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RESEARCHES UPON THERMO-MECHANICAL STRESSES TO THE HOT ROLLING MILLS CYLINDERS

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ABSTRACT
The rolling mills cylinders are apply to thermo-mechanical stresses who are variable, complex, with extremely marked influences. Therefore, to intensify the rolling processes we need to observe the durability limits. To this purpose it is necessary to know as accurately as possible the type of stress, the materials, and a detailed characterises evaluation, to determine exploitation timing and to compare with previously established values. Theoretical and experimental research upon thermo – mechanical processes that take place during plastic deformation in rolling cylinders, constitutes a factor, which reduces the possibilities of rational exploitation in rolling mills. In the context of market economy a new evolution is necessary in the field of scientific research, in order to modernize metallurgical equipment, using the most efficient solutions to obtain performing cylinders on an international scale. The paper presents the mechanical and thermal stresses upon the rolling processes using to most actual problems related to the increase the durability of rolling mill cylinders.
Keywords: stress, mechanical, thermal

1.INTRODUCTION
Knowing the negative, destructive effects of rolls, in order to diminish and eliminate the destruction causes through roll cracking and breakage, a detailed, complex theoretical and experimental research is required, upon the mechanical and thermal stresses present in the mechano-thermal roll strain process during rolling.

2. MEASUREMENT EQUIPMENT
For the researches of the thermo – mechanical stresses which apear in the hot rolling cylinders, the Laboratory of Technological Equipment from the framework Faculty of Engineering Hunedoara disposes of an experimental rolling mill with the diameter of 220 mm, presenting the advantage were a scaled-down copy (1:5) of the industrial rolling mill with a diameter of 1300 mm. This rolling mill represents a complex equipment which corresponds all the parameters of roughing rolling mills incorporate in the technological process of industrial production. The experimental rolling mill is endowed with a plant for the determination of the lamination forces and of the variations of temperature fields in cylinders , which uses the electronic calculus technique, [1]. The forces of lamination is measured in temporally experimentations of a help installation finded in the endowment rolling mill, in the aim verification of the stress from cylinders in order to subjected to excessive forces, which can produce ruptures or the damage of the rolling mill. In fig.1 presents the montage of tension-meter 1, which take over half of rolling forces transmits in bearing holder 3. The tension-meter is located under the axial bearing, lied on the head of the pressure screw 4, in a rigid metallic box, with the steel tie, at the superior cylinder's 5 equilibrate bend.

In figure 2 is presented the temperature variation measurement equipment which uses the electronic calculus technique. The thermocouples are placed at depths Δr = 0.2; 1.5; 3.0 and 6,0 mm from the surface of the cylinders. The first thermocouple placed at the depth 0.2 mm is considered to be the surface thermocouple where the temperature variation are on the maximum level. The main axis of the equipment, assembled on bearing 4 is drilled through the axis on the passive side, thus ensuring to transmit the compensation cables from the thermocouples to thermo tension collector 5, built with coal brush 6. Collecting the thermo tension from the thermocouples is through the copper rings 7, assembled on isolate textolite disks, with a link on coupling 8. The electric conductors from the collecting brushes were connected to borne 9 then to connection box 10 which contains connection analogical modul that through a transmission socket connects with source 11 to the computer 12, recording the temperature variation.

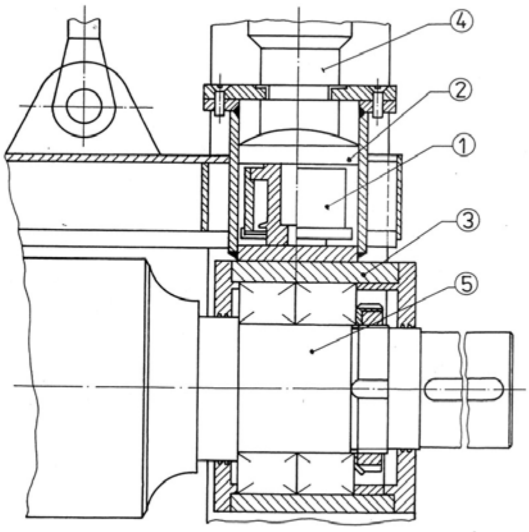

Figure 1. The tensiometer's montage with resistive traductors assembled in the experimentally roughing rolling mills of blooming type ϕ 220 mm

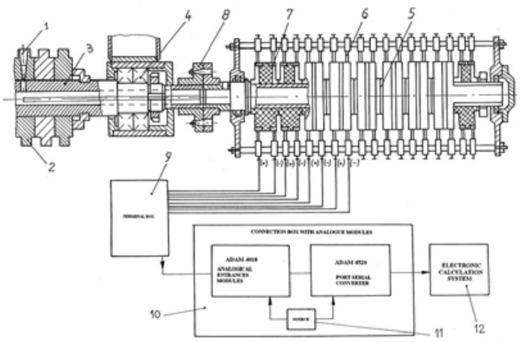

Figure 2. Temperature variation measurement equipment

3. ISOCRONAL DIAGRAMS

The temperature variation is represented by exponential diagrams which are presented in the figures 3 and 4. For the experiments the minimal value of the rotation number of the cylinders test being as 35,7 rot/min and the maximal value is 226,4 rot/min.

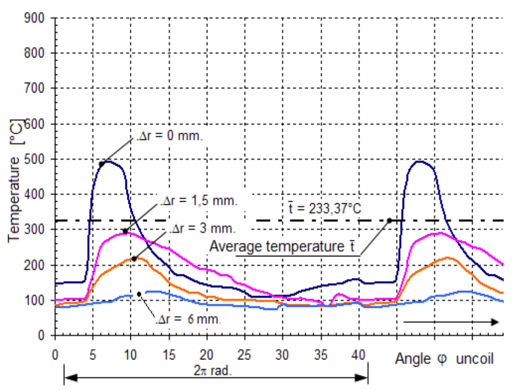

Figure 3. The variations diagram of the hot rolling mill cylinders for a rotation, in time of experimental rolling with n_1 = 32,5 rot/min

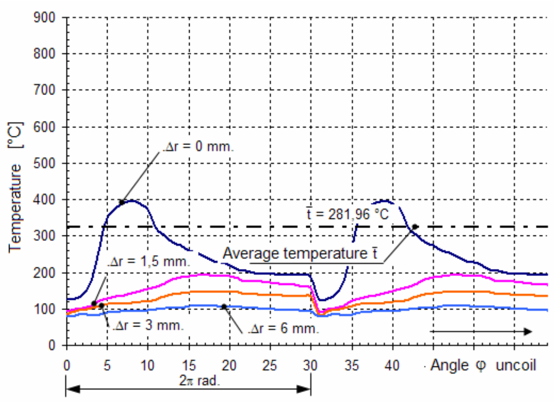

Figure 4. The variations diagram of the hot rolling mill cylinders for a rotation, in time of experimental rolling with n_2 = 226,4 rot/min

4.THE THERMO-MECHANICAL STRESSES

The data processing from these diagrams allowed the determination of the symmetrical and asymetrical temperature fields, which action on surface and in radial section of hot rolling mill cylinders. Separating the temperature fields in radial symmetrical and asymmetrical fields allows the separate study not only of temperature fields but also of the produced thermal tensions.

In table1 enters indicative dates synthesis for the mechanical stresses and in table 2 enters indicative dates synthesis for the thermal stresses calculated to the experimental rolling, after analysis registred the isocronal diagrams. After analized these tables we observe that the temperature fields registred to the experimental rolling, from analysis registred diagrams distinguishes the character exponential of curves was of presumed temperature in logical analysis of hot rolling process.

Table 1. The synthesis of the calculus of the mechanical stresses.

The depth Δr [mm]	Lamination force P [daN]	Bending moment M_i [daN·mm]	Bending stress σ_i [daN/mm^2]	Contact pressure stress σ_{pc} [daN/mm^2]
Isocronal diagram fig. 3 with n = 32,5rot/min				
Δr = 0	1720	351310	1,236	1,46
Δr = 1,5			1,217	-
Δr =3,0			1,198	-
Δr = 6,0			1,160	-
Isocronal diagram fig.4 with n = 226,4rot/min				
Δr = 0	2040	416670	1,466	1,73
Δr=1,5			1,443	-
Δr = 3,0			1,421	-
Δr = 6,0			1,376	-

Table 2. The synthesis of the calculus of the thermal stresses.

Isocronal diagram fig. 3 with n = 32,5rot/min					
The thermal stresses		The values of the thermal stresses [daN/mm^2]			
		Δr = 0 mm	Δr =1,5 mm	Δr = 3,0 mm	Δr = 6,0 mm
The symmetrical thermal stresses	σ^s_{rr}	0	0,296261	0,5422795	0,708251
	$\sigma^s_{\varphi\varphi}$	-83,31496	-66,79048	-48,670102	-36,72202
	σ^s_{zz}	-66,81282	-50,54459	-32,710742	-20,928307
The asymmetrical thermal stresses	σ^{as}_{rr}	0	0	0	0
	$\sigma^{as}_{\varphi\varphi}$	0,18	0,20	0,18	0,20
	σ^{as}_{zz}	-138,21	-94,16	-57,18	-29,45
Isocronal diagram fig. 4 with n = 226,4 rot/min					
The thermal stresses		The values of the thermal stresses [[daN/mm^2]			
		Δr = 0mm	Δr =1,5mm	Δr =3,0mm	Δr = 6,0mm
The symmetrical hermal stresses	σ^s_{rr}	0	0,565842	0,93613	0,879685
	$\sigma^s_{\varphi\varphi}$	-100,66151	-65,23443	-42,28421	-39,80565
	σ^s_{zz}	-82,38947	-47,528116	-24,948313	-22,413309
The asymmetrical thermal stresses	σ^{as}_{rr}	0	0	0	0
	$\sigma^{as}_{\varphi\varphi}$	0,31	0,30	0,31	0,31
	σ^{as}_{zz}	-58,10	-39,65	-22,04	-19,02

5. CONCLUSIONS

The researches of the mechano - thermal stress that action in the rolling mills cylinders is impetuously necessary not only to diminish the fissures caused by thermal fatigue, to increase the exploitation duration, but also to avoid thermal shocks, which are very dangerous in the exploitation process and produced of life by large variations, temperature snapshot that lead to shearing of caliber beads in cylinders. The mechanical and thermal stress are necessary to calculate the resulting main stresses and the equivalent stresses which acting in the rolls material.

The mechanical stresses are insignificant value in comparison with the thermal stresses.

The thermal stresses resulting from the variation of symmetrical and asymmetrical thermal fields, which appear during the exploitation process of rolling cylinders, produced thermal fatigue, that largely depend on the following factors: rolling temperature; rolling speed, respectively the number of rotations and cylinder diameter; length of the cylinders; pause duration during the rolling process, the mass of the laminate compared with the mass of the rolling cylinders.

The paper presents the evolution of stresses produced by symmetrical and asymmetrical temperature fields, both on the surface and in the radial section of the rolls. The work also calculates the stresses produced by mechanical strain, which combined with the thermal ones algebrically will define the resulting main tensions that act upon a material element of the cylinder.

6. REFERENCES

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