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THE EQUIVALENT STRESSES IN THE HOT ROLLING MILL CYLINDERS

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ABSTRACT:
This paper presents the equivalent stresses from the hot rolling mills cylinders, in avoiding to increase the durability in exploitation. We determine using original mathematic equations established for the numerical calculus of the symmetrical and asymmetrical field of temperature, with experimental data that allow the study of evolution of these tensions and determining the conditions in which the thermal fatigue specific cracks appear. Applying the deformation energy theory, the equivalent stresses are determined, for which, initially, the resulting main stresses acting in the element of the rolls material, in three - dimensional coordinates.

KEYWORDS:
stresses, equivalent, thermal, deformation

1. INTRODUCTION

The researches upon the equivalent stresses from the hot rolling mills cylinders represent an important scientific, theoretical, experimental and economical issue. These are generated by the thermal stresses which are variable, complex, with extremely marked influences. Therefore, to intensify the rolling processes we need to observe the durability limits, with thermal stresses produced in symmetrical and asymmetrical temperature fields, at a large number of stress cycles. 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.

The thermal fatigue specific fissures in the form of cracks are produced under the action of thermal stresses resulting from the variation of symmetrical and asymmetrical thermal fields, which appear during the exploitation process of rolling cylinders, tensions, 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 study and research of stresses that action in the rolling 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 by large variations, temperature snapshot that lead to shearing of caliber beads in cylinders.

2. ANALITICAL AND EXPERIMENTAL RESEARCHES

The researches regarding the equivalent stresses from the hot rolling mills cylinders, are tries to give answers to most current problems related to this domain of activity. For this researches the exponential curve type according to the rotation angle of the cylinders is established, following a thorough analysis of the hot rolling process. The temperature variation curves on the surface and the radial section of the rolls are determined experimentally, and particularly, the superficial layer of the calibres is studied. Using original mathematic equations established for the numerical calculus of the symmetrical and asymmetrical field of temperature, with experimental data that allow the study of evolution of these stresses and determining the conditions in which the thermal fatigue specific cracks appear. Applying the deformation energy theory, the equivalent tensions are determined, for which, initially, the resulting main tensions acting in the element of the rolls material, in three-dimensional coordinates, are calculated.

The resulting main stresses which compose the equivalent stresses are presented in three-dimensional coordinates, as presented in figure 1, [1].

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 figure 1, σ_{rr} – radial normal stress; σ_{zz} – axial normal stress; $\sigma_{\varphi\varphi}$ – circumferential normal stress; τ_{zr},τ_{rz} , $\tau_{r\varphi}$,$\tau_{\varphi z}$,$\tau_{z\varphi}$ – tangential stress.

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.

The equivalent stresses are to be calculated applying the deformation energy theory after relation (1) and the resultates are presented in table 1.

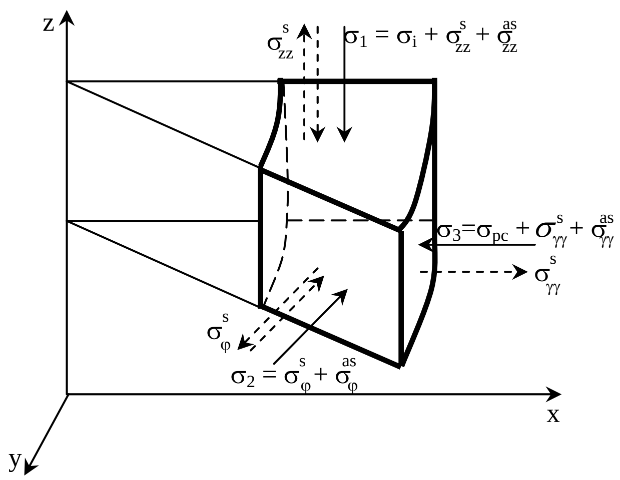

FIGURE 1. The action scheme of the component stress to determine the resulting main stresses

$$\sigma_{ech} = \sqrt{\sigma_1^2 + \sigma_2^2 + \sigma_3^2 - 2\nu\left[\sigma_1\sigma_2 + \sigma_2\sigma_3 + \sigma_3\sigma_1\right]} \quad (1)$$

In relation (1) the resulting main stresses are notice with σ_1, σ_2 and σ_3 and the calculus relations are: $\sigma_1 = \sigma_i + \sigma^{s}_{zz} + \sigma^{as}_{zz}$; $\sigma_2 = \sigma^{s}_{\varphi\varphi} + \sigma^{as}_{\varphi\varphi}$; $\sigma_3 = \sigma_{pc} + \sigma^{s}_{rr} + \sigma^{as}_{rr}$ where

σ_i is the stress of flexion and σ_{pc} represents the stress of contact pressure. In this relations σ_i and σ_{pc} are mechanical stresses.

TABLE 1. The calcululs of the equivalent stress σ_{ech}

The number of rotation of the cylinders n=32,5rot/min					
The stress	The value of the equivalent stress [daN/mm^2]				
	Δr = 0mm	Δr =1,5mm	Δr = 3,0mm	Δr = 6,0mm	Δr = 98mm =R
σ_i	1,236	1,217	1,198	1,160	0
σ_{pc}	1,46	-	-	-	-
σ_1	-203,78682	-143,48759	-88,692742	-49,218307	-51,948307
σ_2	-83,13496	-66,59048	-48,490102	-36,52202	-46,749607
σ_3	1,46	0,256261	0,5422795	0,708251	-10,619154
σ_{ech}	196,1282	139,0050	87,6479	52,10283	53,95301
The number of rotation of the cylinders n=65,2rot/min					
The stress	The value of the equivalent stress [daN/mm^2]				
	Δ_r= 0mm	Δ_r=1,5mm	Δ_r=3,0mm	Δ_r= 6,0mm	Δ_r=98mm =R
σ_i	1,566	1,542	1,518	1,470	0
σ_{pc}	1,85	-	-	-	-
σ_1	-189,50064	-108,26528	-70,81963	-54,29738	-47,09738
σ_2	-90,7746	-65,30894	-53,78742	-41,13576	-50,35852
σ_3	1,85	0,406377	0,5782389	0,769664	-10,313095
σ_{ech}	184,78079	108,56657	75,27648	57,83494	53,23915
The number of rotation of the cylinders n=95,3rot/min					
The stress	The value of the equivalent stress [daN/mm^2]				
	Δ_r= 0mm	Δ_r=1,5mm	Δ_r=3,0mm	Δ_r=6,0mm	Δ_r=98mm=R
σ_i	1,552	1,528	1,505	1,420	0
σ_{pc}	1,83	-	-	-	-
σ_1	-157,90485	-90,94362	-57,24484	-43,86782	-45,37782
σ_2	-82,09551	-59,79783	-43,62025	-36,48226	-40,80539
σ_3	1,83	0,35242	0,608256	0,724227	-4,04802
σ_{ech}	155,44296	92,820162		46,15779	49,19648
The number of rotation of the cylinders n=226,4 rot/min					
The stress	The value of the equivalent stress [daN/mm^2]				
	Δ_r=0mm	Δ_r=1,5mm	Δ_r=3,0mm	Δ_r=6,0mm	Δ_r=98mm=R
σ_i	1,466	1,443	1,421	1,376	0
σ_{pc}	1,73	-	-	-	-
σ_1	-139,02347	-85,735116	-45,56713	-40,057309	-37,443309
σ_2	-100,04	-64,93443	-41,97421	-39,49565	-47,30699
σ_3	1,73	0,565842	0,93613	0,879685	-5,901656
σ_{ech}	125,78522	90,9844	52,35428	47,51845	48,08205

3. CONCLUSIONS

The main resultant tensions σ_1 and σ_2 have only negative values and they turn out compresion with values excessively big on surface and in the shallow stratum of drums, until the depth of 6 mm.

The main tensions σ_3 are poitive on surface and become negative and grow them down to the cylinders axes. The biggest absolute values of main tensions are one from the axial direction σ_1, they have maximum values to small turnovers of rolling drums effected with n = 35,7rot/ min, these tensions have the maximum value σ_1 = - 203,786 daN/mm^2. The main tensions σ_1 which have the axial direction in cylinder have scared values and turn out circulars cracks form in the shallow stratus. These cracks are perpendicular on the main stresses direction σ_1. In the exploitation process, these cracks grow gradually, arriving at some cracks with the opening of over 3…5 mm, cracks what propagate deep until 20…30 mm. As it can observe from the table 1 main weight in the main axial tensions value σ_1, it have the tensions , the skewed fields products temperature, which whereas they are the accountable for circulars cracks production on the hot rolling cylinders calibres and they give the indicative aspect heat weariness. The main stresses in direction circumferentiala σ_2 they are also negative, but on drums surface represents half from the axial main stresses value σ_1. If it analyses the table 1 observes as main component of stresses σ_2 they are the tensions, the regular fields products temperatures.

These main circumferential stresses σ_2, i turn out on rolling drums surface cracks longitudinal, parallels with generators cylinders – journal to beads, forming a „link" to network. These cracks are silkier, it grows gradually and arrive at an opening of 1…2 mm with a depth of 1 …2 mm. The radial main stresses σ_3 on cylinders surface have relative small values until 8…10 daN/mm^2 and have negative values, but immediate in the surface approach when $\Delta r < 1,5$ mm, become`s positive, but with small values, unimportant in comparison with the stresses σ_1 and σ_2, which have the decisive weight in the equivalent stresses value. The equivalent stresses values sech they are influenced preponderent of the tensions σ_1 and σ_2, which have maximum values to small rotation speeds of hot rolling cylinders n = 35,7 rot/ min, so the maximum registered value (passage 9) is of σ_{ech} = 196,1282 daN/mm^2. It was remarking the fact as the rolling cylinders can put up with the main stresses σ_1 şi σ_2, ever big in the shallow stratum of calibres, only for the fact as these stressses are of compresion, it acts a relative highly short time, of the tail-coatporder of second or to some passages the one much one or two seconds. In this situation, until the cracks appearance with cracks hues circumferential and longitudinal, the stuff puts up with stresses with values of three - four or bigger than the wreck tensions values.

So, can to conclude as the calls from the rolling drums have a cyclical character, they occur to each turnover of drums, while the tension state is in main skewed temperatures fields action result regular, what turn out heat weariness on surface and in the shallow stratum of rolling drums warmly.

REFERENCES / BIBLIOGRAPHY

[1.] TOADER Şt, PINCA C., PLEŞA D.- Thermal fatigue of the hot rolling mill cylinders, Timişoara, ISBN 973-625-185-3, Romania, 2004

[2.] PINCA C., TIRIAN G.O., KISS I., JOSAN A. – Experimental researches under the durability of rolling mill cylinders, 9th International Research / Expert Conference „Trends in the developement of Machinery and Associated Technology, TMT 2005, Antalya, Turkey.