Experimental Research of the Thermal Stress in the Rolling Mill Rolls

Imre Kiss, Vasile Alexa, Vasile George Cioata

Abstract: *The paper proposes to evaluate the thermal stresses produced by the temperature fields in the hot rolling mill rolls using experimental date. The research of the thermal stress that action in the rolling rolls 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 calibre beads in rolls.*
Key words: *thermal stress, steel and iron rolls, temperature, thermal fatigue.*

INTRODUCTION

The hot rolling mill rolls are machinery parts which produce plastic deformation of the metal within the rolling process and are the most stressed parts from the whole rolling equipment. The temperature variation on the surface of the roll, during one rotation where angle $\varphi = 2\pi$ rad has a maximum limit t_{max}, with values more reduced than the temperature of the laminate, and a minimum limit t_{min} with values closed to that of the cooling water. The temperature variation on the surface of the roll is represented by an exponential curve. These curves both on the surface of the roll and in the radial section are obtained experimentally, in a research laboratory belonging to the Faculty of Engineering Hunedoara. The number values of the experimental rolling rolls entailed statistical after the number of rotation of rolls from the industrial rollers, resulted n_1=32.5 rot/min, n_2=65.2 rot/min, n_3=95.3 rot/min n_4=226.4 rot/min. To be do not influence the character of exponential variation of the temperature fields which is in function of the number of rotation of the rolling mills have registered the variations of the temperature in rolling mills to angler speeds constants, on which new appoint states isochrones in rolls.

THE VARIATION OF THERMAL STRESSES

For the researches of the variation of the thermal stresses which appear in the hot rolling rolls, 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 complex equipment which corresponds all the parameters of roughing rolling mills incorporate in the technological process of industrial production.

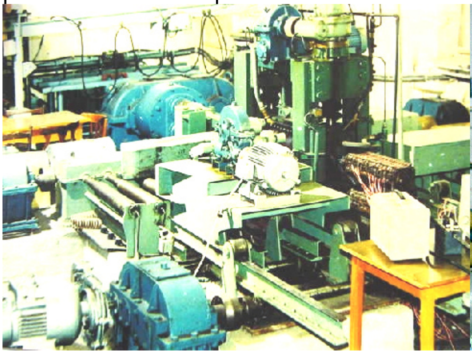

Fig. 1. Ensambly of the experimental Rolling Mills (blooming ϕ 220mm)

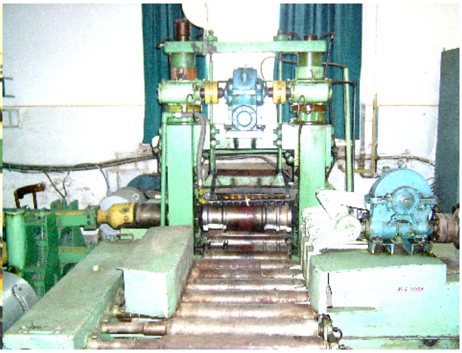

Fig. 2. Ensambly of the experimental Rolling Mills. Front of view

The experimental rolling mill is endowed with a plant for the determination of the variations of temperature in rolls, which uses the electronic calculus technique. This temperature variation is represented by exponential diagrams which are presented in the next four figures.

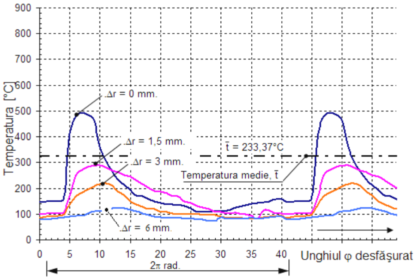

Table 1. Temperature fields registered to the experimental rolling, from analysis registered isochronal diagram (figure 3, n_1= 32.5 rot/min)

Angle for introduction heat $\varphi_î$		Angle for evacuation heat φ_e	
$\varphi_î$ = 81C = 1.413 rad		φ_e = 279C = 4.867 rad	
Determined temperature			
t_{max} [^{0}C]	Δr [mm]	$\bar{t}$ [^{0}C]	t_{min} [^{0}C]
493.3	Δr = 0	233.37526	108.3
289.9	Δr = 1.5	187.80601	80.7
220.1	Δr = 3.0	137.85123	83.1
125.8	Δr = 6.0	104.84721	71.7

Fig. 3. The variations diagram of the hot rolling mill rolls, in time of experimental rolling (n_1=32.5 rot/min)

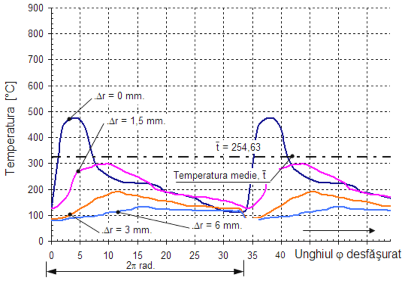

Table 2. Temperature fields registered to the experimental rolling, from analysis registered isochronal diagram (figure 4, n = 65.2 rot/min)

Angle for introduction heat $\varphi_î$		Angle for evacuation heat φ_e	
$\varphi_î$=102^{0}54' C = 1.786 rad		φ_e=257^{0}46' C = 4.494 rad	
Determined temperature			
t_{max}[^{0}C]	Δr[mm]	Medie $\bar{t}$ [^{0}C]	t_{min}[^{0}C]
457.9	Δr = 0	254.63496	110.4
297.9	Δr = 1.5	184.52471	125.1
191.2	Δr = 3.0	152.67694	85.3
134.1	Δr = 6.0	117.71828	80.1

Fig. 4. The variations diagram of the hot rolling mill rolls, in time of experimental rolling (n_2=65.2 rot/min)

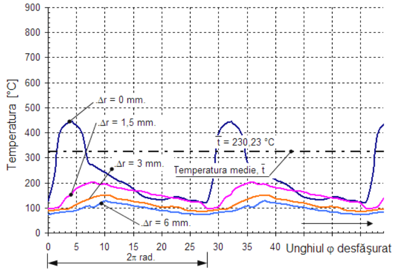

Table 3. Temperature fields registered to the experimental rolling, from analysis registered isochronal diagram (figure 5, n = 95.3 rot/min)

Angle for introduction heat $\varphi_î$		Angle for evacuation heat φ_e	
$\varphi_î$ =133^{0}33' C = 2.325 rad		φ_e=226^0 67' C = 3.955 rad	
Determined temperature			
t_{max} [^{0}C]	Δr [mm]	$\bar{t}$ [^{0}C]	t_{min} [^{0}C]
444.0	Δr = 0	230.23953	123.9
204.4	Δr = 1.5	168.79632	96.1
150.3	Δr = 3.0	124.1695	84.4
128.0	Δr = 6.0	104.49997	71.8

Fig. 5. The variations diagram of the hot rolling mill rolls, in time of experimental rolling (n_3=95.3 rot/min)

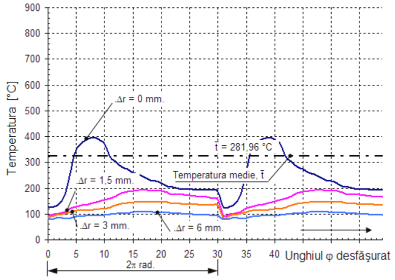

Table 4. Temperature fields registered to the experimental rolling, from analysis registered diagrams. Isochronal diagram figure 6, with n = 226,4 rot/min

Angle for introduction heat $\varphi_î$		Angle for evacuation heat φ_e	
$\varphi_î$ =106^{0}8' C = 1.862rad		φ_e=253^{0}2' C = 4.418rad	
Determined temperature			
t_{max} [^{0}C]	Δr [mm]	$\bar{t}$ [^{0}C]	t_{min} [^{0}C]
396.9	Δr = 0	281.96502	124.9
191.7	Δr = 1.5	184.31451	92.8
147.1	Δr = 3.0	121.0654	85.5
107.5	Δr = 6.0	113.96455	80.3

Fig. 6. The variations diagram of the hot rolling mill rolls, in time of experimental rolling (n_4=226.4 rot/min)

The data processing from these diagrams allowed the determination of the symmetrical and asymmetrical temperature fields, which action on surface and in radial section of hot rolling mill rolls. 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 the *Tables 1…4* are presented the indicative dates synthesis for the temperature fields registered to the experimental rolling, from analysis registered diagrams distinguishes the character exponential of curves was of presumed temperature in logical analysis of hot rolling process.

It was maximum variation of temperature are to small rolling speeds, respective small numbers of rotation of rolls. 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 rolls this difference of temperature becomes smaller whole. In that time was observing as top of temperature to different levels under surface. They are displaced horizontally, having a gap to a certain angle, fact what shows the time sending of warmth in roll meal. The results (presented in *Tables 1…4*) will be used for the study of the durability of the hot rolling mill rolls and their behaviour in exploitation.

CONCLUSIONS AND FUTURE WORK

The research on thermal stresses evolution is to be extended further on different brands of steels and irons used for the manufacturing of hot rolling mill rolls, depending on the durability's up to the point of fissures and thermal fatigue cracks. Therefore, it is recommended to use the most rational and economical materials, as well as new, more performing materials to manufacture hot rolling mill rolls.

The evolution act of thermal stresses that action in the rolling rolls 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 variation, temperature snapshot that lead to shearing of calibre beads in rolls.

The results presented in this work will be used for the study of the durability of the hot rolling mill rolls.

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