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THE STUDY OF THE BEHAVIOR IN SERVICE OF ROLLING CYLINDERS

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ABSTRACT
Estimate the behavior of explotation process is impetuously necessary not only to diminish the fissures caused by thermal fatigue, to increase the exploitation life, but also to avoid thermal shocks, which are very dangerous in the explotation process and produced by large variation, temperature snapshot that lead to shearing of caliber beads in cylinders. The researches have an appearances of which basic research contain concrete elements of practical immediate utility in the metallurgical enterprises, for the improvement quality of cylinders, having in last as aim the growth durability and the safety in exploitation.
Keywords: caliber, cylinder, fissures

1. INTRODUCTION
The results of the tests made for rolling cylinders manufactured in warm environment (while warm) demand for further study for the most frequently causes for their failure. These causes are: the average running durability between two sizing, the thickness of the layers removed from the diameter of a piece after sizing it, the number of rolling processes, the quantity (expressed in tones) of rolling pieces of the same size, the shape and the thickness of the degraded layers of one size, the weight of the cylinder, the main size of the cylinder, the quality of the raw material used for manufacture.
The basic criteria for establishing the parameters of use of any rolling cylinder is the running durability.
Currently, in case of parameters used for establishing the level of working of rolling cylinders, specialists use the following economic parameters:
- the number of cylinders used - expressed in kg - related to 1 tone of rolling steel;
- the quantity - expressed in tones - of rolling product related to each mm of the cylinder's diameter.

Both methods of appreciating the behaviour in service of rolling cylinders are approximating and informative, and do not refer to the durability in service related to the effects of thermal fatigue. In this paper work, we shall make further research concerning thermal fatigue durability.

2. DURABIITY TESTING
Durability testing is done on a series of five rings, achieved from the cylinders' axles resulted from the industrial operation and which accomplished the rolling drives. In experiments 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 (A regime), water (B regime) and carbonic snow jets (C regime), [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. With a view to choosing the materials on which hardness testing is about to be done, and respectively the types of steel and cast iron frequently used at the achievement of rolling cylinders, it was necessary the studying of constructive parameters and the features on the behavior in operation of all cylinders found in the

industrial housing of a rolling-mill from an iron and steel combine, to the types of steel and cast iron used at the achievement of cylinders, as well as: 55VMoCr 12 – steel used to manufacture rolls from semi-finished mills; 90VMoCr12 - steel used to manufacture rolls from heavy section mills; OTA3 - Steel used to manufacture rolls from heavy, medium and light mills; FNS 2 – iron used in the making of rolls in heavy section mills; FD2 - iron used in the making of cylinders in heavy section mills and light section and wire mills.
For the study of the durabilities of the hot rolling cylinders, where have been registred isochronal diagrams representing the rolling cylinders temperature variations. The experimental installation for the durability of thermal fatigue is presented in fig.1.

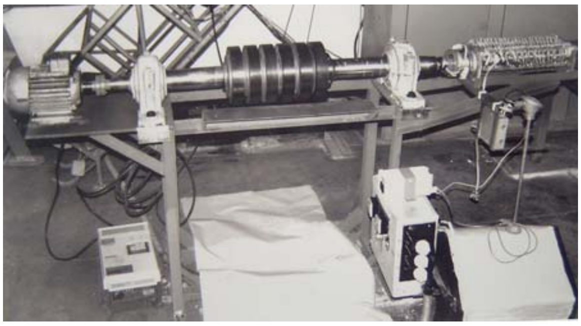

Figure1. The experimental installation for the durability of thermal fatigue

Figure 2. The electric furnance having four curled spirals

Regarding the temperature of the electric furnance which is presented in fig.2, medium intended for experimental rings warming, this has to be as high as possible in order that the tryouts reach a stabilized regime to a maximal possible temperature. In our case, the temperature of the two resistors electric furnance medium, having four curled spirals each, was calculated to 1000 C, but the experiments were effectuated at 900 ± 10 C.
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. Each of the three sets of rings consisting in five rings were constrained to a working regime, pursuing the calculated moment of the appearance of the thermal fatigue first cracks, registering the number of loading cycles. Based on the previous data presented, we chose three experimental thermals regimes, having the main elements. The order of the experiments was regime A, B and C. After experiments we observe that: in stress regime A, the materials under study resisted longest at stress cycles, untill the first thermal fatigue cracks appeared, and this regime is called loading regime. In stress regime B, the first thermal fatigue cracks appeared in a smaller number of stress cycles and this is a medium regime. In stress regime C, the thermal fatigue cracks appeared at the lowest number of stress cycles and it is called a heavy regime. After the study the durability in laboratory we compare the resultates with the durability cylinders from the industrial bar mills.

3. COMPARATIVE RESULTATES

In order to evaluate the results of the researches upon the experimental rings durability to thermal fatigue and the extension of comparative results with the durability cylinders exploitation from the industrial bar mills, is imperative to determine the temperature fields variations also in un-dimensional form. So, the temperature field's variations during both the experimental rolling, and during the durability experimentations of the rings, will be calculated in specific un-dimensional temperature variations, which is determined with relation (1).

$$\theta = \frac{t - t_{min}}{t_{max} - t_{min}} \quad (1)$$

In which: θ – specific temperature, it is a parameter, it`s values are between 0 and 1;

t – variable temperature in the cylinder; t_{min} – minimum temperature; t_{max} – maximum temperature

In this sense, the number of rings real thermal fatigue solicitation cycles would have been bigger in the case of similar solicitations then in the case of the experimental rolling. So, in order to establish the real number of solicitation cycles, it is imperative to calculate the thermal coeficient K_T, which is determined with relation (2).

$$K_T = \frac{\overline{\overline{\theta}}_{exp.rings}}{\overline{\overline{\theta}}_{exp.ind}} \qquad (2)$$

In which: $\overline{\overline{\theta}}_{experimentalrolling}$ – mean specifically temperature, middle of the three variations level of temperature (Δr = 0; 1,5; 3mm) from the experimental rolling diagram with n = 35,7 rot/min.

Through similar calculus are determined the specific temperature, mean of middle values $\overline{\overline{\theta}}$, corresponding the experimental regimes A, B and C, with n = 35,7 rot/min. The results are presented in Table 1, among the values of the thermal coefficient, K_T

In order to determine the real solicitation cycles number until the appearance the first thermal fatigue cracks, we have to multiply the experimental cycles number with the values of the thermal coefficient, K_T, obtained through calculus for each experimental regime, table2.

Table 1. The determination of the thermal influence coeficient K_T for the level of the cyclical variations of temperature under A,B and C working

The specific average temperature, average from the averages calculated to the experimental rolling $\overline{\overline{\theta}}_{la\,min\,are} = 0{,}263453$		
The values of the specific average temperature, $\overline{\overline{\theta}}$		
Working regime A	Working regime B	Working regime C
$\overline{\overline{\theta}}_A = 0{,}556759$	$\overline{\overline{\theta}}_B = 0{,}529776$	$\overline{\overline{\theta}}_C = 0{,}511069$
Thermal influence coeficient		
$K_{TA} = \frac{0{,}556759}{0{,}263453} = 2{,}11331$	$K_{TB} = \frac{0{,}529776}{0{,}263453} = 2{,}01089$	$K_{TC} = \frac{0{,}511069}{0{,}263453} = 1{,}93988$

Table 2. The real solicitation cycles number until the appearance the first thermal fatigue cracks in the works regime A,B and C calculated with the values of the thermal coeficient, K_T

No.	The steel and cast iron marks	Working regime A	Working regime B	Working regime C
		The values of the thermal influence coeficient		
		$K_{TA} = 2{,}11331$	$K_{TB} = 2{,}01089$	$K_{TC} = 1{,}93988$
1.	55VMoCr12	11118,1	8053,6	7074,7
2.	90VMoCr15	19275,5	15994,6	13792,5
3.	OTA3	38088,1	32419,5	28836,3
4.	FNS2	22451,8	18757,5	16853,6
5.	FD2	19184,6	17333,8	14488,9

To compare the rings durabilities, expressed in number of thermal cycles, with the durabilities of the industrial exploitation of cylinders, we have to compare each analyzed type of materials (steels and irons). Therefore, we transform the quantity of rolled materials expressed in product-tones on caliber into linear meter of finite products, and through there division at cylinders caliber circumference, we obtain the number of thermal solicitation cycles of the industrial rolls. The mean values of durabilities in the industrial exploitation, expressed in thermal solicitation cycles, are presented in table 3, comparative with the real values of durabilities, obtained in the research of thermal solicitations of the representative types steel and iron, used in the hot rolling cylinders making process.

Table 3. The mean values of durabilities in the industrial exploitation, comparative with the real values of durabilities

No.	The steel and cast iron marks	The medium number of thermal loading cycles for the experimental sample	The medium number of thermal loading cycles for the industrial rolling mills
1.	55VMoCr12	8748,8	6120,61
2.	90VMoCr15	16354,2	10881,02
3.	OTA 3	33114,6	22428,15
4.	FNS 2	19354,0	4721,85
5.	FD 2	17002,2	25654,51

4. CONCLUSIONS

Analyzing the results, one can notice that:

- for the steel grades under consideration, ie. 55VMoCr12, 90VMoCr15 and OTA 3, the hardness values are relatively similar.
- under industrial work conditions, hardness values are smaller than in laboratory, because of the influence of the mechanical effects, such as friction between grooves during the rolling process.
- the mean hardness of cylinders made of cast iron FNS 2 is, under industrial exploitation, 9.09 times smaller than the mean hardness obtained experimentally on the samples tried for thermal fatigue.
- The hard cast iron FD 2, used in manufacturing rolling cylinders for the intermediary and finishing train of the small section rolling train, gave very good results under industrial exploitation, its mean hardness being 1.5088 times higher than on experimental sample rings.

The differences of mean hardness are fully justified, as we have determined the experimental values of hardness under work conditions A, B and C at a rotation speed of 35,7 rot/min, and the industrial cylinders of the intermediary and finishing stands of the small section rolling mill had a rotation speed of 266…575 rot/min, which corresponds to a speed coefficient K_v = 6,33…16,106 that increases the number of thermal fatigue stress cycles up to the appearance of the first specific fissures.

In this situation, we can conclude that for relatively small rolling rates, temperature variations are higher and the phenomenon of thermal fatigue is more accentuated. At high rolling rates, where the number of rotations is significant, reaching in this case la 266…575 rot/min, temperature variations are small and thermal fatigue is dimmed, while the number of thermal fatigue stress cycles increases up to the appearance of the first fissures, specific to this phenomenon.

5. REFERENCES

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