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A STUDY ON PLANETARY ROLLING PROCESS

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The paper presents the study results concerning the cynematics and dynamics of the planetary rolling and the specific features of semi-planetary rolling.

Introduction

The planetary rolling confers high productivity, low material and energetic specific consumption, facilities for work mechanization and automation.

There are cases when the technological conditions for the fabrication of semi-products or for special properties assurance of the semi- products, as in the case of the continuous cast of slabs, the induction of superficial compression stress is necessary.

In this cases using of planetary or semi-planetary rolling is recommended.

The principled scheme of semi-planetary rolling showed in figure 1 [1].

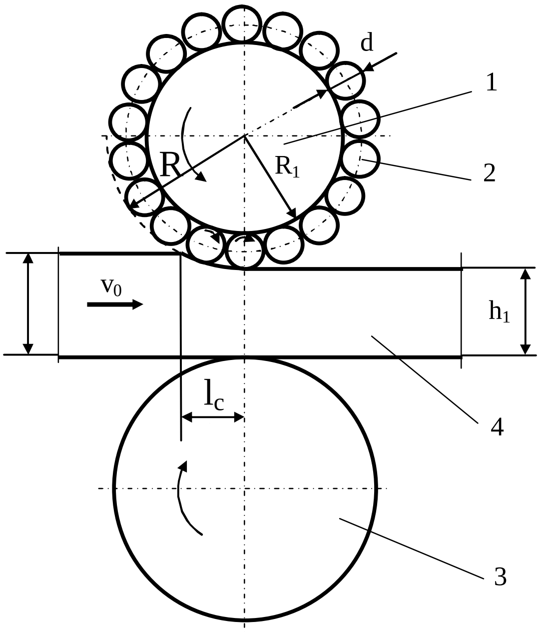

Fig. 1. Scheme of semi-planetary rolling:
1-planetary cylinder, 2-satellite cylinder,
3-inferior cylinder, 4-semi-product

Analysis of deformation conditions to semi-planetary rolling

Because the satellite cylinder has small diameter, in comparison with inferior cylinder, the strain state will be localized to marginal layer to contact surface of semi-product and planetary cylinder.

Suppose the movement of semi-product is described by speed v_0 constant. The revolution of the inferior cylinder is also, constant and corresponds to speed v_0.

The planetary cylinder may be turned in sense of the speed v_0 (equi-current) or in contraire sense (counter-current).

Suppose the axis of planetary cylinder is included in vertical plan of inferior cylinder and the rotation sense corresponds to direct sense of the semi-product displacement (fig. 2).

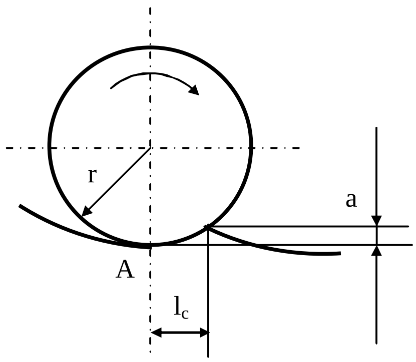

Fig. 2. Deformation zone

Denote *n* number of satellite cylinders.

The angle between two successive satellite cylinder is:

$$\theta = \frac{360^0}{n} \quad \text{sau} \quad \theta = \frac{2\pi}{n}, [\text{rad}]. \tag{1}$$

The time between the successive planetary cylinder is:

$$\Delta t = \frac{\theta}{\omega} = \frac{1}{n \cdot N}\ , \tag{2}$$

where *w* is the angular speed and N is the revolution of the superior cylinder.

Thus, the advance of semi-product between two satellite cylinders will be:

$$l_c = v_0 \cdot \Delta t\ , \tag{3}$$

and represents a dimension of the contact surface between satellite cylinder and material.

Denote *l* the dimension of this contact surface. This depends by the reduction of the thickness of semi-product:

$$l = \sqrt{2(R+d)\cdot \Delta h}\ . \tag{4}$$

Supposed that the deformation to inferior cylinder is negligible. The force to the satellite cylinder is:

$$F = p \cdot B \cdot l_c = p \cdot B \cdot v_0 \cdot \frac{1}{n \cdot N}. \quad (5)$$

In this relation, *p* is the mean deformation pressure and B is the width of semi-product. Consequently, the force depends by the revolution of the planetary cylinder. The diminution of force is result of increasing of planetary cylinder revolution.

For calculation of the mean pressure, we consider a slip line into deformation zone (fig. 3).

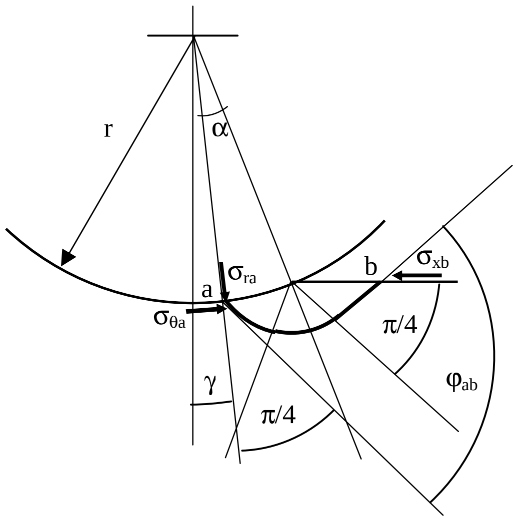

Fig. 3. Slip line into the deformation zone

As result of the Hencky theorem, the relation for calculation of stress σ_{ra} is [2]:

$$\sigma_{ra} = R_d(1 + \varphi_{ab}). \quad (6)$$

The deviation angle φ_{ab} is:

$$\varphi = \frac{\pi}{2} - \gamma, \quad (7)$$

and

$$\sigma_{ra} = -R_d\left(1 + \frac{\pi}{2} - \gamma\right). \quad (8)$$

The elementary force to the contact surface is:

$$dF = |\sigma_{ra}| \cdot B \cdot r \cdot d\gamma. \quad (9)$$

After integration for $\gamma \in [0,\alpha]$ we obtain the formula for calculation of mean pressure:

$$p = R_d \cdot \alpha \cdot \left(1+\frac{\pi}{2}-\frac{\alpha}{2}\right), \tag{10}$$

where R_d is the deformation resistance of the material.

Establishing of trace equation of deformed surface

The trace of the contact surface is described by the point M (see fig. 4). The motion of this point, relative to the fixed coordinate system, with the base point O, is composed by the rotation motion of the planetary cylinder and linear motion of the semi-product. We consider the contra-current case.

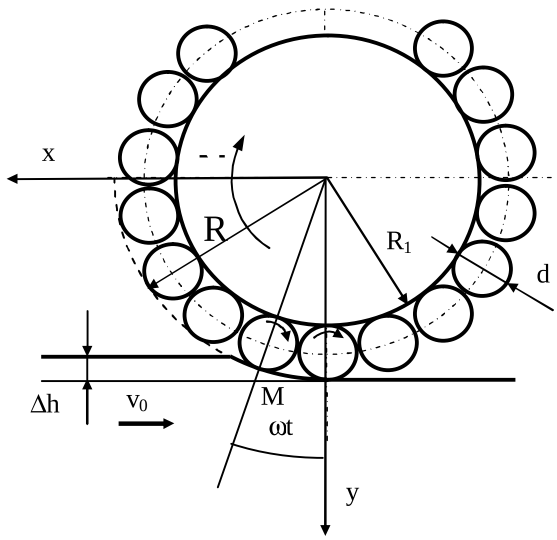

Fig. 4. Scheme for calculation of trajectory equation

To the moment t the coordinates of point M are described by the following relations:

$x = R\cdot\sin(\omega t) + v_0\cdot t$; $y = R\cdot\cos(\omega t)$, $t\in[0,t_0]$,

where t_0 is the time of effective contact between the satellite cylinder and semi-product. Is the time from entrance and exit of satellite cylinder in contact with semi-product.

We denote Δh, the variation of thickness made by the planetary cylinder. We have:

$y_0 = R - \Delta h = R\cdot\cos(\omega t_0)$,

and

$$t_0 = \frac{1}{\omega}\cdot\arccos\left(\frac{R-\Delta h}{R}\right). \tag{13}$$

For normalization we admit the parameter $\eta = (t/t_0)$, and $\eta\in[0,1]$.

After the elimination of the trigonometric functions in the relations (11) we obtain:

$$\left(x - v_0 \cdot t_0 \cdot h\right)^2 + y^2 = R^2 \text{ , } y \in \left[R - \Delta h, R\right]. \qquad (14)$$

The relation (14) represents the equation of the trace of deformation surface.

Conclusions

In the special cases, the superficial deformation of the long semi-product the semi-planetary rolling is necessary. This fact awards the advantage of the controlled stress and strain states.

This method induces a favorable stress state in the superficial layer of the long semi-product.

The semi-planetary rolling enables, for example, the continuous casting of the slabs from steels alloyed with manganese, chrome and other added elements and eliminates the superficial fissures and finally the defects to the rolled product.

The kinematics and dynamics of the semi-planetary rolling is a complex process and its study is necessary.

References

1. Cananau, N. Teoria deformării plastice. Universitatea din Galați, 1995.
2. Dragan, I. Tehnologia deformării plastice. Editura didactică şi pedagogică, Bucureşti, 1979.
3. Kachanov, L. Éléments de la théorie de la plasticité. Editions Mir, Moscou, 1975.
4. Sokolovskii, V. Teoria plasticității. Editura tehnica, Bucuresti, 1972.
5. Adrian, M. Tehnologia laminării. Editura didactică şi pedagogică, Bucureşti, 1977.

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STUDIU ASUPRA PROCESULUI DE LAMINARE CU CILINDRI PLANETARI

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Lucrarea prezintă rezultatele studiilor efectuate cu privire la cinematica şi dinamica laminării cu cilindri planetari şi particularitățile laminării semi-planetare.

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