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THEORETICAL AND ECONOMICAL CONSIDERATION ABOUT PARAMETRICAL FORCES OF ASYMMETRICAL ROLLING

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ABSTRACT:
The theoretical analysis made in this paper is valid for industrial scale practice at the trio section rolling mills.
If the difference between the periphery roll speeds becomes considerable, the situation when the smaller-diameter rolls acts like a brake interferes, endangering the reliability of technological equipment.

KEYWORDS:
Rolling mills, analysis, trio rolling section, roll speed, roll diameter, asymmetrical rolling

1. INTRODUCTION

In the rolling theory literature there are usually depicted the phenomena characterizing the symmetric rolling process, which means the case when both rolls are geared and they have equal angular and periphery speeds. It is supposed that the metallic material being rolled is homogenous, it moves steadily and the friction conditions of each roll are identical. In this case the stresses and strains on the rolled bar section are represented synthetically in comparison with the symmetry axis.

2. THEORETICAL STUDY OF THE PROBLEM

The aspects raised by the strain between unequal diameter rolls are due to the particularities introduced in this case by the non-uniform distribution of the strains and stresses across the section.

Considering that the diameter D_1 of the high roll exceeds the diameter D_2 the low roll, we should mention that angular speeds are equal and peripheral speeds depend on diameters:

$$\begin{cases} v_1 = \dfrac{\pi D_1}{60} n \\ v_2 = \dfrac{\pi D_2}{60} n \end{cases} \tag{1}$$

As consequence of difference between the peripheral speeds, the front end of the rolled product coming out from the rolls tends to bend towards the low roll having smaller peripheral speed. But the guiding chisels are apposed to this phenomenon obliging the rolled product to move in straight line, thus exercising some stress o that chisel (figure 1.a).

To compose the equilibrium equation of forces we note that normal pressure exerted by the chisel over the rolled product with Q, the friction coefficient between the chisel and rolled product with f, the friction force between these Qf, the forces exerted by the rolls over the rolled product R_1 and R_2, T_1 and T_2.

Projecting all the forces to the rolling direction, we obtain the equation:

$$R_1 \sin\varphi_1 + R_2 \sin\varphi_2 + Qf = T_1 \cos\varphi_1 + T_2 \cos\varphi_2 \tag{2}$$

and to the vertical axis:

$$R_1 \cos\varphi_1 + T_1 \sin\varphi_1 = R_2 \cos\varphi_2 + T_2 \sin\varphi_2 + Q \tag{3}$$

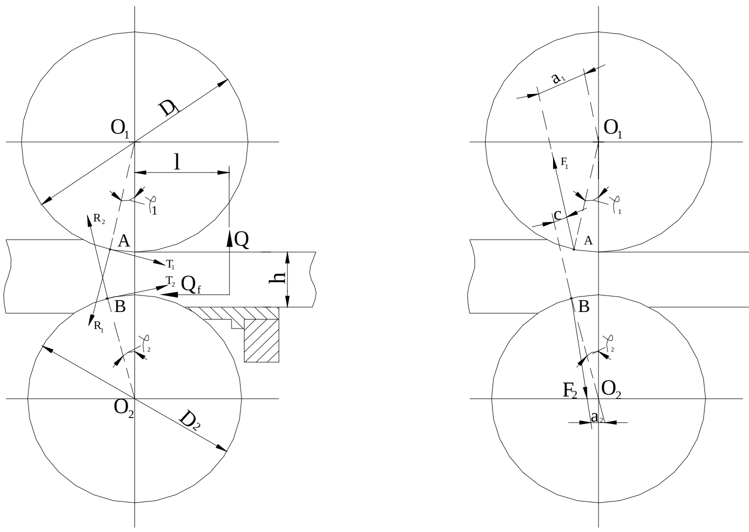

FIG.1. The interaction of forces between the metallic and the rolls of different diameters: a - the forces actioning on the rod; b - the forces actioning on the rolls.

The force momentum sun in relation with the point (3) will be relation (4):

$$(R_1 \sin\varphi_1 - T_1 \cos\varphi_1)\left[h + r_1(1-\cos\varphi_1) + r_2(1-\cos\varphi_2)\right] - (R_1 \cos\varphi_1 + T_1 \sin\varphi_1)(r_1 \sin\varphi_1 - r_2 \sin\varphi_2) = Ql \tag{4}$$

The force moments R_2 and T_2 passing through the point 3 are equal to zero. The force moments Qf, because of its negligible arm, are ignored.

To simplify the equation solving (2) and (3) we also neglect the force Q and Qf, because of the reduced value comparative with the forces R and T. These, the equation (2) and (3) become:

$$R_1 \sin\varphi_1 - T_1 \cos\varphi_1 = T_2 \cos\varphi_2 - R_2 \sin\varphi_2 \tag{5}$$

$$R_1 \cos\varphi_1 + T_1 \sin\varphi_1 = R_2 \cos\varphi_2 + T_2 \sin\varphi_2 \tag{6}$$

Solving the two equations we obtain that resultants of the bar pressure on the rolls (low and high) are equal and parallel one with the other. Noting (figure 1.b) the resultant of metal pressure on the roll with F_1 and its arm with "c" (the perpendicular line drawn from the point A to the resultant direction F_2), the equation (4) becomes:

$$F_1 c = Ql \tag{7}$$

Analyzing the equation it can be seen that the more the moment caused by the chisel reaction increases, the bigger the arm "c" must be, able to perform by increasing the difference between the angles φ_1 and φ_2 by the force inclination F_1 and F_2 against the horizontal line.

Because the values $r_2 \sin\varphi_2$ and $r_1 \sin\varphi_1$ are very close, and the arcs of contact of both rolls are about equal, the forces F_1 and F_2 will not be vertical.

Thus, at rolling with high and low pressure there appear side pressures acting over the rolls and the bearings as a result of equality and parallelism between the forces F_1 and F_2. These pressures are equal for both rolls, but toward different directions namely the less- diameter roll presses on the bearing in the rolling direction, and the one having larger diameter in the opposite direction.

If we note the vertical pressure with y and the horizontal one with x, the latter will be:

$$x = \frac{Ql + y(r_1 \sin\varphi_1 - r_2 \sin\varphi_2)}{h + r_1(1 - \cos\varphi_1) + r_2(1 - \cos\varphi_2)} \tag{8}$$

where:

S - is the static moment of the bar section coming from rolls;

k - is the yield point of the metallic material at the given temperature.

By hot rolling, at the trio section rolling mills, the bend moment Ql can be established approximatively with the aid of the equation:

$$M_{bend} = Ql = Sk \tag{9}$$

The moment necessary for turning around the low and high rolls can be established using the measurements already known y and x.

$$M_1 = yr_1 \sin\varphi_1 + yr_1 \cos\varphi_1 \tag{10}$$

$$M_2 = yr_2 \sin\varphi_2 - yr_2 \cos\varphi_2 \tag{11}$$

Out of the equation (10) and (11) it can be seen that moment necessary for the roll rotation is distributed uneven; at the roll higher peripheral speed than at be seen in the figure 1.b.

$$F_1 a_1 = F_2 a_2 \tag{12}$$

In case of a considerable difference between the peripheral speeds of the rolls, both arms of the equation (10) can become equal. Then $M_2 = 0$, because the force F_2 will be pass through the low roll center, and the moment necessary for rolling must be applied entirely to the other roll with higher peripheral speed. If:

$$yr_2 \sin\varphi_2 > yr_2 \cos\varphi_2 \tag{13}$$

the force F_2 passes above the point O_2 and the low roll acts as brake.

The cases analyzed can be met in the industrial scale practice at the trio section rolling mills. It is usually known that at the high pressure rolling, the moment for the low roll is not reduced up to zero, so that the driving moment is distributed in the gearing stand, approximately in this way:

- for the rotation (turning around) of the bigger diameter roll:

$$M_2 = (0{,}6 - 0{,}8)M_{mot} \tag{14}$$

- for the rotation of the smaller-diameter roll:

$$M_2 = (0{,}2 - 0{,}4)M_{mot} \tag{15}$$

If we admit that $\varphi_1 = \varphi_2$ and $D_1 = D_2$ for simplifying the calculations, we can determine the difference between the moments orientatively:

$$M_1 - M_2 = \frac{QlD \cos \varphi}{h + D(1 - \cos \varphi)} \tag{16}$$

3. CONCLUSIONS

The theoretical analysis made in this paper is valid for the industrial scale practice at the trio section rolling mills. If the difference between the peripheral speeds of the rolls becomes considerable, there interferes the situation when the roll having the smaller diameter acts like a brake, endadangering the reliability of the technological equipment.

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