CONSIDERATION REGARDING THE QUALITY OF THE STEEL USED FOR MAKING ROLLING STOCK COMPONENTS

Constantin Andronache, Ana Virginia Socalici, Teodor Heputț
University "Politehnica" Timisoara,
Faculty Engineering Hunedoara,

ABSTRACT

The work presents the manner of settlement of the specific problems of steel ingot cast in a smooth cylinder format and its use as semi-finished product, compatible with the manufacturing of monoblock wheels, under the quality conditions thereof imposed by the manufacturing regulations. By means of the proposed research and experiments we intend to get to know the specific characteristics of the ingot and the optimization thereof in order to satisfy the quality requirements imposed on the products (monoblock wheels). During the manufacturing of wheels the chemical composition and the gas content (hydrogen, nitrogen, oxygen) are to a large extent the decisive elements regarding the obtaining of the main characteristics of the wheals corroborated with the hot deformation of the cast semi-finished product and the adequate thermal treatment. The main physical and mechanical characteristics established for the wheels are: resistance to rupture; yield point; elastic limit; elongation; rupture resistance or energy upon shock bending; strength; K1C tenacity.

KEYWORDS:
steel, quality, monoblock wheel, rolling stock

1. INTRODUCTION

Various flow sheets are used, around the world, for the manufacturing of monoblock railroad wheels, which use as raw material semi-finished goods cut from ingots or blooms.

The casting process for the steel wheels is constantly improved, which ensures an increase of the quality and efficiency of their production.

In Romania the manufacturing of monoblock railroad wheels is 35 years old in the former Factory of Axles and Bogies of Balş, which is currently called SC Subansambluri de Material Rulant – SA.

For the manufacturing of monoblock railroad wheels we have the following main technological processes: the obtaining of the starting semi-finished product which includes – the manufacturing of the steel, the casting of the ingots, the potential rolling of the blooms, the division of the ingots or blooms; the forging of the wheels which includes: the heating of the bars resulting from the division of the ingots or blooms, the actual forging with its stages (stamping, rolling, forming – calibration, perforation of the central hole in the hub), the cooling of the forged wheels; the thermal treatment of the wheels; the mechanical processing of the wheels which is usually performed in most of the cases in two stages, namely before and after the thermal treatment of the wheels [1].

2. RESEARCH RESULTS

Starting from the obtaining of the starting semi-finished product, we can very well say that until the manufacturing of an almost ideal semi-finished product, obtained by computer assisted development in duplex or triplex system continuously cast conjugate aggregates, certain improvements can be obtained even with the current equipment: a chemical and

structural homogeneity of the ingots; advanced purity regarding the non-metallic inclusions as well as the gases; economic format of semi-finished product.
The following shortcomings must be noted regarding the manufacturing of the liquid steel and the casting of the ingots: the full development of the steel in electric-arc furnaces is uneconomical, and the quality of the steel is not fully satisfying, due to the chemical and thermal inhomogeneity, the high content of endogenous inclusions and gas.
For the performed researches, objectives were established which could harmonize the influences of certain ingot technological manufacturing – casting factors upon the behavior of the semi-finished obtained product in the process of plastic deformation and upon the physical – mechanical characteristics of the manufactured wheels.
For the manufacturing of the monoblock railroad wheels high quality carbon steels are used and only in few cases attempts have been made regarding the use of alloy construction steels.
During the manufacturing of wheels the chemical composition and the gas content (hydrogen, nitrogen, oxygen) are to a large extent the decisive elements regarding the obtaining of the main characteristics of the wheals corroborated with the hot deformation of the cast semi-finished product and the adequate thermal treatment. The main physical and mechanical characteristics established for the wheels are: resistance to rupture; yield point; elastic limit; elongation; rupture resistance or energy upon shock bending; strength; K1C tenacity.
Experimental data obtained on the influence of chemical composition on the characteristics of resistance were processed in MATLAB computer program results are presented in graphical and analytical. Regression equations are hyper surfaces:

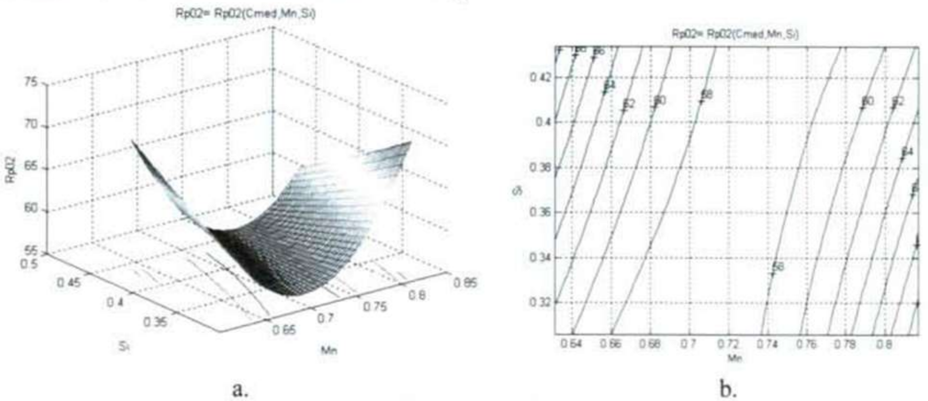
$$R_{p02} = 3166{,}0724 \cdot C^2 + 1058{,}3734 \cdot Mn^2 + 61{,}2307 \cdot Si^2 - 3325{,}4213 \cdot C \cdot Mn - 776{,}9659 \cdot Mn \cdot Si + 452{,}6587 \cdot Si \cdot C - 1385{,}3279 \cdot C + 676{,}2154 \cdot Mn + 258{,}2772 \cdot Si + 154{,}6653;$$

$$R^2 = 0{,}6786 \qquad (1)$$

$$R_m = -5855{,}5287 \cdot C^2 + 744{,}9656 \cdot Mn^2 - 2965{,}8212 \cdot Si^2 + 311{,}5921 \cdot C \cdot Mn - 2718{,}9645 \cdot Mn \cdot Si + 10521{,}6074 \cdot Si \cdot C + 2666{,}5643 \cdot C - 256{,}6329 \cdot Mn - 1889{,}0331 \cdot Si - 246{,}9728;$$

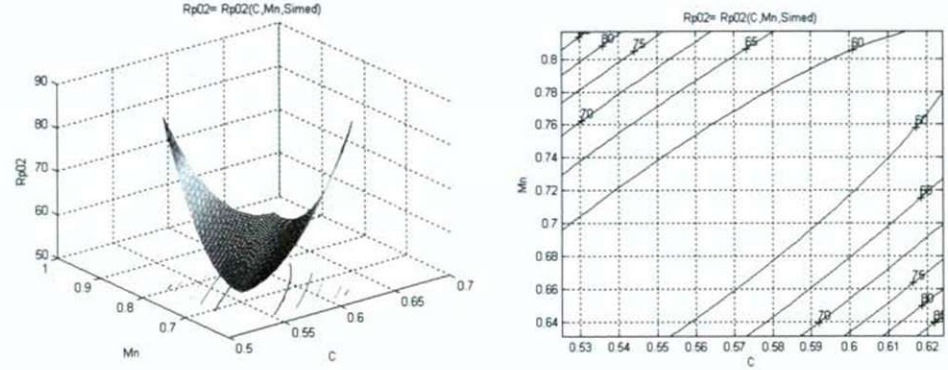
$$R^2 = 0{,}8768 \qquad (2)$$

Because these hyper surfaces can be represented in space with four dimensions, was used to replace, in succession, independent variables with each of its average value. Surface regression obtained and the contour lines are shown in Fig.1-6.



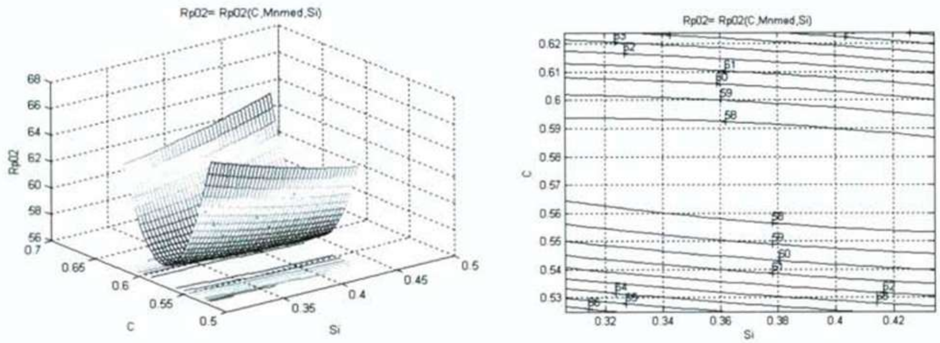
a. b.

Figure 1. $R_{p0,2} = f(C_{med}, Si, Mn)$***. a – regression surface, b – contour lines***



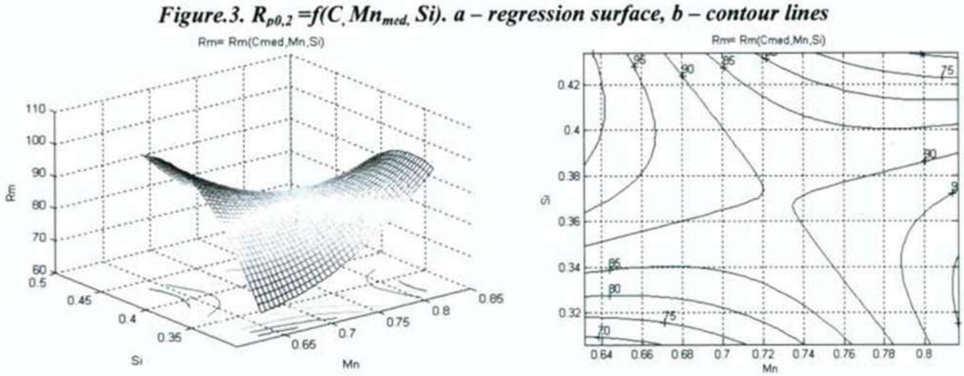
a. b.

Figure.2. $R_{p0,2}=f(C, Mn, Si_{med})$. ***a – regression surface, b – contour lines***



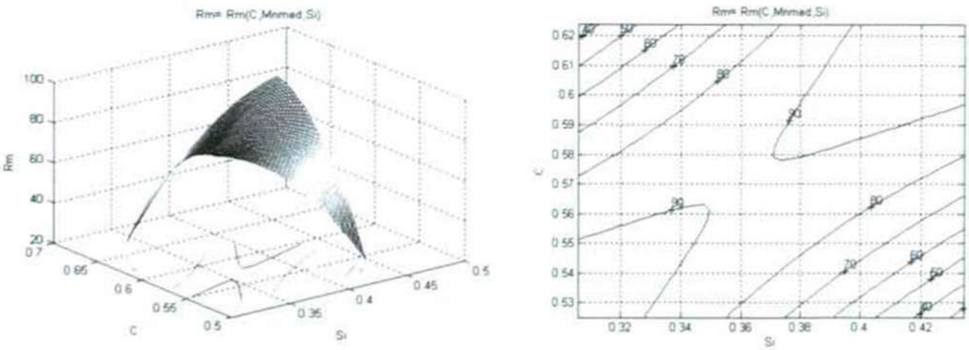
a. b.

Figure.3. $R_{p0,2}=f(C, Mn_{med}, Si)$. ***a – regression surface, b – contour lines***



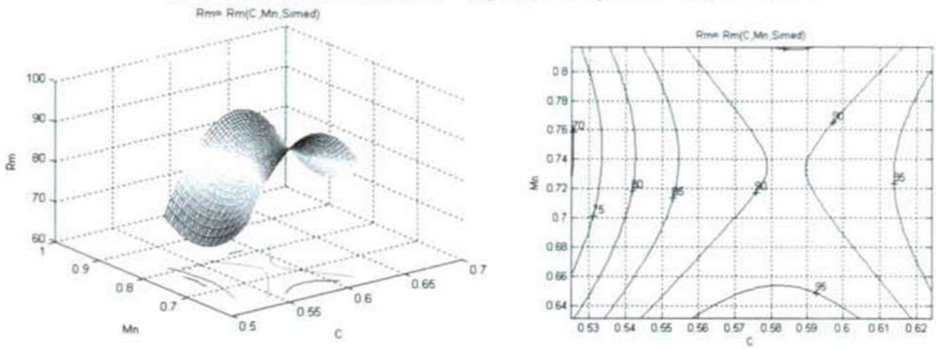
a. b.

Figure.4. $R_m=f(C_{med}, Mn, Si)$. ***a – regression surface, b – contour lines***



a. b.

Figure.5. $R_m = f(C, Mn_{med}, Si)$. a – regression surface, b – contour lines



a. b.

Figure.6. $R_m = f(C, Mn, Si_{med})$. a – regression surface, b – contour lines

Surface regression equations for the mechanical strength are:

$$R_{p02}C_{med} = 1058{,}3734 \cdot Mn^2 + 61{,}2307 \cdot Si^2 - 776{,}9659 \cdot Mn \cdot Si - 1240{,}4365 \cdot Mn + 519{,}1733 \cdot Si + 407{,}9662 \quad (3)$$

$$R_{p02}Si_{med} = 3166{,}0724 \cdot C^2 + 1058{,}3734 \cdot Mn^2 - 3325{,}4213 \cdot C \cdot Mn - 1215{,}5809 \cdot C + 384{,}8532 \cdot Mn + 260,\ 1298 \quad (4)$$

$$R_{p02}Mn_{med} = 61{,}2307 \cdot Si^2 + 3166{,}0724 \cdot C^2 + 452{,}6587 \cdot Si \cdot C - 307{,}142 \cdot Si - 3805{,}3277 \cdot C + 1207{,}2665 \quad (5)$$

$$R_mC_{med} = 744{,}9656 \cdot Mn^2 - 2965{,}8212 \cdot Si^2 - 2718{,}9645 \cdot Mn \cdot Si - 77{,}0426 \cdot Mn + 4175{,}2388 \cdot Si - 655{,}2397 \quad (6)$$

$$R_mMn_{med} = -2965{,}8212 \cdot Si^2 - 5855{,}5287 \cdot C^2 + 10521{,}6074 \cdot Si \cdot C - 3867{,}6977 \cdot Si + 2893{,}3184 \cdot C - 39{,}2075 \quad (7)$$

$$R_mSi_{med} = -5855{,}5287 \cdot C^2 + 744{,}9656 \cdot Mn^2 + 311{,}5921 \cdot C \cdot Mn + 6612{,}1671 \cdot C - 1276{,}2446 \cdot Mn - 1372{,}4289 \quad (8)$$

3. CONCLUSIONS AND PROPOSALS

From the analysis of the data processed in a graphic and analytical form a series of conclusions can be drawn:

- the increase of the resistance to traction and of the yield point with the increase of the carbon content is due on the one hand to the increase of the pearlite ratio in the structure, constituent with superior values for these characteristics, and on the other hand due to the favorable action of the carbon upon the deoxidation and desulphuration process;

manganese as element which is present in almost all steels dissolves in iron and forms solid solutions increasing their resistance. On the other hand, the manganese from the steel also has a deoxidation and desulphuration role, which can be noticed in the improved resistance characteristics;

- regarding the silicon, it dissolves in ferrite increasing its resistance and toughness. At the same time, the silicon is also a deoxidizing agent with a great deoxidation power having the capacity to calm the steel completely and as a consequence decreases progressively the oxygen content of the steel, element which has a negative influence upon quality;
- in the analyzed steels phosphorous is present in very small concentrations and therefore it causes no negative effects, on the contrary when dissolved in iron it leads to the formation of mixed crystals which in their turn determine an increase of the toughness of the steel. The existing phosphorous content of the analyzed steel does not create the risk of the formation of a ternary eutectic $Fe_3P - Fe - C$ with a melting temperature of 953°C which would cause the cracking of the ingot upon its processing due to the plastic deformation;
- regarding the sulphur content a decrease of the values for resistance to concentrations of more than 0.018% was found. Regarding the range of 0.011-0.018% we can say that its negative influence is insignificant. We believe that for values between 0.018 and 0.022% an inhomogeneity may exist regarding the distribution of the sulphur in the structure of the ingot, which may influence its characteristics;

Further research shall be performed in order to establish certain complex dependence relations, namely the data will be processed with the Matlab software by analyzing the influence of three independent factors (C, Mn, Si) upon the independent parameters (tensile resistance, yield point etc) and based on the obtained results we will be able to establish an optimal chemical composition. Moreover, we will also have in view the establishing of the dependence relations for other characteristics: toughness, resilience, elongation, as well as the gases content of the steel (a very important aspect for the steels destined for the manufacturing of rolling stock components).

REFERENCES

1. Butnaru, I., Geantă, V., Tehnologii speciale de elaborare şi rafinare a oţelurilor, Bucharest Polytechnic University Lithography, 1993.
2. Vacu, S., ş.a., Elaborarea oţelurilor aliate, vol.I and vol II, Tehnică Publishing House, Bucharest, 1980.
3. Nica, Ghe., Socalici, A., Ardelean, E., Heputţ, T., Tehnologii pentru îmbunătăţirea calităţii oţelului, Mirton Publishing House, Timisoara, 2003.