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# THE RESEARCHES OF INFLUENCE OF THERMAL TREATMENT TO STRUCTURE AND PROPERTIES OF CORE OF ROLLS WITH LAYER OF HIGH ALLOYED CAST IRON

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S u m m a r y. The paper is dedicated to researches of influence of thermal treatment to quality of rolls' core. It has been established that high temperature of heating promote to changes in metal base of such material. It has been showed that such structural changes do not reduce properties' level of core of rolls.

K e y w o r d s: properties, roll, stresses' level, structure, thermal treatment

## INTRODUCTION

During rolling the surface of rolls barrel is heated from rolled metal and it cooled by water or by air. Its induce appearance of temperature stresses of surfaces compression. Such thermal and inside stresses of rolls are added. Cracks appear on rolls surface as a result of stresses' values exceeding above limit of their material elasticity. The cooling of surface cause strengths stresses appearance and gradual formation of cracks grid with following crumbling of corpuscle of surface-layer. During rolling separate cracks of fatigue origin gradually rise and can lead to destruction of rolls [Tretyakov, Garber, Davletbaev 1976; Budagyants, Karssky 1983; Skoblo, Voronov, Rudyuk 1994; Budagyants, Zhizhkina, Sirota, Kondratenko, Saushkin 2000].

That is why their stability to wear and destruction is main indexes of rolls' quality. During rolling process quality of core determine stability of roll against shock and strength loading, torsional and bending moments. Chemical compositions of used alloys, crystallization speed and following types of treatment equivalently influence at formation of level their properties [Treyger, Prykhodko 1988; Zhizhkina, Budagyants, Gutko 2010; Zhizhkina 2011].

The analyses of problem of wear-resistant rise and increase of rolls' service life [Beashlik 1955; Levi, Kantenik 1967; Budagyants, Zhizhkina 2003; Budagyants, Zhizhkina, Kondratenko 2004; Zhizhkina, Budagyants, Gutko 2008; Ryabicheva, Tsirkin, Usatyuk 2010] show that next main directions of researches and developments:

- the optimization of chemical compositions of used materials and development new ones;
- the improvement of existing technology and making new processes;
- the development effective methods of thermal treatment;
- the making of new construction of rolls;
- the reconstruction of working surface;
- the improvement of exploitations conditions;
- the development reliable methods of quality control and main valuing criterions.

## OBJEKT OF RESEARCH

The experience of production of bimetallic rolling rolls [Budagyants, Zhizhkina, Gutko 2009; Budagyants, Zhizhkina, Gutko,2010; Zhizhkina 2012] showed that different areas such castings

have distinctive speeds of crystallization. This lead to rise of level of inside stresses into products and to reduction of rolls' work capacity. The method of production and rolls' materials determine their appearance. As a result of gradual advancement of crystallization front rolls casting is preliminary tense product. Besides availability of nonmetallic inclusions in metal lead to local rise of stresses' level [Zhizhkina, Budagyants, Gutko 2010]. But stresses field is changed. Processes of smoothing of local distortion of bodies structure, redistribution and justification of stresses are springing up into roll. This lead to partial relaxation of stresses.

Individual facts of this are good known. For example, during long rolls presence in warehouse general level of stresses is reduced as a result of redistribution of them along the whole volume of casting. The duration such "natural olding" amount to 3-12 mouth [Budagyants, Karssky 1983]. But researches [Zhizhkina 2011] showed that during such process stresses in rolls are reduced to 25-30 % (or 50-70 MPa).

It has been established that thermal treatment is more effective method of reduce of increased level of stresses [Zhizhkina, Budagyants, Gutko 2008; Zhizhkina 2011]. Their difference from other methods consist in change of goods properties as a result certain combination of heating and cooling. Researches of peculiarities of structure formation of rolls of different types and sizes made it possible to develop special conditions. Such conditions reduce residual (casting) stresses of good and give it special properties: resistance to wear, fatigue itc. [Zhizhkina 2011]. However thermal treatment of rolling rolls is sufficiently complex process. More phases turning in metal matrix provide treatment. Such turning influence properties level.

## ANALYSIS OF PUBLICATIONS IN RELATION TO RESEARCH OBJECT

In world practical experience rolling rolls are subjected to high temperatures thermal treatment. It ensures good alloys' treating, high strength and wear-resistance [Treyger, Prykhodko 1988]. Researches [Zhizhkina 2011] showed that thermal treatment of rolls for rise hardness would be reduce to crumbling and at some cases – to destruction rolls. The carrying out complementary tempering promote to redistribution of residual stresses into bimetallic rolls. However such treatment is complex process. That is why it necessary to value at quantity of residual starting austenite in matrix, its stability and to forecast formation possible products of decay during thermal treatment. Researches' results [Bolkhovitinov 1946; Bogachev 1952; Bunin, Malinochka, Taran 1969; Zhizhkina 2011] showed that such thermal treatment disturb mechanical characteristics complex of central part of roll.

However such technology's application for bimetallic rolls is problematical process, because they are produced of heterogeneous cast irons [Zhizhkina, Budagyants, Gutko 2008]. That is why during massive rolls' production multistage thermal treatment are more effective processes. Such regimes are combination of annealing and considerably strength of material [Zhizhkina 2011].

The relaxation annealing receives extensive application for massive rolls with high alloyed working layer and core of gray low alloyed cast iron. It lead to essential reduction of level residual stresses, to rise of thermal endurance, strength, wear-resistance of working layer and stickiness of core [Zhizhkina 2011]. Its recommendations temperature fluctuates at interval 200-750 $^0$C.

It has been established that the temperature is more essential factor than time of observance. The heating to 500 $^0$C without observation reduce residual stresses fifty one per cent. The rise of time to six hours with such heating reduces it sixty per cent. Considerable reduction of stresses (eighty per cent) is improved when temperature of annealing is higher. At that moment the choice of regime and parameters of thermal treatment are depended on changes which take place in core of rolls ingot.

That is why the aim of this paper – researches of influence of high temperature thermal treatment on structure and physical and mechanical properties of rolls' core.

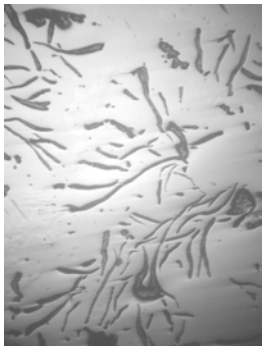
To reach this aim the following problems should be solved:

- to value influence of high temperature and speed of cooling on structure of core's material;
- to analyze change of properties of cast iron during thermal treatment.

## RESULTS OF RESEARCHES

Researches of influence of high temperature and time of heating on structure and properties of cores material of analyzed rolls were carried out in laboratory. Samples were taken from neck of rolls for these researches according to [Bogomolova, 1978].

It is known that the rise of temperature of thermal treatment increase carbon dissolving in austenite [Bolkhovitinov 1946; Bunin, Malinochka, Taran 1969]. It is corroborated results of one's researches of heating of cores material to temperature 920 $^0$C (fig. 1).



*a, non-etching, magnification: 100 x*

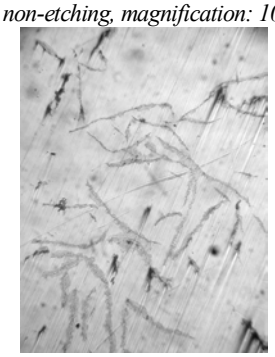


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**Fig. 1** The influence of heating temperature (T=920 $^0$C) on graphite inclusions' dissolving into structure of cast iron for rolls' core: a – cast sample, b – sample after thermal treatment

Under certain conditions of super cooling austenite with big quantity of carbon disintegrate without formation of excessive ferrite. As a result pearlites' structures are formed.

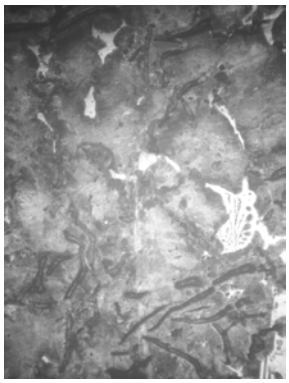
Researches of influence of high temperature of heating on phase composition of metallic matrix of core were realizated. It has been established that cast samples with more 2 % silicon are characterized by uneven and rough structure. Individual areas with big quantity of carbides or flake graphite are observed in such structure (fig. 2).

Under production conditions rolls are cooled slowly for prevention of thermal stresses and cracks' formation. That is why under laboratory conditions speed of samples' cooling was small.

Such cooling and big content of silicon in areas with excess quantity of graphite contribute to turning of austenite to ferrite (look fig. 2).

Changes are taken place in areas with excess quantity of carbides of pearlite matrix. As a result the flake pearlite turned into granular ones.

The influence of structure turning on level of properties is interested. As a result of thermal treatment formation of spherical carbides and small rise of pearlite matrix microhardness are taken place. Microhardness of carbides is not changed.



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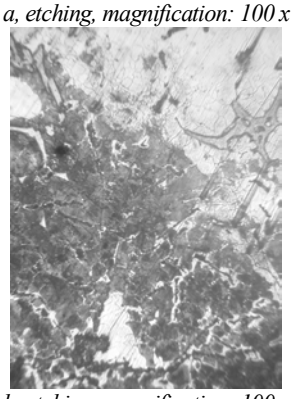

*b, etching, magnification: 100 x*

**Fig. 2**. The influence of heating temperature (T=920 $^0$C) on phase composition of metallic matrix of rolls' core: a – cast sample, b – sample after thermal treatment

After thermal treatment the discharge of ferrite with lesser value of microhardness was taken place in most of samples. That is why general level of hardness did not change (table 1).

Thus structural dispersion and nonuniformity are increased as a result of high temperature (920 $^0$C) treatment. The austenite disintegrated to ferrite and graphite in areas with big quantity of graphite. The flake pearlite turned into granular ones in metallic matrix near carbides' inclusions. Such nonuniformaty in structure essentially did not

influenced on general level of hardness and strength.

**Table 1.** The level of properties of material of core and necks of rolls with working layer of high alloyed cast iron **at cast** condition and after high temperature treatment

| Properties | Condition | Sample | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| Microhardness of structure parts, HV: pearlite | cast | 340,5 | 331,4 | 329,9 | 303,6 |
| | after thermal treatment | 363,9 | 321,5 | 375,1 | 358,2 |
| carbides | cast | 904,3 | 924,7 | 924,7 | 927 |
| | after thermal treatment | 880,6 | 880,6 | 957,4 | 957,4 |
| General hardness, HB (Brinell tests) | cast | 248 | 277 | 241 | 255 |
| | after thermal treatment | 241 | 285 | 255 | 262 |
| Bending strength, MPa | cast | 364 | 456 | 451,5 | 455 |
| | after thermal treatment | 417,3 | 461,5 | 431,4 | 438,4 |

## CONCLUSIONS

Rolls casting is good with high level of inside stresses. It has been established that thermal treatment is more effective method of reduce of increased level of stresses.

Researches' result of influence of high temperature treatment on quality of rolls core showed that during heating to 920 $^0$C changes are taken place in metallic base. The austenite disintegrates to ferrite and graphite in areas with big quantity of graphite. The flake pearlite turns into granular ones in areas with big quantity of carbides.

It has been established that such structural changes do not reduce level of properties. However such structural nonuniformity made reduce exploitations' index of rolls. That is why work continues at this direction.

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# ИССЛЕДОВАНИЕ ВЛИЯНИЯ ТЕРМИЧЕСКОЙ ОБРАБОТКИ НА СТРУКТУРУ И СВОЙСТВА СЕРДЦЕВИНЫ ВАЛКОВ С РАБОЧИМ СЛОЕМ ИЗ ВЫСОКОЛЕГИРОВАННОГО ЧУГУНА

*Наталья Жижкина*

Аннотация. Статья посвящена исследованиям влияния термической обработки на качество сердцевины валков. Установлено, что высокая температура нагрева способствует изменениям в металлической основе такого материала. Показано, что такие структурные изменения не снижают уровень свойств.

Ключевые слова: валок, структура, свойства, термическая обработка, уровень напряжений.