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THE STUDY OF THERMAL REGIME OF THE HOT ROLLING MILL CYLINDERS

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ABSTRACT
The classic methods for evaluating the durability ofhot rolling mill cylinders do not provide an answer to many of the phenomena accruing in the rolling process, between cylinders and laminate. These methods do not take into consideration the highly important thermal influences, which constitute one of the fundamental causes leading to the destruction of hot rolling mill cylinders and, also, may reach considerable values that can be observed only through experiments.
Keywords: thermal, temperature, cylinders

1.INTRODUCTION
The hot rolling mills cylinders are submitted to thermal fatigue, which represents the distruction, in time, of calibres by a system of specific fisure under the predominance action of thermal tensions. In the rolling process these tensions are turned out of regular by symmetrical and asymetrical temperature fields.
The study and research of thermal tension that action in the rolling cylinder`s is impetuosly 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 by large variation, temperature snapshot that lead to shearing of caliber beads in cylinders.
Keep on these aspects one of the studies the most important over the hot rolling mill cylinders represent the durability to those in exploitation. The endurance researches of hot rolling mill cylinders, must realized in several stages, in the first way through the sighting concequences of the thermal cyclical effects, respective thermal fatigue effects over to those. In this aim is needed to know the thermal regime in hot rolling mill cylinders.
The classic methods for evaluating the durability of cylinders do not provide an answer to many of the phenomena accruing in the rolling process, between cylinders and laminate. These methods do not take into consideration the highly important thermal influences, which constitute one of the fundamental causes leading to the destruction of hot rolling mill cylinders and, also, may reach considerable values that can be observed only through experiments.
Up to present days, several aspects of hot rolling thermal regime have been under less detailed study. The lack of detailed, 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, [1].
Following a logical analysis of the hot rolling process becomes known the temperature variation on the surface of the rolling cylinders. Thus, if we analyze the temperature variations on an elementary surface (figure 1a), performing a rotation, it is noticeable that in the area of angle φ_1, the temperature increases highly in point II, when abandoning contact with the laminate. Afterwards, it decreases in the area of angle φ_2 (delimited between points II – III). Around angle φ_3 (delimited between points III – IV), the temperature decreases up to the temperature of the cooling water, followed by an increase of temperature, being heated through radiation in the area of angle φ_4 (delimited between points IV –

I). The temperature variation curve of the elementary surface has been traced on the surface of the inferior cylinder (3) and the represented in Cartesian coordinates (figure 1b), with angle φ noted on the abscissa and the evaluated temperature noted on the ordinate.
The temperature variation on the surface of the cylinder, during one rotation (where angle $\varphi = 2\pi$ radians) has a maximum limit (t_{max}), with values more reduced than the temperature of the laminate, and a minimum limit (t_{min}) with values with values closed to that of the cooling water. Meaning, the temperature variation on the surface of the cylinder is represented by an exponential curve, which enlarges in depth δ of the radial section of the cylinders, where, at depth $\gamma = \gamma_\delta$, the temperature becomes constant – symmetric – this corresponding to the stationary or quasi-stationary thermal working condition, [2].

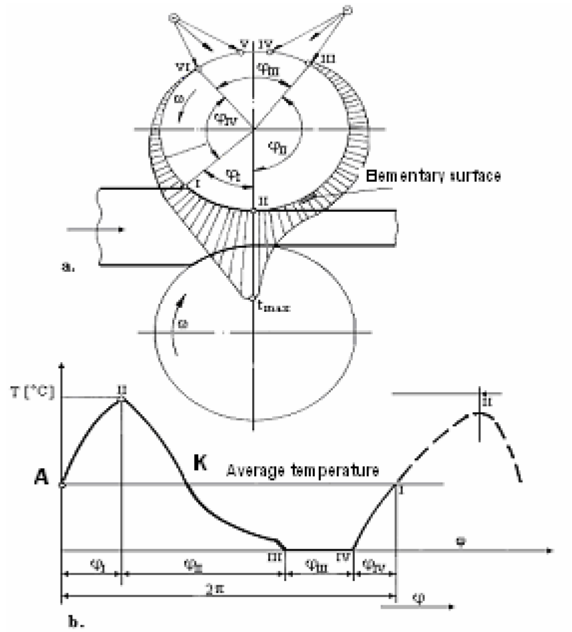

Figure 1.The temperature variation on the rolling mill cylinders results from logical analysis of hot rolling procedure:
a –the repartisation of temperature on the circumference of the cylinder;
b –the unfolding diagrama of the temperature variation on surface of hot rolling mill cylinders

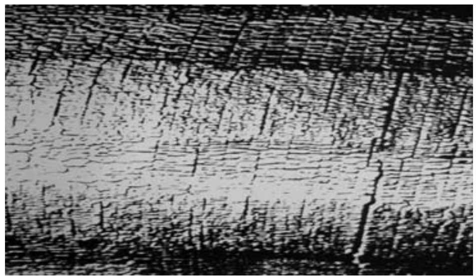

Figure 2. Aspect of the calibers surface in the form of fissures and longitudinal cracks,specified of the thermal fatigue

Figure 3. Aspect of the calibers surface in the form of fissures and longitudinal cracks,specified of the thermal fatigue

The curves of temperature variation, both on the surface of the cylinder and in the radial section are obtained experimentally, in a research laboratory belonging to the Faculty of Engineering Hunedoara (Romania).
The straight line that represents the values of medium temperature makes an intersection with the exponential curve of temperature variation in point K, delimiting on the abscissa angles φ_i and φ_e. Thus, for stationary or quasi-stationary thermal working conditions, in the interval of angle φ_i heat is introduced in the roll, will in the interval of angle φ_e the evacuation of heat is done. Superior to the level of the medium temperature line, on the segment A – K, an area A_1 is delimited, equal to A_2, segment K – A, and curve f(φ) representing equal areas $A_1 = A_2$.
The variable temperature, which surpasses the level of medium temperature, is defined as asymmetric temperature. This variation of temperature occurs repeatedly at every rotation of the cylinders, respectively it has a cyclic character and produces thermal fatigue in the form of fissures and cracks (circumferential and longitudinal), as presented in figure 2, 3.

2. EXPERIMENTAL INSTALATION FOR STUDY THE THERMAL REGIME

The study of thermal conditions in hot rolling and the highlight of characteristic thermal variation curves on the roll surface and superficial layer in a radial section are performed in an experimental rolling mill from the technological equipment laboratory at the Faculty of Engineering of Hunedoara. This miniature rolling mill has the advantage of being a reduced copy (1:5) of blooming rolling mill Ø 1300 mm, a fact which creates the possibility of applying the law of similitude and extending the result for an industrial use purpose.

In figure 4 the assembly of the experimentally roughing rolling mills, and in figure 5 the scheme of equipments are presented. This rolling mill has the possibility of laminar ingots (models 115/130x144/196x690 mm) or billet squares 120 x 120 mm and produce squares profiles with the 46x46 mm section. In this constitutive rolling mill is presented the mill stand (1), driven by the direct current electric motor (2), with the power 25,8 kW, the reducing gear (3), which drive the gear stand (4), and the coupling bars (5), fig.5.

The experimental rolling mill is endowed with a plant for the determination of the variations of temperature in cylinders measured by dint of the oscillograph H115, fig.6. The working principle of the equipment for temperature variation measurements is based on the thermoelectric effect in the thermocouples.

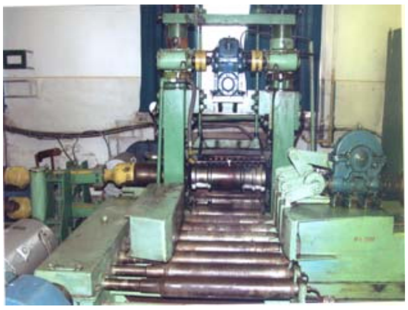

Figure 4. The assemblies of the mill stand with the attendance equipments

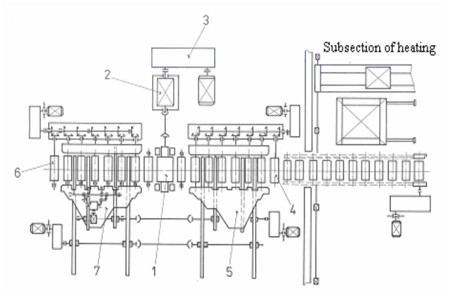

Figure 5. Scheme of equipments location in the experimentally roughing rolling mills

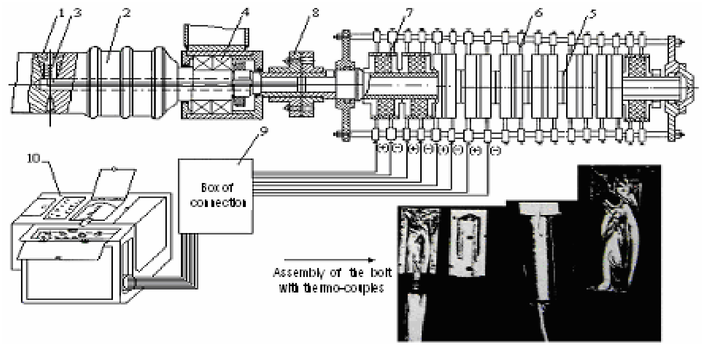

Figure6. The instalation scheme for the gauging of the variations of the temperature on the surface and in radial section of hot rolling mills cylinders

3.THE DETERMINATION OF THE TEMPERATURE VARIATION IN THE HOT ROLLING MILL CYLINDERS

Concurrent with the variation of temperature have registreded rolling forces and the number of the rotations of hot rolling mill cylinders. The number values of the experimental rolling cylinders entailed statistical after the number of rotation of cylinders from the industrial rollers, resulted an average of $n_1 = 35,7$ rot/ min. To be do not influence the character of exponenciale variation of the temperature fields which is in function of the number of rotation of the rolling mills have registreded the variations of the temperature in rolling mills to unghiular speeds constants, on which new appoint states izocrone in cylinders. Figure 8 presents the registreded osclillogram in experimental rolling time with 35,7 rot/ min, while in figure 9 presents the study of the registreded osclillogram after several passages, in those conditions to that number of rotation of hot rolling mill cylinders. 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.

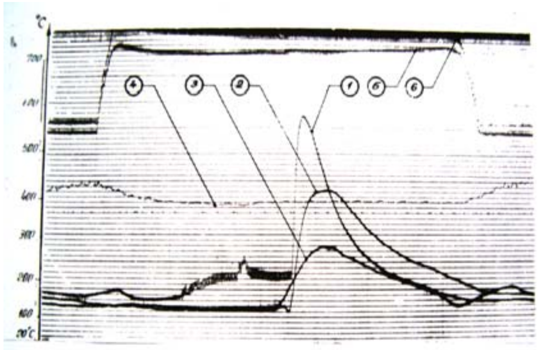

Figure 7. The oscillogram of the variations of the temperature fields, recorded with oscillograph;1…3 temperature variation on the surface and in the superficial layer of hot rolling mill cylinders; 4 - lamination speed; 5,6 – lamination forces

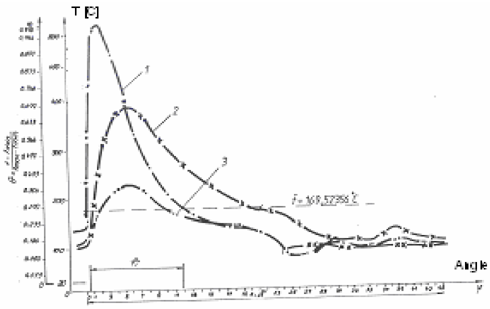

Figure 8. The variations diagram of the hot rolling mill cylinders for a rotation of the hot rolling mill cylinder,in time of experimental rolling with n_1 = 35,7 rot/min.

4.RESULTS AND CONCLUSIONS

In table1 enters indicative dates synthesis for 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. Indicative dates synthesis for the temperatue fields registred to the experimental rolling

Diagrama figure 8; n_1 =35,7 rot/min				
The angle for introduction heat φ_i = **1,6388 rad**			The angle for evacuation heat φ_e= **4,4429 rad**	
Specific radius	The determined temperature			
	Maximum		Average	
	^{0}C	θ	^{0}C	θ
ρ_o; Δr = 0 mm	**524,8**	**1,0**	**169,5**	**0,29738**
ρ_1; Δr = 1,5 mm	**362,9**	**0,680**	**172,4**	**0,30320**
ρ_2; Δr = 3 mm	**211,6**	**0,380**	**115,33**	**0,11898**

It was maximum variation of temperature are to small rolling speeds, respective small numbers of rotation of cylinders. In cases majority after the calibre surface arrive in jets angles zone of cold watery, temperature to this becomes smaller than shallow stratum temperature until to depth of about 3 mm according as increase the number of rotation of cylinders this diference of of temperature becomes smaller whole. In that time was observing as top of temperature to different levels under surface of(Δr = 1, 5; 3, 0 mm). They are displaced horizontally, having a gap to a certain angle, fact what shows the time sending of warmth in cylinder meal. These resultates will be used for the study of the durability of the hot rolling mill cylinders

5. REFERENCES

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