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THE INFLUENCE OF THE ELEMENTS C, Cr AND Mo UPON THE HARDNESS OF THE BIMETALLIC CASTED IRON PIG MILLING ROLLS

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ABSTRACT

The bimetallic hard-crusted iron rolls casting, for decrease of the hardness and the wear resistance destine the hard iron, alloyed with Cr and Mo. This paper suggests a mathematical shaping of the influence of the main alloy elements upon the mechanical features of this iron type, for 50 industrial batch, resulting the average values and average square aberration of the variables HSh, Cr and Mo, the equations of the hyper surface in the four dimensional space, they appealed to the successive replacement of each independent variable with the average value, resulting the equations that belong to the tree dimensional space, which are graphically represented and easy to interpret by technologists. Knowing the level curbs allows the correlations of the values of the two independent variables so that the hardness value (HSh) can be obtain in the requested boundaries.

KEYWORDS

bimetallic milling rolls, alloy elements, hardness, wear resistance

1. INTRODUCTION

Technical conditions imposed to the milling rolls are very different and often contradictory. Thus, raised hardness from the crust correlated with mechanical resistance and raised high temperature, as well as with the raiser resilience of the alloys from the middle and journals, are enough difficult to obtain. For this reasons, the realization of the rolling mills is complexes enough, being necessary the obtaining mechanical-physical properties different in diverses points of the one and the same cast piece. Because the properties of each cast piece from de steel and pig irons are determined by the microstructure which is formed during the solidification and cooling of this, the base criterion, which determine the physical and mechanical properties of the milling rolls, is this structure.

In cast milling rolls from the pig iron are found all the carbon-iron alloys structures. One of the base factor which determine the given structure of the rolls is the chemical composition of the alloy and his speed cooling besides of the iron and the usually elements: carbon, silicon, manganese, phosphor, sulphur there are found also: chromium, cerium, nickel, calcium, molybdenum, copper, magnesium and aluminum. For the whiten degree correction of the liquid pig iron, purposed to crusting rolls with white crust, are utilized at large action of the tellurium. Besides of those previous showed, in any alloy for the milling rolls there also found gases: oxygen (almost entirely on shape of oxides), hydrogen and nitrogen. The exposed elements exert up to the alloy a carburide or graphiting action (figure 1) [1].

Chromium is one of the most established active elements of carburides. His contain in the very different types of pig iron rolls various in 0,15 … 1,5% limits, and some of the specials types rolls in 12 … 25% limits. In fated alloys to rolls cast, chromium builds established carburides, increase the hardness and the depth of the whit crust, in the conditions favorizing the development and the depth of the passing area, mitigating by these mechanical characteristics and the thermic resistance of the rolls. Therefore at the manufacture of whit crust rolls, for flatting mill, which work at heat, it isn't use chromium alloyment his content limiting to 0,2% maximum.

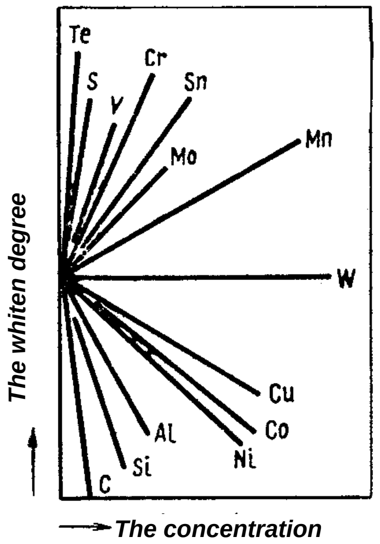

Fig.1. The carburide action of chemical elements over the alloyments fated to the rolls

The manufacture of the bimetallic milling rolls with high hardness used to flatting mill influence of chromium it is used in the major measure. For the increasing of the cruxes and journal, this rolls are washed with gray pig iron. As a consequence, the chromium content from the rolls axis area it dwindles until 0,3%.

It is useful of reminding the property of alloy white crust rolls with chromium: near bay the chromium carburides and the complexe carburides of chromium and iron, in whit crust it is appear, gnarled graphite microscopic dissociating, which provocate, after the rolls burnish, the appearance of the mat nuance of the work surface (indefinite structure) the presence of graphite nodule dwindles some way the rolls hard crust hardness.

In alloyed high bimetallic rolls, of different types, the content of chromium may various in: 0,5 … 0,8% large limits to the hardness of the hard crust of 70 … 85 HSh; 1,2 ... 1,5% to the crust with indefinite structure and harnesses of 75 ... 88 HSh.

Chromium capacity to maintain the hardness during the entire section of the piece has a big importance in the rolls manufacture case for profile, where it is request a little fall of the hardness for the gauges depth accomplished by mechanical processing.

The rolls for profile are as a rule, alloy with chromium in 0,6 … 1,5 % limits, indifferent of their type. In this cases, usually it is adding also nickel, of which content is with 0,2 … 0,3% upper from the chromium content. A such report between chromium and nickel assurance the equality of the hardness by the rolls area and dwindles, in the same time, of their fragility.

Chromium in Fgn formed established carburide, but her influence in this case it is amplified because the establishing action of the magnesium. Therefore, the chromium content in rolls of white pig iron in which with all content upper of silicium, in comparison with the rolls from alloyed lamellar graphite with chromium and nickel, it must not pass over the value of 0.4%.

For the increasing of the resistance to usance of the profile roll, although of the plate rolls, this it if manufacture from pig iron with 14…18%Cr. The hardness of this milling rolls is of the 400 HB on plate, but she is lower, in big measure, on the hard crust depth. In the structure of this rolls are founding 20 … 30% eutectide carburides of the type $(FeCr)_7O_3$, which by their discontinues structure in net shape, assure those a big resistance to wear (see figure 1) [1].

Alloyed high rolls manufacture with chromium with bimetallic structure it is achieved in abroad by centrifugal casting. Achieved rolls bay this procedure presented in harnesser upper serviceability.

The molybdenum belongs the carburides elements group but her influence it is evince only to the contents over 0,6 % Mo. To the lower contents 0,6% Mo in reports kept conditions from structural elements, it is obtain thick structure with fine granulation on the entire section of the rolls, event in the hard rust, and also in her center, also in journals trifles. In this way it is obtain the resistance increase at usuance and at height temperatures of the hard crust, of the mechanical resistance and the dur5abulity in harnesser of the rolls resistance. Even to the low content of molybdenum, this dissolving in perrlite-ferrite, provokes the increasing of the base metallic mass resistance and, as consequence, of the total resistance of the rolls. The content over 0,4% Mo, dispersion metallic mass of base increase in a visible way.

In alloyed height bimetallic rolls with the contents over 3,8%Ni and 0,8%Cr, in hard crust appear frugal contents of silicon and height in chromium, can not stop the graphite process from alloyed pig iron with nickel in a long time maintaining conditions of pieces in temperature plane 900 … 950^{o}C. Linked with the reduction the carbon content in the austenite arias, being in the neighborhood of the graphite, the iron uncompose it is deploy faster. The presence of an enough quantity of molybdenum induce the stopping of this uncomposing. Because of this, the rolls with alloyed lamellar graphite with chromium, nickel and molybdenum are distinguished by higher hardness and, as a result, they have a higher resistance to usance.

At the contents of 1%Mo, when it is develop her carburide action, the depth of the crossing area on the entire section of the roll. Therefore, at the rolls for table rolling, the content of molybdenum is limit at 0,3 … 0,6%. The rolls casting with molybdenum under 0,25%, it is not reasonable, because it not conduct to the visible improvement of their structure.

The pig iron alloyment for rolls casting wit molybdenum, which it is solidifing with frugal speeds, it is needful the assurance of some frugal contents of phosphor (under 0,15%), because the formation of the complexes eutectoids of molybdenum and phosphor it is followed by the molybdenum diffusion from the base metallic mass, fact which increases the roll alloyment with molybdenum. In the fast solidification case of the whit area (so as this take place at the casting in chill, mold) eutectoid of Mo-P it not succeed to form and, therefore the properties influence of molybdenum in crust it is maintain even to the raiser contents of phosphor.

The adding molybdenum in pig iron for rolls presents one of the safe method of increasing of the resistance to usance and high temperature, also the all-out resistance of those [1] .

2. THE RESULTS OF THE EXPERIMENTS

In this paper we suggest a mathematical shaping of the influence of the main alloy elements over the mechanical characteristics of this type iron pigs, resulting the average values and average square aberration of the variables HSh, Cr and Mo, the equations of the hyper surface in the four dimensional space.

For the statistical and mathematical analysis, there were used 50 industrial batches.

The average values and the average square aberration of the variables are:

C	3.2152	0.049
Cr	1.4484	0.23358
Mo	0.2946	0.039152
HSh	69.58	3.8808

Next, there are shown the results of the multidimensional processing of experimental data. For that purpose, we searched for a method of molding the dependent variables depending on the independent variables x, y, z:

$$u = c_1 \cdot x^2 + c_2 \cdot y^2 + c_3 \cdot z^2 + c_4 \cdot x \cdot y + c_5 \cdot y \cdot z + c_6 \cdot z \cdot x + c_7 \cdot x + c_8 \cdot y + c_9 \cdot z + c_{10} \quad (1)$$

The optimal form of molding, studied on a sample of 50 batches is given by the equations:

$$HSh = - 13.72 \cdot C^2 - 8.297 \cdot Cr^2 + 428.9 \cdot Mo^2 - 101.2 \cdot C \cdot Cr - 12.59 \cdot Cr \cdot Mo - 41.07 \cdot Mo \cdot C + + 252.9 \cdot C + 359.7 \cdot Cr - 110.7 \cdot Mo - 594.7, \quad (2)$$

where the correlation coefficients are:

$$r = 0.38141835933719, \quad (3)$$

and the aberrations from the regression surface are:

$$s = 3.58739648457368. \quad (4)$$

These surfaces from the four dimensional space allow a saddle point, having the following co-ordinates:

$$C_ş = 3.271$$
$$Cr_ş = 1.487$$
$$Mo_ş = 0.3075$$
$$HSh_ş = 69.23 \quad (5)$$

3. CONCLUSIONS

The chemical, physical and mechanical properties of alloyed reach pig iron are induced, in first place, by their chemical composition (nature and content of alloy elements) and the way of thermal manufacture, but the big importance is the casting and elaboration method, so as to obtain a pure pig iron regarding of the gases content (oxygen, hydrogen, nitrogen) and nonmetallic inclusions, wit chemical homogeneous and advanced structural.

The hard pig iron, alloyed with Cr, Ni and Mo, it is fated to casting the bimetallic rolls crust, in purpose of their hardness in creasing and of the usuance resistance.

In the technological field, the behavior of these hyper surfaces in the vicinity of the saddle point, or of the point where three independent variables take their average value, can be studied only tabular, which means that the independent variables are attributed values on spheres concentric to the studied point.

Because these surfaces cannot be represented in the three-dimensional space, the independent variables were successively replaced with their average values. This is how the following equations were obtained.

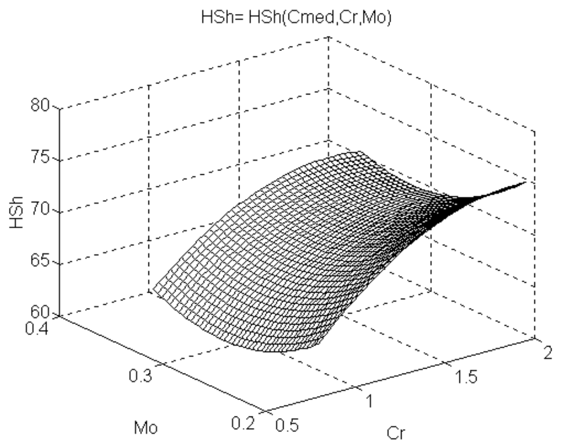

Fig.2. The surface
HSh = HSh(C_{med}, Cr, Mo)

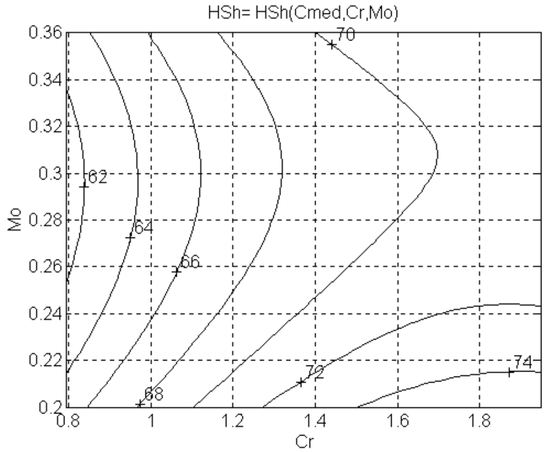

Fig.3. The level curves of distribution
HSh = HSh(C_{med}, Cr, Mo)

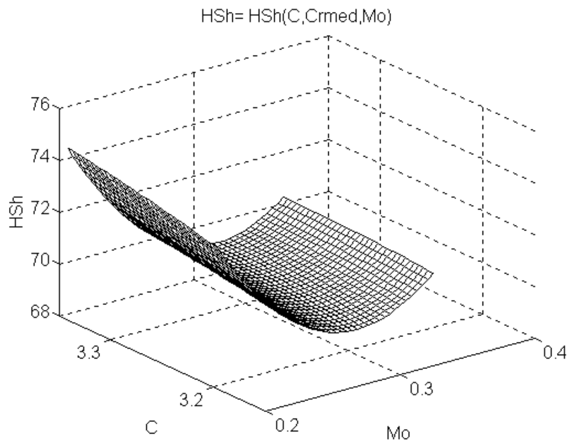

Fig.4. The surface
HSh = HSh(C, Cr_{med}, Mo)

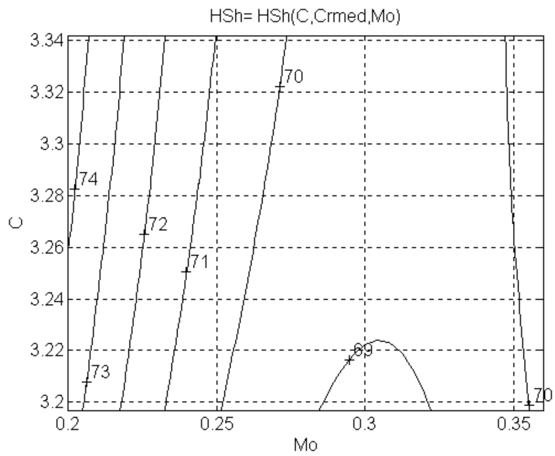

Fig.5. The level curves of distribution
HSh = HSh(C, Cr_{med}, Mo)

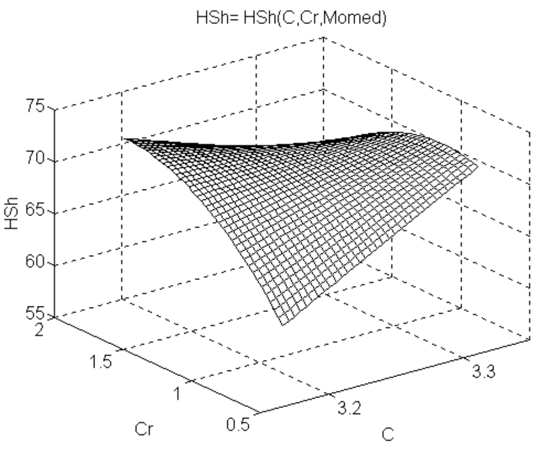

Fig.6. The surface
HSh = HSh(C, Cr, Mo_{med})

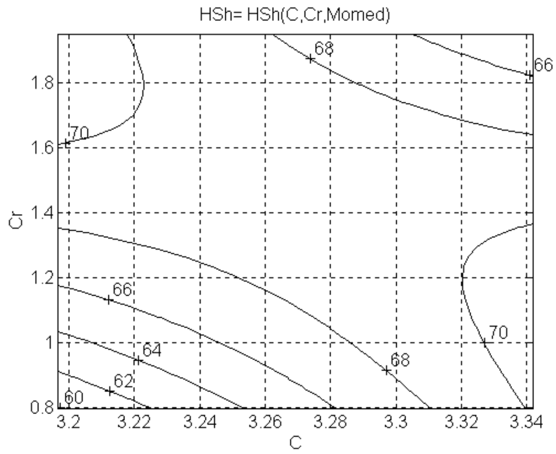

Fig.7. The level curves of distribution
HSh = HSh(C, Cr, Mo_{med})

$$HSh(C_{med}) = - 8.297 \cdot Cr^2 + 428.9 \cdot Mo^2 - 12.59 \cdot Cr \cdot Mo + 34.17 \cdot Cr - 242.7 \cdot Mo + 76.57 \quad (6)$$
$$HSh(Cr_{med}) = 428.9 \cdot Mo^2 - 13.72 \cdot C^2 - 41.07 \cdot Mo \cdot C - 128.9 \cdot Mo + 106.2 \cdot C - 91.12 \quad (7)$$

$$HSh(Mo_{med}) = - 13.72 \cdot C^2 - 8.297 \cdot Cr^2 - 101.2 \cdot C \cdot Cr + 240.8 \cdot C + 356 \cdot Cr - 590.1 \quad (8)$$

These surfaces, belonging to the three-dimensional space, can be represented and, therefore, interpreted by technologists. The surfaces are represented in figures 2, 4 and 6. For a more correct quantitative analysis, in figures 3, 5 and 7 there were represented the corresponding level lines, resulting the following conclusions: in the case of C = C_{med}, the hardness HSh allows a maximum for Mo of minimum value and Cr = 2%, and a minimum for Mo = 0,3% and Cr of minimum value; in the case of Cr = Cr_{med} it can be observed a maximum values in the maintained area of Mo = 0,22% and C = 3,35%, the minimum value being touched for Mo = 0,31% and for the minimum values of the carbon; in the case of Mo = Mo_{med} the surface allows a minimum point for Cr of maximum value and C =3,22%, therefore has a great importance because they offer stability to the process in the vicinity of this point, stability that should be either preferred or avoided. In our case, it is preferred.

Knowing these level curves allows the correlation of the values of the twos independent variables so that HSh can be obtained in between the requested limits.

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