The influence of chemical composition on the mechanical properties of steels used for manufacturing monoblock railway wheels

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Abstract: - Monoblock railroad wheels are subjected to extremely complex mechanical and thermal stress due to external factors such as friction, shock, braking. They must meet stringent quality criteria in terms of material quality on the one hand and on the other hand in terms of surface quality and dimensional accuracy. Chemical composition limits varies very tight, this variation is limited by compulsion to achieve certain mechanical properties. This paper aims to establish correlations between chemical composition and mechanical properties of monoblock railway wheels.

Key-Words: - steel, forging, chemical composition, mechanical properties, monoblok wheels, quality

1 Introduction
For manufacturing monoblock railway wheels, we can highlight the following processes [1]:
- Obtaining the starting workpiece (development and treatment of steel, casting ingots and bars division);
-Forging monoblock wheels (heating the semi-finished products, the forging and the cooling of the forged wheels);
- Heat treatment of monoblock wheels;
- The mechanical processing of the monoblock railway wheels.
The railway network of the European Union uses as material for manufacturing railway wheels carbon steel quality according to international standards for manufacturing the wheels UIC 812-3/84 [2]. In addition they also use a number of national standards which take into account the experience and tradition of different countries in producing and running the rolling stock.

Worldwide, the choice of materials used in manufacturing monoblock railway wheels is done so that they meet during operation a number of conditions related to traffic safety and durability. To achieve these goals the chemical composition of the steel for producing monoblock railway wheels must provide the desired properties.

Both the international and national standards set a number of conditions for both product manufacturers as well as monoblock railway wheels. Thus, the standards imposed are: the chemical composition of the steel with references to content elements (C, Mn, Si, S, P, Cr, Ni, Cu, Mo, V, H2), the way of processing the semifinished products, how to determine the chemical composition, mechanical characteristics, degree of purity in nonmetallic inclusions, surface characteristics, dimensional tolerances, etc..

The steel quality is influenced in large proportion by its chemical composition. In the production of railway wheels [3-4] chemical composition and gas content affects the mechanical characteristics of the products.

Increasing the carbon content leads to increased hardness and tensile strength properties while reducing plasticity obtaining a decrease in steel machining.

Manganese as accompanying element in all steels dissolves in iron and constitutes solid solutions increasing their resistance. On the other hand manganese in steel acts as a deoxidizer and desulphuriser what is found in improved strength characteristics. Increasing manganese content leads to an increase in wear resistance. Also with increasing the manganese content occurs an increase of the susceptibility in the work austenite which leads to worsening austenite plasticity and toughness properties.

In what concerns the silicon it is dissolved in ferrite, increasing its strength and hardness. At the same time silicon is strongly appreciable deoxidation deoxidizer with complete capacity of calming the steel and thus reduces the strongly the content of oxygen in steel, this being an element with a negative influence on quality. With increasing the silicon content there has been an increase in hardness and tensile strength respectively.
a decrease in elongation and resilience.

In these steels the phosphorus is in very small concentrations so that its negative effects do not occur but instead dissolved in iron it leads to formation of mixed crystals which in turn increases the resistance and the hardness of steel. The phosphorus content of the steel analyzed there is no risk in forming a ternary eutectic Fe3P - Fe - C with a melting temperature of 953°C that would lead to ingot cracking by plastic deformation processing.

In what concerns the sulfur content there is a decrease in values for the characteristics of resistance at concentrations above 0.018%. Between 0.011 to 0.018% we can say that its negative influence is insignificant. We believe that the values in the range 0.018 to 0.022% can have no homogeneity in the distribution of sulfur in the structure of the ingot which could influence these characteristics.

The chemical composition of steels meant for manufacturing monoblock railway wheels varies close, this variation is even more restricted by the requirement to obtain certain mechanical characteristics that vary in very narrow limits. The main physical and mechanical characteristics determined are: tensile strength, yield strength, elongation, yield stress, hardness and toughness [5].

2 The Pilot-Stage Experiments

Data on chemical composition and mechanical properties of analyzed heats were processed in Excel program resulting in a series of graphical and analytical correlations.

Fig.1-Fig. 10 shows the variations of the mechanical characteristics according to the chemical composition as well as the limits of variation of these characteristics.

![Fig.1. Tensile strength variation depending on carbon content](image1)

![Fig.2. Yield strength at break variation depending on carbon content](image2)

![Fig.3. Tensile strength variation depending on manganese content](image3)

![Fig.4. Yield strength at break variation depending on manganese content](image4)
Fig. 5. Tensile strength variation depending on silicon content

Fig. 6. Yield strength at break variation depending on manganese content

Fig. 7. Tensile strength variation depending on sulphur content

Fig. 8. Yield strength at break variation depending on sulphur content

Fig. 9. Tensile strength variation depending on phosphorus content

Fig. 10. Yield strength at break variation depending on phosphorus content
The mechanical characteristics required to monoblock railway wheels gives the product a combination of toughness properties with the ones of resistance to wear and fatigue leading to safe rail traffic [6-7].

3. Results. Discussions
After processing the data in Excel program correlations were obtained between chemical composition and qualitative characteristics of steel expressed both graphically and analytically.

Also, for each feature, their limits of variation of both the lower and upper limit are presented. In what concerns the equations analytically expressed, all the correlations the coefficient is representative, 21 of them having 0.9 and the others vary within 0.8-0.9.

The fact that the equations are representative is reflected in the narrow variation especially for yield. Knowing the correlation equations allow us a good deoxidizing control and according to carbon content we can adjust the contents of manganese and silicon to accommodate the characteristics of resistance within the limits specified in standards.

4. Conclusion
Among the physico-mechanical characteristics and chemical composition for the heats analyzed there are representative correlations exist with areas of variation in narrow limits. The significant influence on the characteristics of resistance have specific elements for non-alloy steel namely carbon alloy steels, manganese and silicon. In what concerns the sulfur content it does not affect the quality of the steel in terms of resistance within standard limits.

Quality conditions for steel monoblock railway wheels have evolved with changing international standards, is becoming more stringent, given the intense demands of operation and traffic safety.

The monoblock wheel manufacturing chemical composition and content of gases are largely determined to achieve the mechanical characteristics.

References: