,004	0,030	0,010	20	2,5			
R320 Cr	Liquid	0,60/0,80	0,50/1,10	0,80/1,20	0,020	0,008/0,025	0,80/1,20	0,004	0,030	0,009	20	2,5	1080	9	320/360
	Solid	0,58/0,82	0,48/1,12	0,75/1,25	0,025	0,008/0,030	0,75/1,25	0,004	0,030	0,010	20	2,5			
R350 HT	Liquid	0,72/0,80	0,15/0,58	0,70/1,20	0,020	0,008/0,025	0,15 max	0,004	0,030	0,009	20	2,5	1175	9	350/390
	Solid	0,70/0,82	0,13/0,60	0,65/1,25	0,025	0,008/0,030	0,15 max	0,004	0,030	0,010	20	2,5			
R350 LHT	Liquid	0,72/0,80	0,15/0,58	0,70/1,20	0,020	0,008/0,025	0,30 max	0,004	0,030	0,009	20	2,5	1175	9	350/390
	Solid	0,70/0,82	0,13/0,60	0,65/1,25	0,025	0,008/0,030	0,30 max	0,004	0,030	0,010	20	2,5			

Table 3 Maxumum residual elements

	Mo	Ni	Cu	Sn	Sb	Ti	Nb	Cu, 10Sn	others
R200, R220, R260, R260Mn	0,02	0,10	0,15	0,030	0,020	0,025	0,01	0,35	0,35 (Cr+Mo+Ni+Cu+V)
R320Cr	0,02	0,10	0,15	0,030	0,020	0,025	0,01	0,35	0,16 (Ni+Cu)
R350HT	0,02	0,10	0,15	0,030	0,020	0,025	0,04	0,35	0,25 (Cr+Mo+Ni+Cu+V)
R350LHT	0,02	0,10	0,15	0,030	0,020	0,025	0,04	0,35	0,20 (Mo+Ni+Cu+V)

Conclusions

Based on insight into the current national international documents that regulate the quality of tracks and access to the existing situation in the Serbian Railways can conclude the following:

- In order to increase functionality, and safety of railway traffic, the rails as part of the railway infrastructure, are paid special attention to the aspect of continuous improvement of their quality.
- Standard of UIC 860 V: 1996 - prescribed four types pearlite steel rails in the range of tensile strength from 700 to 1300 MPa.
- Standard EN 13674 - 2003, provides seven types pearlite steel hardness in the range 200 to 390 HBV, types steel in accordance with EN 13674, based on the values of hardness (R 200, R 220, R 260, R 260 Mn, 320 Cr, 350 HT, 350 LHT).
- According to the requirements of new European standards for rails, rail manufacturer is obliged to harmonize its procedures with the procedural requirements of the standard EN ISO 9001: 2000.
- According to standard EN 13674 is introduce qualifying tests due to check of manufacturers
- Acceptance test appear new requirements for the quality of tracks such as:
    - fracture toughness
    - measurement of crack propagation
    - Fracture Mechanics
    - continuous ultrasound control rails (70% heads and 60% web)
    - Holders of higher tensile strength and hardness of the rails are chemical elements: carbon, manganese and chromium, and also prescribed the maximum value of residual elements in steel, which greatly reduce ductile properties.

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