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CONSIDERATIONS CONCERNING THE IMPACT OF THERMAL FATIGUE UPON THE HOT ROLLING CYLINDERS

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ABSTRACT:

The paper propose rolling cylinder analysis by Utilization of electronic calculation technique to study the hot rolling cylinders thermal regime is a novelty from scientific and experimental viewpoint.

This research of thermal fatigue strength of hot rolling cylinders is a novelty and it’s an original concept in this field and the damage survey of these cylinders is one of the most interesting issues from economical and scientific viewpoint.

KEYWORDS:
thermal fatigue strength, rolling cylinder

1. INTRODUCTION

The research of thermal fatigue strength of hot rolling cylinders is a novelty and it’s an original concept in this field and the damage survey of these cylinders is one of the most interesting issues from economical and scientific viewpoint.

Many aspects of the hot rolling thermal regime are still less studied and currently there are no efficient methods to determine and adjust the rolling cylinders temperature.

The purpose of this work is to present few directions concerning the quality improvement of rolling cylinders, aiming the increasing of durability and safety in operation.

The hot rolling cylinders work in composed variable stress conditions, that are due to the rolling process carried-on in a cyclic succession.

Repeating of heating and cooling to each rotation produces cyclic temperature variations both on the surface and in the cylinders’ section, causing thermal stresses that exceed in many cases the strength limit of the cylinder’s material, leading to specific cracks in the surface layer according to the pictures from fig.1.

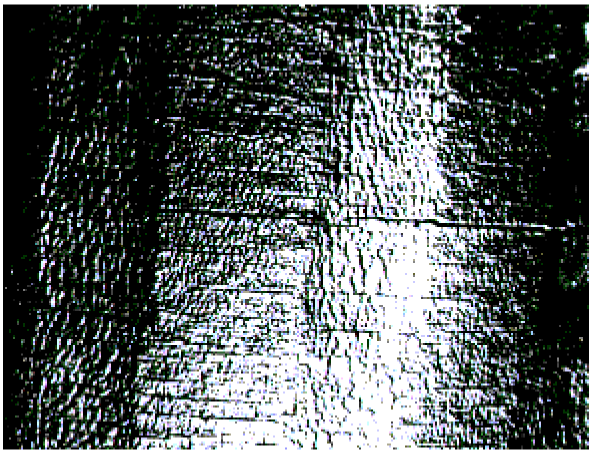

Fig. 1 *The aspect of the caliber surface of a rough rolling cylinder with nuances of circular cracks and longitudinal cracks*

It is known that during the hot rolling process the surface of the work cylinders is heated and cooled periodically at each cylinder’s rotation. In fig. 2 is shown the plastic deformation and temperature variation principle diagram on the cylinders surface, resulted from the logical rolling process analysis [1].

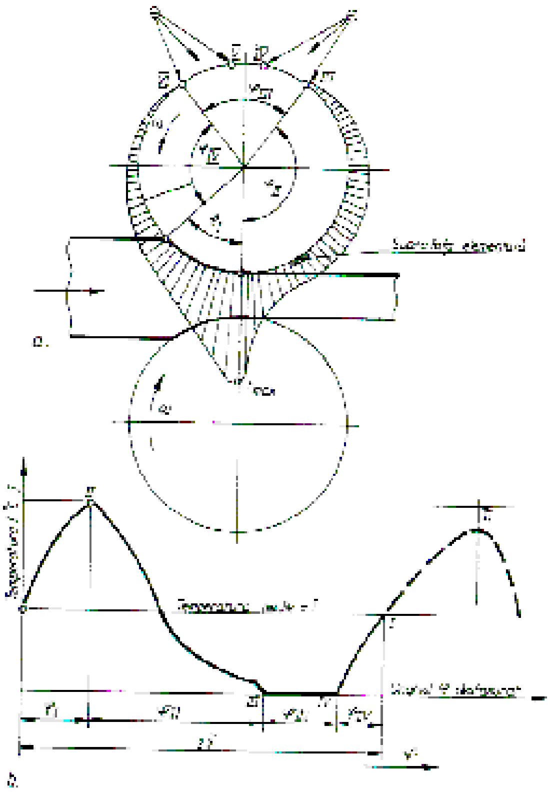

Fig. 2 *The hot rolling process diagram and the temperature variation on the rolling cylinders surface*

2. UTILIZATION OF ELECTRONIC CALCULATION TECHNIQUE AT THE STUDY OF THERMAL REGIME OF THE HOT ROLLING CYLINDERS

The study of hot rolling cylinders thermal regime by electronic calculation technique is a novelty both from scientific and experimental viewpoint. This study has been achieved on an experimental rolling mill, using an installation adapted in this purpose, shown in fig. 3.

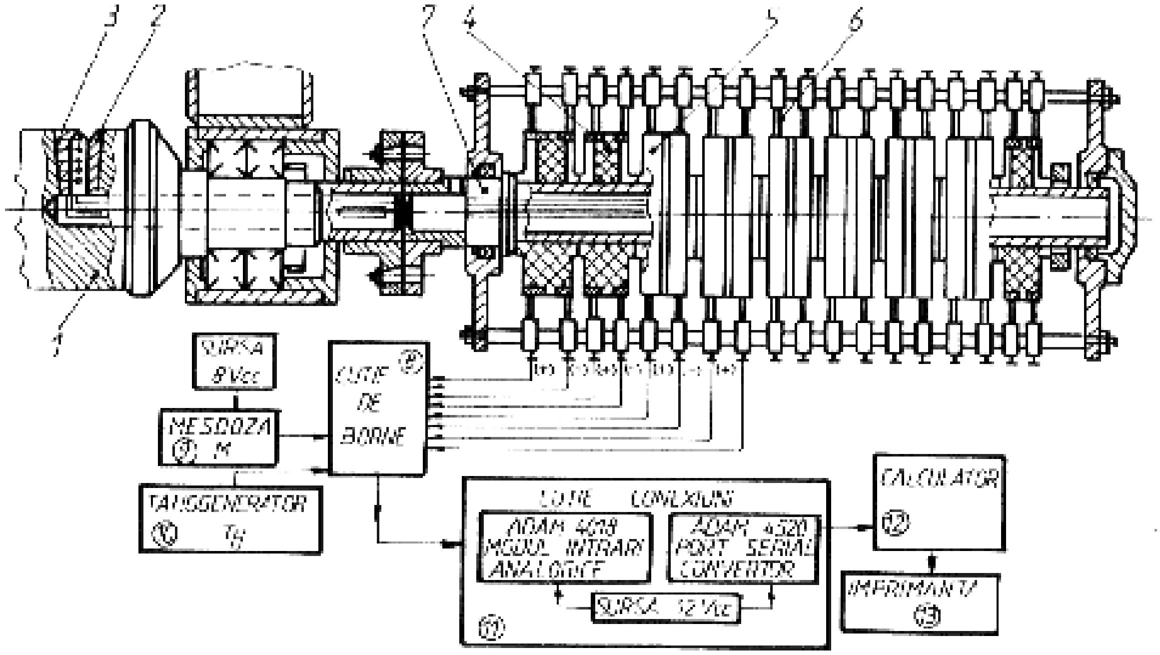

Fig. 3 *Experimental installation for the study of the rolling cylinders thermal regime by electronic calculation technique*

The collecting principle of thermal stresses from cylinder no. 1 has been achieved in classical mode, by the tapered bolt 2, in which were initially implanted the thermocouples 3, connected to the graphite brushes 4, having the copper rings 5 and graphite brushes 6.

The thermal stresses produced by the thermocouples were transmitted through the cables to the terminal box 8, to which were also connected the signals in mV from the dose 9 and tachogenerator 10. By a connection plug, the signals from the terminal box were transmitted in the switch box (fig. 4) with analogue modules of ADAM 11 type and further were undertaken by the electronic calculation system 12 and 13.

From the analysis of the characteristic parameters of more work cylinders from the stands of semis, profiles and wire rolling mills within a steel works company, resulted that, inside the rough stands, the cylinders' rotations number is between n_{1min}=30,2 rot/min and n_{5max}=182,3 rot/min.

Meantime were studied also the middle values from the range of the analyzed rotation number, being established that the most cylinders have rotation speeds between n_2=61,2 rot/min, n_3=87 rot/min and n_4=129 rot/min.

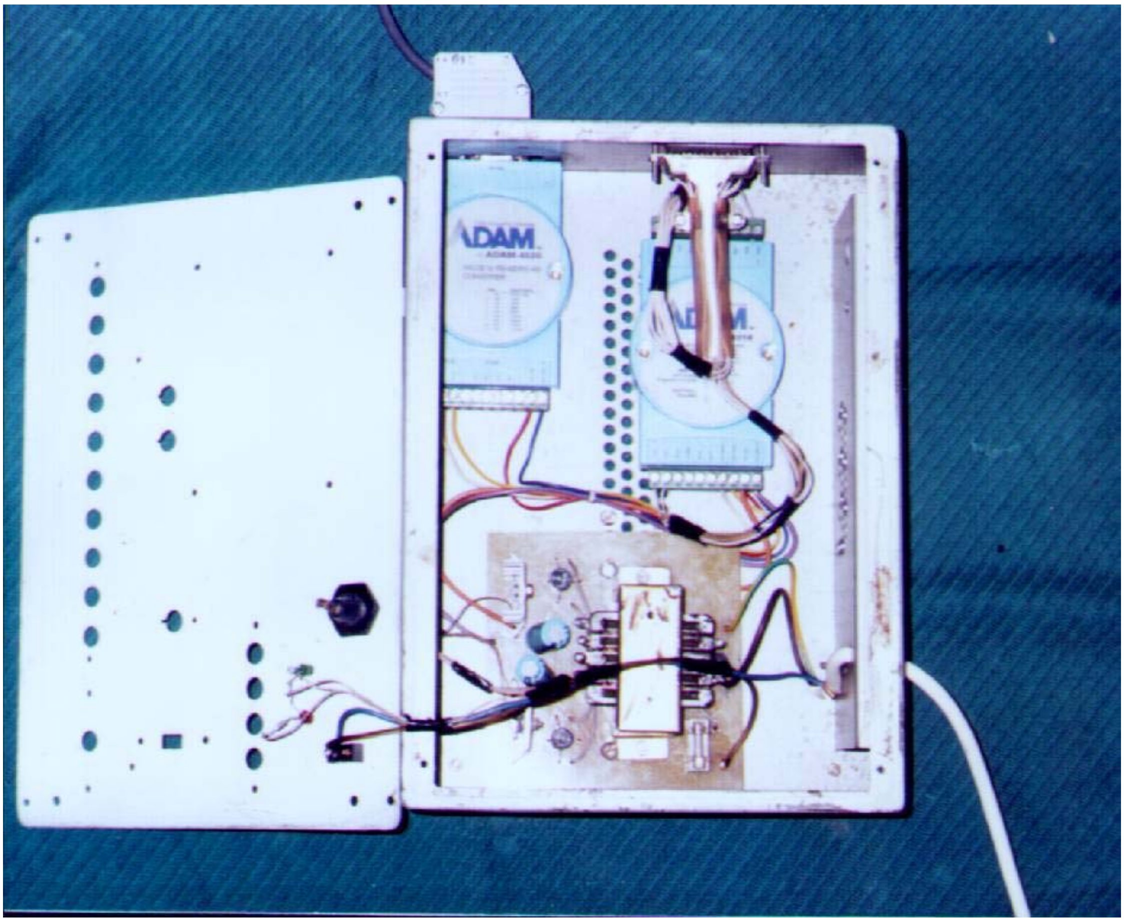

Fig. 4 *The terminal box unit with ADAM-type analogue modules*

Thus, our research on the rolling cylinders thermal regime was performed after five isochrones conditions for which were rolled 50 pcs. of OLC 45 steel bars, having the dimensions of 50x50x300 mm and a rolling temperature of 1150^0C.

In order to obtain measurements of the temperature variations given by bolt-implanted thermocouples was necessary to draw-up a calculation program with the following components:

ADAMTH.CPP file – contains program enter data ("main 0" function). This is interpreting the control line, initializes the acquisition module and reads the data at a given interval by pressing the ESC key (code 27).

ADAM.H file – contains declarations of functions from ADAM.CPP and other types of used data.

ADAM.CPP file – contains functions to initialize and transmit controls, as well as to receive data from the acquisition module.

COMMON.H file – contains declarations for COMMON.CPP module.

COMMON.CPP file – contains functions necessary to display data on the screen.

For the five isochrones experimental conditions were registered five files, for each of them being established the pitch number within a rotation interval of 2π radians, being registered the surface and section temperatures of the cylinders, at depths of Δr = 0.2; 1.5; 3; 6 mm, as well as the related rotation number n[rot/min] and rolling forces F[kN].

Table 1 *Extract from file IV for experimental rolling with n = 129 rot/min*

No.crt./division		V_0=TC_1 Δr = 0,2mm	V_1=TC_5 Δr = 1,5mm	V_2=TC_2 Δr = 3mm	V_3=TC_3 Δr = 6mm	n [rot/min]	Dose F[kN]
	0	1	2	3	4	5	6
0	0,00	115,6	82,3	70,5	65,2	131	11
1	1,00	169,3	88,6	73,4	68,4	129,2	11,7
2	2,00	315,5	102,9	75,4	69,4	129,7	11,8
3	3,00	372,9	119,5	78,4	70,9	129,9	11,8
4	4,00	386	139,7	80,1	73,4	129,5	11,9
5	5,00	388,6	164,5	84,3	76,6	130,1	12
6	6,00	370	178,2	95,7	79,4	131,2	11,9
7	7,00	320,2	187,7	104,5	80,5	129,3	11,9
8	8,00	271,8	190,4	110,4	86,2	129,1	11,9
9	9,00	240,5	199,3	114,6	90,2	128,7	12
10	10,00	230,2	206,7	123,3	99,6	128,5	12
11	11,00	216,4	210,2	127,6	105,3	128,2	11,9
12	12,00	214,1	206,9	130,1	112,2	128	12
13	13,00	210,5	202,7	133,7	115,1	128,3	12
14	14,00	209,1	198,5	134,4	120,3	128,5	12
15	15,00	203,4	186,7	135,5	124,6	129	12,1
16	16,00	194,7	183,5	129,4	125,3	129,3	12,1
17	17,00	186,1	177,6	119,4	120,4	129,4	12
18	18,00	177,3	172,5	113,3	115,5	129	12,1
19	19,00	165,9	166,4	110,5	109,2	128,6	11,9
20	20,00	163,8	163,2	107,1	106,5	128,5	11,9
21	21,00	159,8	158,6	106,3	102,4	128,7	11,9
22	22,00	156,1	151,3	103,9	92,3	128,9	12
23	23,00	151,4	147,5	102,2	83,4	129,3	11,9
24	24,00	148,7	142,8	100,8	72,6	129,2	11,9
25	25,00	147,2	137,3	94	72	128,7	11,9
26	26,00	146,1	132,1	88	71,6	128,6	12
27	27,00	139,2	129,3	84,6	72,1	128,9	12

In table 1 is shown the file IV obtained at the experimental rolling with n = 129 rot/min and in fig. 5 is shown the diagram of rolling cylinders temperature variation, resulted from the experimental rolling with n = 129 rot/min.

From a careful analysis of the five isochrones diagrams of registered temperatures, the maximum temperature variations on the cylinders surface and in section are produced at low rolling speeds. For example, in the diagram achieved with n = 30.6 rot/min the maximum temperature was 481^{0}C. Also in this diagram we can see high temperature values also in the cylinders section, at depths of Δr = 1.5; 3; 6 mm respectively. The peaks of temperature variation curves have a certain horizontal movement, this being the heat transfer time in cylinder's section depth. Characteristic to the temperature variation curves is also the fact that at relatively low speeds, in the area of cylinder's cooling water jets angles, the temperature on the cylinder surface decreases substantially, being lower than the temperature of the superficial layer at the depth of Δr = 1.5 mm.

But this situation is not appearing anymore at high rolling speeds, when the rotation number exceeds the value of n = 129 rot/min, the curves Δr = 0.2 mm and Δr = 1.5 mm are almost tangent and when n = 182.3 rot/min, these curves stay spread and the sub-cooling phenomenon of the cylinder's surface is not appearing anymore.

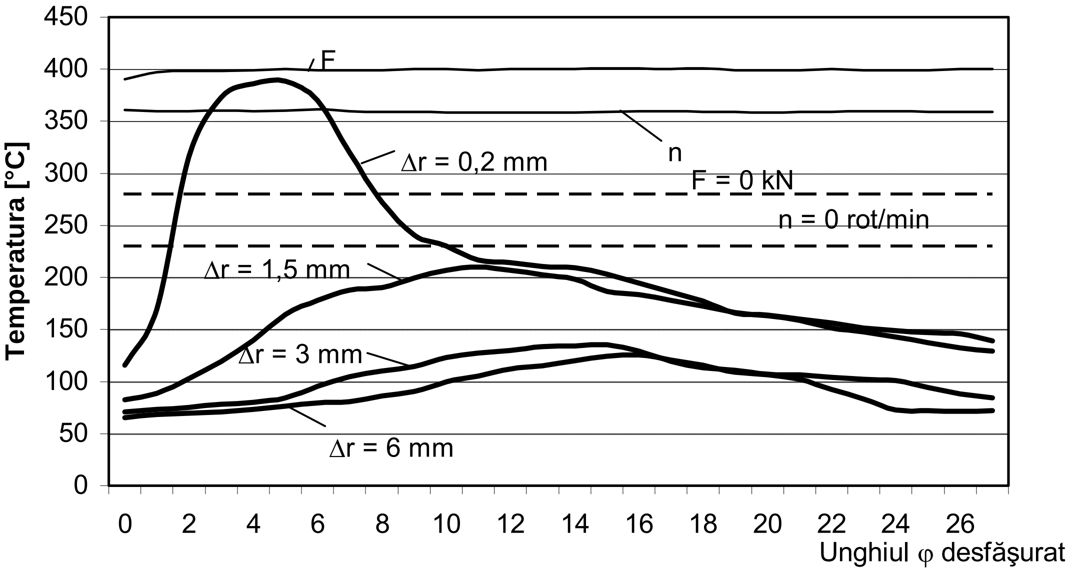

Fig. 6 *The diagram of rolling cylinders temperature variation, resulted further the experimental rolling with n = 129 rot/min.*

3.CONCLUSIONS

The thermal fatigue phenomenon of the hot rolling cylinders is produced more deeply at low rolling speeds, when the circular and longitudinal cracks network is pronounced.

Utilization of electronic calculation technique to study the hot rolling cylinders thermal regime is a novelty from scientific and experimental viewpoint.

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