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POSIBILITIES TO INCREASE THE DURABILITY OF THE HOT ROLLING MILLS CYLINDERS

Camelia B. Pinca
Gelu O. Tirian

University "POLITEHNICA" of Timişoara, Romania
331128 Hunedoara, Revoluției street no.5, Hunedoara

ABSTRACT

The researches on the durability in exploitation of hot rolling mill cylinders represent an important scientific and economical issue and this researches are little approached in the reference literature, both in Romania and in worldwide. In the context of market economy a new evolution is necessary in the field of scientific research, in order to modernize the metallurgical equipment, using the most efficient solutions to obtain performing cylinders on an international scale. Our researches are trying to give answers to most actual problems related to the increase of hardness of rolling mill cylinders. The study representes a detailed approach of the influence of various technological factors on the durability in exploitation of rolling mill cylinders made of different steel and pig iron grades and suggests solutions meant to increase the hardness of rolling mill cylinders in exploitation.
Keywords: steel, iron, durability

1. INTRODUCTION

The paper propose to present solutions to growing the durability of the hot rolling mills cylinders and to increasing of durability and safety in operation. The reserches use data collected from the industrial use at the Iron and Stell Integrated Plant of Hunedoara (Romania) , as well as laboratory experiments carried out on a unique, complex and original installation.

2. EXPERIMENTAL RESEARCH

Durabilities testing is done on a series of rings, achieved from the cylinders' axles resulted from the industrial operation and which accomplished the rolling drives. These rings are subject to different conditions of cyclic thermal requirements, that during a rotation, they turn to heat in a furnace containing electric resistors, at different imposed temperature on the one hand and on the other hand, they turn cold in different environments: air (thermal regime A), water (thermal regime B) and carbonic snow jets (thermal regime C), [1].

In the experimentally installation for the research on the durability in exploitation of the steel and iron marks, until the appearance of the thermal fatigue cracks is presented in fig.1. This installation provides the possibility of further studiers and also to establish the durability in exploitation for all types of rolls used presently in industrial mills.The experiments are made on groups of six rings with a 250 mm exterior diameter, carried out from the studied types of industrial rolls: 65VMoCr15; 55VMoCr12; 90VMoCr12; OTA3; FNS 2; FD 2. During the experiments, after a certain number of stress cycles, the surface of the sharp sides of the rings presents signs of cracks because of the thermal fatigue. They appear at different intervals during the stress, intervals according to the number of cycles are to be established. These cycles are different and depending on the type of materials studied. To perform the measurements of temperature variation in the experimental rings, one of them is implanted with a conical pin with initially equipped Pt – Pt/Rh thermocuples which is presented in fig.2. The wire diameter is 0,06 mm and the inertion response under a tenth of a second. These thermocuples measure temperature variation on the surface of the sample and in the radial section of the rolls at depth Δr = 0; 1,5 and 3,0 mm. After establishing the number of stress cycles, untill the first thermal fatigue caused cracks appear, durability histograms are done to esch type of material, used to manufacture rolling mill cylinders and to each type of stress.

Figure1. The assembly of the experimentally installation for the research on the durability

Figure 2. The assembly of the bolt with thermo-couples in mounted stage

The results are to be compared with those in the industrial exploitation of the "MITALL STEEL" COMPANY of HUNEDOARA, in the rolling mills sectors.
In the researches we chose the minimal value for the rotation number of the rings constrained durability test being as 35,7 rot/min, producing the highest thermal fatigue because the thermal tension appearing as effect of temperature variations are maximal and after a relative small number of rotations, appear the first thermal fatigue cracks. Regarding the temperature of the electric furnance medium intended for experimental rings warming, this has to be as high as possible. In order to increase the number of the loading cycles, until the first thermal fatigue cracks appear, we have tried to maintain as high as possible temperature for tryouts and the cooling fast and accentuated.

3. POSIBILITIES TO INCREASE THE DURABILITY

The current world-wide tendency is to replace the forged steel cylinders with cast cylinders, eliminating the forging which limits the chemical composition within a small range - most of all, the contain of carbon and other elements of alloying.
In our country, OTA3 steel is mainly used in Metallurgic industry. Because of the poorest results when using forged steel such as 55VMoCr12 and 90VMoCr15-types, specialists have reached the conclusion that this type of steel must be replaced by another, [2]. They have proposed cast steel type 150MoNiCr15 which reacts better to thermal fatigue and resists better to weariness. Rolling cylinders made by this type of hypoeutectoid steel could be manufactured with the help of an advanced technology - moulding them into metallic iron chill, totally avoiding forging. Both chemical composition and mechanical properties of this type of steel are contained in table no. 1.

Table1.The chemical composition and the mechanical properties of hypereutectoid steel 150MoNiCr 12 type

The chemical composition[%]							
C		Si		Mn		S	
1,46…1,48		0,39…0,5		0,71…0,76		0,025…0,027	
P		Cr		Ni		Mo	
0,025…0,027		1,17…1,24		0,98…1,24		0,05…0,19	
The mechanical properties							
Resistance breaking [N/mm^2]		Resistance of flow [N/mm^2]		Impact bending K [daN m/cm^2]		Hardness Shore HS (Shore)	
L	T	L	T	L	T		
1200…1300	1100…1150	min.950	min.900	min.1,1	min. 0,9	38…46	
L – values for longitudinal sample; T – values for tangential sample							

Recommended thermal treatment for 150MoNiCr12-type steel that specialists have proposed for manufacturing rolling cylinders was the process of being re-steeled at 820^0C ± 10^0C and reaching normal temperature (letting it cool off in open air) of 1050^0C. The microstructure of this type of steel after the thermal treatment for reaching the normal running temperature is a type of pearlitic sorbitol with decomposed dispersed net of coagulated cementite. The running durability of these cylinders made from the type of steel we have proposed is 2.5-3 times bigger than that of the currently manufactured cylinders, made of forged types of steel.
The cylinders made of semi-hard cast iron FNS2 have many quality flaws which influence the running durability. Therefore, it is compulsory to take some serious measurement for improving their quality. We could also consider that cylinders made of semi-hard cast iron - FNS2 and hard cast iron - FD2 (standard trade mark in the 1980's) do no longer correspond to the production needs, referring to the new techniques of the year 2000. Therefore, we propose a new quality of the material - the alloy of cast iron type 250TiW3Cr24, whose chemical composition is contained in Table no. 2.

Table 2. The chemical composition of the alloy 250TiW3Cr24

C	Si	Mn	S	P	Cr	W	Ti
2,3…2,6	max. 0,4	max. 0,4	max. 0,15	max. 0,15	20…28	1…4	0,05…0,1

As far as the alloy we have proposed for manufacturing rolling cylinders is concerned, the contain of carbon and chromium is ensuring a steady composition/structure of the austenite within the range of temperature proper for pearlitic transformation. That is to say that the alloy is being steeled in open air. This type of alloy works better in case of thermal fatigue and increases the durability of the cylinders more than types FNS2 and FD2. Therefore, the running durability increases up to more than 4-5.5 times than that of the currently used cylinders. All research intended for establishing the durability in case of thermal fatigue was made using steel type 150MoNiCr12 and alloy type 250TiW3Cr24. All tests were performed on the prototype-equipment especially meant for testing the durability of products in case of cycles of thermal tests.
For that purpose, we have produced two test-rings made of steel type150MoNiCr12 and alloy type 250TiW3Cr24.The contain of chemical composition/structure and certain mechanical properties of the test-ring made of steel type150 NoNiCr12 are contained in Table no 3, and those made of alloy type 250 NiW3Cr24 are contained in Table no 4.

Table 3. The chemical composition and the mechanical properties of the test-rings representing the hypereutectoid steel type 150MoNiCr12 determining after bulletin analyse

No.	The chemical composition [%]							
1;2	C	Si	Mn	S	P	Cr	Ni	Mo
	1,46	0,47	0,75	0,026	0,05	1,20	1,13	0,13
	The mechanical properties							
	Resistance breaking [N/mm^2]		Resistance of flow [N/mm^2]		Impact bending K [$daN\ m/cm^2$]		Hardness Shore (Shore)	
	L	T	L	T	L		45	
	1263	1120	970	930	1,12			

During the technological process of the test-rings, after they have been mould, they were subject to thermal treatment for being steeled, and after having been manufactured, they were thermally treated through the process of reaching normal running temperature.
Test-rings made of steel type 150 MONiCr12 and alloy type 250 TiW3Cr24 were checked out for their durability with the help of the equipment previously presented in Picture no 1, and subject to thermal fatigue according to type B of running (water). The number of rotations the test-rings were subject to was of n = 35,7rot/min, and the average temperature of the oven was of 900^0C ± 10^0C.

Table 4. The chemical composition and the mechanical properties of the test-rings representing the alloy type 250 TiW3Cr 24 determining after bulletin analyse

No.	The chemical composition [%]							
1;2	C	Si	Mn	S	P	Cr	W	Ti
	2,44	0,3	0,36	0,12	0,14	26,4	3,4	0,09
	Hardness Shore HS = 64							

During the durability test, in case of thermal tests, we have intended to see if there was any possibility of failure - specific cracks caused by thermal fatigue, seldom situated on the side edges, in case of test-rings with 250 mm in diameter. We are able to present the results of the tests we have come to after a certain number of test-cycles until any crack on the test-rings had occurred - in case of rings made of steel type 150 MoNiCr12 and of alloy type 250TiW3Cr24 - in the following histograms of durability – figure no. 3 and 4.

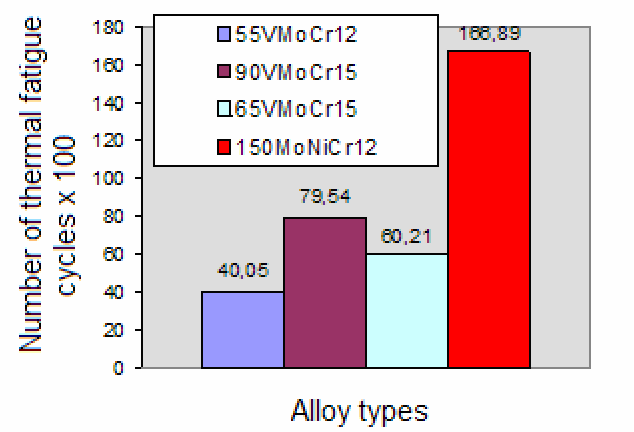

Figure 3. Durability histogram of experimental-tests (type B of running) subject to thermal fatigue of the test-rings made of alloy type 150MoNiCr, compared to cast iron used for manufacturing current rolling cylinders.

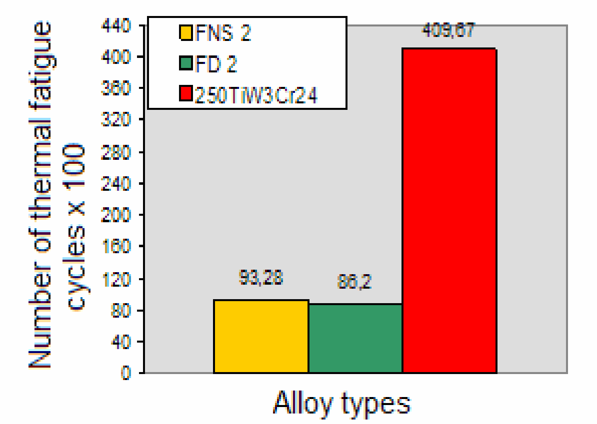

Figure 4. Durability histogram of experimental-tests (type B of running) subject to thermal fatigue of the test-rings made of alloy type 250TiW3Cr24, compared to cast iron used for manufacturing current rolling cylinders.

4. CONCLUSIONS

The estimating figures for the running durability of industrial rolling cylinders have been established after certain cycles of running, using thermal fatigue as referring point.

Amongst the three types of thermal testing for the test-rings made of steel type 150MoNiCr12 and alloy type 250TiW3Cr24, type B-running was the most difficult.

After having made the test, we have come to the following facts:

- the running durability in case of the types of steel we recommend - 150MoNiCr12 , was 2.5-3 times bigger than that of the currently used cylinders;
- the running durability in case of the types of alloy we recommend are 4 times bigger than that of the currently used cylinders.

Both cases provide better results in case of thermal fatigue than any other type currently used.

5. REFERENCES

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