ANNALS OF THE FACULTY OF ENGINEERING HUNEDOARA
2004, Tome II, Fascicole 2

THE MAIN ALLOYED ELEMENTS INFLUENCES UPON THE NODULAR CAST IRON SEMIHARD ROLLS HARDNESS

[1] Imre KISS; [1] Vasile George CIOATA; [1] Vasile ALEXA;

[1] "POLITEHNICA" UNIVERSITY – TIMISOARA,
FACULTY of ENGINEERING – HUNEDOARA, ROMANIA

ABSTRACT

The technical conditions, which are imposed to the cast iron rolls in the exploitation period, are very different and often contradictory. The obtaining of various physical and mechanical properties in the different points of the same foundry product meets difficult technological problems in the industrial condition. This supposes us to know many technological factors, which lead to this deformation equipment.

The rolls must present high hardness at the crust of rolls and lower hardness in the core and on the necks, adequate with the mechanical resistance and in the high work temperatures. If in the crust the hardness is assured by the quantities of cementite from the structure of the irons, the core of the rolls must contain graphite to assure these properties.

One of the parameters, which determine the structure of the irons destined for rolls casting, is the chemical composition. If we not respect this composition, which guaranties the exploitation properties of the each roll in the stand of rolling mill, it will lead to rejection. Also, the inadequate treatment with magnesium for obtaining the nodular graphite's iron can produce one of the important forms of rejection in the case of cast iron rolls. This paper presents an analysis of the main factors in the practical conditions of the foundry, factors that have influences on the durability of the magnesium treatment and on the later inoculation effect on irons destined to cast rolls, and presents also some graphical addenda.

KEYWORDS: *nodular semihard cast iron rolls, alloyed elements, hardness*

1. INTRODUCTION

Ductile iron belongs to the family of cast graphitic irons, which possess high strength, ductility and resistance to thermal shock. Its strength, toughness and ductility duplicate many grades of steel and far exceed those of standard grey irons. Yet it possesses the advantages of design flexibility and low cost casting procedures similar to grey iron. The difference between ductile iron and grey iron is in the graphite formation.

The nodular graphite cast iron is considered as one of the most versatile roll materials nowadays. A small proportion of magnesium added to the melt as nickel-magnesium or alternative alloy, or as pure magnesium produces it. In the nodular graphite's iron roll, the free carbon takes the shape of spheroids or nodules, thereby eliminating the notch effect of flake graphite and improving upon the mechanical properties of the cast iron. Nodular graphite cast iron rolls are so superior in wear resistance to that of cast steel rolls that they are specially adapted for roughing and intermediate plate mills and rod or bar mill roughers. As a result of the spherical form of the graphite, these iron rolls are much stronger than rolls of the clear-chill type and the gradual fall in hardness is an added advantage. As such, these rolls are particularly suitable for strip mills, also bar billet mills, and are being increasingly used for other applications.

The improved mechanical properties increase its resistance to breakage from physical load, or mechanical and thermal shock far above that of grey iron. The corrosion resistance of ductile iron is equal or superior to grey cast iron and to cast steel in many corrosives. Its wear resistance is comparable to some of the best grades of steel and superior to grey irons in heavy load or impact load situations. Because it can be cast with the same low cost procedures used for grey iron it is considerably less expensive than cast steel and only moderately more expensive than grey iron.

The nodular cast iron rolls are characterised by the nodular shaped graphite in the microstructure. Through adjusting the alloy elements of nickel, chrome and molybdenum and heat treatment technique, the different type of rolls of popular nodular graphite cast iron. Large scale alloyed nodular graphite cast iron, pearlitic nodular graphite cast iron and acicular nodular graphite cast iron can be manufactured. All these types of rolls have high strength, excellent thermal properties and resistance to accidents and there is very little hardness drop in the surface work layer.

These type of material may be used to produce large scale rolls in double pouring process, the barrel of rolls has high hardness while the neck has high toughness, so these type of rolls exhibit the properties of high thermal stability and resistance to wear. As the characteristics of any casting are influenced by the microstruture that is formed during the solidification in the casting form, and under the influence of the cooling speed, the main criteria, which determines the mechanical properties of the rolls is the structure. All structural components can be found in cast iron rolls, each of the components having its own well-determined hardness. One of the parameters, which are determined the structure of the irons destined for rolls casting, its is the chemical composition. If we do not respect this composition, which are guarantied the exploitation properties of the each roll in the stand of rolling mill, leads to rejection of this.

All FNS type rolls are alloyed especially with chrome, nickel and molybdenum, in different percentages. The irons destined to these cast rolls belong to the class of low alloyed irons, with reduced content of these elements. The technological instructions firmly state the elements required to rise the quality of rolls. In this case, the contents of these elements stand between large limits. Also, the contents of these alloying elements can be reduced due to the strong effect of the magnesium from the nodulising agent, upon the structure and the form of the graphite.

3. RESULTS OF ANALYSES

In the case of the semihard cast iron rolls, the chrome has a less important influence than in the case of hard and extrahard rolls, as in their case the chrome proves to be the most efficient alloying element to regulate the crust depth. The semihard rolls have chrome content, which is preserved at low limits (a maximum of 0,6%), although this content still assures the necessary hardness on the rolling surface and in the core the rolls. According to the practical values, the graphic from figure 1 has been made, presenting the hardness variation with the chrome content of these irons. An increase of the hardness is to notice, together with a growth of the chrome content.

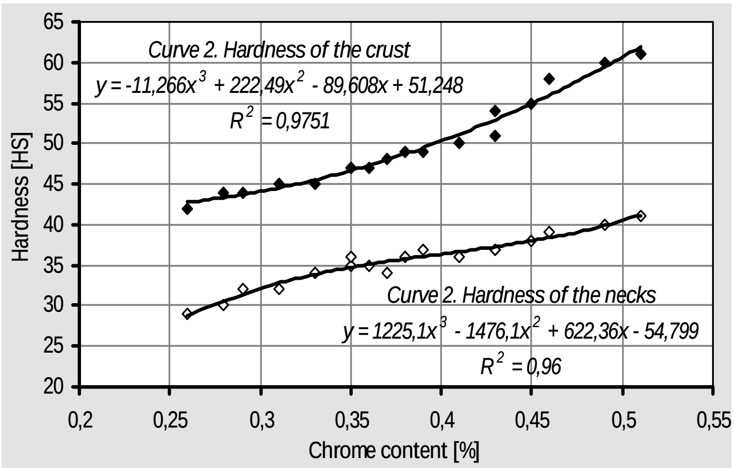

Figure 1. *The Hardness Dependence with the Chrome Content at the Semihard Iron Rolls*

The nickel addition leads to the improvement of the mechanical properties (resistance at wear, resistance at thermal shock, hardness and upon the workability of the cast rolls). If we do not allow this element to increase the graphitisation degrees and the white solidification in the peripherical area of the rolling surface, this content will be considerably reduced. Accordingly, the silicon content of the irons is modified, as this element replaces nickel.

Also, the nickel content is in close accordance with the chrome content of the irons, to favour the formation of the perlitical structure, without the massive and rough carbides. These two elements are added simultaneously, because the addition of chrome compensates the graphitising effect of the nickel. The proportion between the nickel and the chrome is situated between 2 ÷ 4. Figure 2 presents the optimal value of the hardness both on the crust and in the core of rolls, for the obtained contents of nickel. The variation is almost linear, maximum hardness being obtained at a higher limit of the recommended nickel.

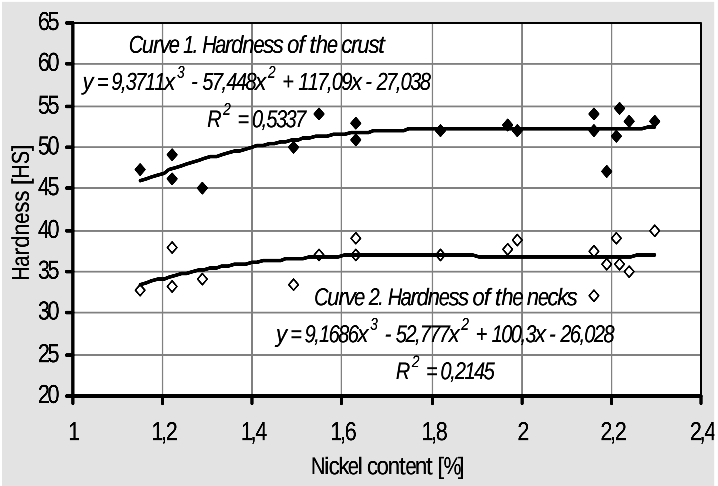

Figure 2. *The Hardness Dependence by the Nickel Content at the Semihard Iron Rolls*

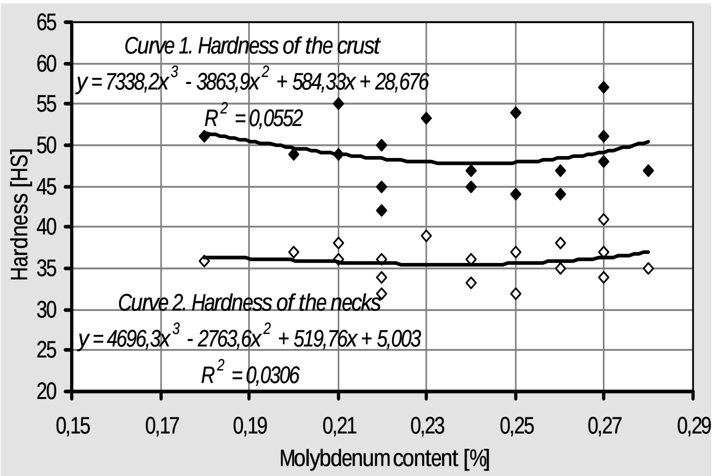

Figure 3. *The Hardness Dependence by the Molybdenum Content at the Semihard Iron Rolls*

The molybdenum is a carburigenous element, but this effect is relevant only at percentage above 0,6%. Below this value, fine structures are obtained on the entire section, also an increase of the wear resistance and to high temperature stabilities, as well as a considerable mechanical resistance.

The molybdenum addition in the irons composition, increases both the resistance at the thermal shock and the fatigue resistance.

In the molybdenum alloyed irons, contents beyond a percentage of 0,15 %, are not recommended, because a portion of the molybdenum is lost through the combination with the phosphorus, and the molybdenum loses a part of its alloying element function.

In the case of semihard rolls, the content of phosphorus does not pass this limit, and is imposed by standards to 0,1…0,3%. The analysed nodular graphite irons present a molybdenum content, which varies between 0,18…0,28 %.

To illustrate this composition interval and for the measured hardness on the rolls' area, the graphic of figure 3 has been made. Although the marks seem dispersed, it is easy to notice the growth of hardness as the content of molybdenum increases in this interval.

Magnesium plays a special part, as it is the element with which the ladle inoculation has been made, either by itself or as a master alloy. The graphite's nodularity in the irons destined to cast rolls (type FNS) assures higher mechanical properties, by eliminating a series of the inconveniences that are to be found at the rolls cast from irons with lamellar graphite. This aspect, concerning the nodularity of the graphite and the inoculation treatment with magnesium, is dealt with a special attention in this study.

4. CONCLUSIONS

- the optimal values of the alloying elements in this irons (chrome, nickel and molybdenum) are to be found on the diagrams of figures 1…3. Thus the optimal additions can be determined in these elements to assure the proper hardnesses;
- an optimal proportion between the silicon and chrome contents is to be respected, the contents originating both from the main charge and from the ferro-alloy additions (FeSi, FeCr);
- a delayed FeCr addition determines the presence of non-uniformities on the semihard crust, due to the incomplete disolvation of the chrome in the metallic mass, which usually is homogenous;
- the smooth decrease of hardness and its maintaining on the depth is performed through optimal carbon contents, and exactly determined proportions between the elements;
- the non-uniformity of the hardness of the crust is due to shape deformations, which cause hard marks on the surface of the rolls, disturbing further mechanical manufacturing;
- the non-uniformity of the crust can be technologically imposed, just as in the case of the passing area;
- the macrostructure is not imposed (except for the nodular graphite irons, where a spherical shape of the graphite is required), conditioned by the adequate quantities of cementite in the crust and graphite in the core and on the necks.

5. BIBLIOGRAPHY / REFERENCES

1. BUDAGHIANŢ, N.A., KARSSKI, V.E. - *Cast Iron Rolls,* Editura Tehnică, Bucureşti, 1984.
2. DIETER, G.E.: *Mechanical Metallurgy,* Editura Tehnică, Bucureşti, 1970
3. PIWOWARSKI, E.: *High Quality Irons,* Editura Tehnică, Bucureşti, 1967
4. SOFRONI, L., RIPOŞAN, I.: *Iron Casting*, Editura Tehnică, Bucureşti, 1985
5. SOFRONI, L., STEFANESCU, D.M.: *Special Irons*, Editura Tehnică, Bucureşti, 1974
6. SOFRONI, L., STEFANESCU, D.M.: *Inoculate Irons with High Properties*, Editura Tehnică, Bucureşti, 1971
7. SOFRONI, L., STEFANESCU, D.M.: *Irons with Nodular Graphite*, Editura Tehnică, Bucureşti, 1974

8. RIPOŞAN, I.: *Nodular Graphite Iron for the Cast Iron Rolls*, in: Buletin of University Politehnica Bucureşti, 1980/3
9. SOFRONI,L., RIPOŞAN, I.: Contribution for the Improvement of the Cast *Iron Rolls Quality,* in: Metalurgia, 1983/10
10. KISS, I.: *Considerations upon the Reject Forms of the Cast Iron Rolls,* at Scientific Conference, Bucureşti, 2000
11. KISS, I.: *The Hardness of Cast Iron Rolls with Indefinite Structure,* in: Symposium, Petroşani, 2001
12. KISS I., HEPUŢ T.: *Mechanical properties of the cast iron rolls, assured by the chemical composition*, Buletinul Ştiinţific al Universităţii Politehnica Timişoara – Mecanics series, 2002
13. KISS I., HEPUŢ T.: *The hardness of the cast iron rolls, assured by the alloy elements and the modification treatment of the graphite nodularity*, Buletinul Ştiinţific al Universităţii Politehnica Timişoara – Mecanics series, 2002
14. KISS I., RAŢIU S., VÎLCEANU L, ALEXA V.: *Particularităţi ale proprietăţilor mecanice la cilindri de laminor turnaţi din fonte cu grafit nodular*, Simpozion International Universitaria ROPET, Petroşani, 2002
15. A. JOSAN, D. PETRE, I. KISS.: *Studies and researches on the influence of chemical composition of cast rolls made of hypereutectic steel, on their hardness in exploatation*, Scientific Conference Research and Development of Mechanical Elements and Systems Jahorina – IRMES, Sarajevo, Bosnia & Hertegovina, 2002
16. KISS I.; RAŢIU S.; NICA GH.: *Some considerations regarding the mechanical properties of the cast iron rolls, assured by the chemical composition and the modification treatment of the graphite nodularity (I)*, Scientific Conference Research and Development of Mechanical Elements and Systems Jahorina – IRMES, Sarajevo, Bosnia & Hertegovina, 2002
17. KISS I.; JOSAN A; CIOATĂ V.: *Some considerations regarding the mechanical properties of the cast iron rolls, assured by the chemical composition and the modification treatment of the graphite nodularity (II)*, Scientific Conference Research and Development of Mechanical Elements and Systems Jahorina – IRMES, Sarajevo, Bosnia & Hertegovina, 2002
18. KISS I., HEPUŢ T., RAŢIU S.: *The Hardness Of The Cast Iron Rolls, Assured by the Alloyed Elements and the Modification Treatment of the Graphite Nodularity*, in: "MASINSTVO" – Journal of Mechanichal Engineering, No.1 / 2003, Zenica, Bosnia & Hertegovina
19. KISS I.: *The Mechanical Properties of the Semihard Cast Iron Rolls Assured by the Basic Elements*, in: "MASINSTVO" – Journal of Mechanichal Engineering, No.4 / 2003, Zenica, Bosnia & Hertegovina