The 4th International Conference
″Computational Mechanics
and Virtual Engineering″
COMEC 2011
20-22 OCTOBER 2011, Brasov, Romania

SIMULATION OF THE ROUGHING PROCESSES

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Abstract: *When a metal strip is passed through a rolling mill to produce an appreciable reduction In thickness, the plastic deformation is generally large compared with the elastic deformation so that the material can be regarded as being rigid plastic .In the first instance the elastic deformation of the rolls may also be neglected. We tried to answer to the main question: how are the elastic contact stress and deformation between curved face in contact influenced by surface roughness?*
Many processes involve the passage of a strip or sheet of material through the nip between rollers. In this paper we consider the strip to be perfectly elastic and investigate the stress in the strip, the length of the arc of contact with the roller, the maximum indentation of the strip and the precise speed at which it feeds through the nip in relation to the surface speed of the rollers. If the strip is wide and the rollers are long in the axial direction it is reasonable to assume plane deformation
Keyword: contact, elastic, strip, rollers, rough,, friction,

1. Elastic contact model of roughing surface

The stresses in an elastic strip due to symmetrical bands of pressure acting on opposite faces have been expressed by Sneddon (1951) in terms of Fourier integral transforms. The form of these integrals is particularly awkward and most problems require elaborate numerical computations for their solution. However, when the thickness of the strip 2b is much less than the arc of contact 2a an elementary treatment is sometimes possible. The situation is complicated further by friction between the strip and the rollers. We can analyses the problem assuming (a) no friction ($\mu = 0$) and (b) complete adhesion ($\mu \to \infty$), but our experience of rolling contact conditions leads us to expect that the arc of contact will, in fact, comprise zones of both "stick" and "slip".

We will look first at a strip whose elastic modulus is of similar magnitude to that of rollers, and write

$$C = \frac{(1-\nu_1^2)/E_1}{(1-\nu_2^2)/E_2} = \frac{1+\alpha}{1-\alpha} \tag{1}$$

Where: α is defined by the equation (11), and 1.2, refers to the strip and the rollers respectively.

$$\alpha = \frac{[(1-\nu_1)/G_1]-[(1-\nu_2)/G_2]}{[(1-\nu_1)/G_1]+[(1-\nu_2)/G_2]} \tag{2}$$

If the strip is thick ($(b \ge a)$ it will deform like an elastic half-space.

At the other extreme, when $b \le a$, the deformation is shown in fig.1.

The compression of the roller is now much greater than that of the strip so that the pressure distribution again approximates to the Hertz

$$p(x) = \frac{2P}{\pi a}(1-x^2/a^2)^{1/2} \tag{3}$$

The strip is assumed to deforms with plane sections remaining plane so that the compression at the centre of the strip is given by

$$d = \frac{b(1-\nu_1^2)p(0)}{E_1} = \frac{2b(1-\nu_1^2)P}{\pi a E_1} \tag{4}$$

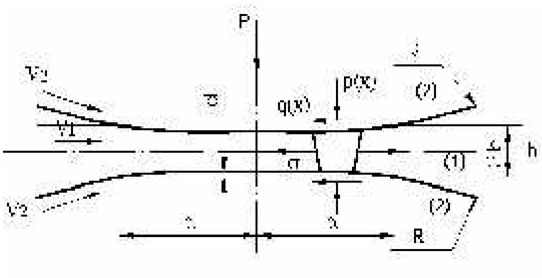

Figure 1

If the deformed surfaces of the strip are more approximated by circular of radius R', then

$$\frac{1}{R'} = \frac{2d}{a^2} = \frac{4b(1-\nu_1^2)P}{\pi a^2 E_1} \tag{5}$$

The rollers are flattered from a radius *R* to *R'* so that

$$a^2 = \frac{4P(1-\nu_2^2)}{\pi E_2} / (\frac{1}{R} - \frac{1}{R'}) \tag{6}$$

Eliminating *R'* from (12) and (13) gives

$$(\frac{a}{a_o})^2 = 1 + C\frac{b}{a} \tag{7}$$

Where: $a_o = (4PR(1-\nu_2^2)/E_2)^{\frac{1}{2}}$ is the semi-contact width for vanishingly thin- slip.

With friction leas rollers the longitudinal stress in the strip σ_x is either zero or equal to any external tension in the strip. Due to the reduction in thickness, the strip extends longitudinally, whilst the roller surface compresses to the Hertz theory, so that in fact frictional tractions *q(x)* arise (acting inwards on the strip) whether or not materials of the strip and rollers are the same. For equilibrium of an element of the strip we have:

$$\frac{d\sigma_x}{dx} = \frac{1}{b} q(x) \tag{8}$$

Slip between the rollers and the strip is governed by the equation (9)

$$\dot{s}_x / V = \xi_x - \psi y / c + (\frac{\partial u_{x1}}{\partial x} - \frac{\partial u_{x2}}{\partial x}) \tag{9}$$

In addition, it is consistent with neglecting second order terms in ϕ to replace h by the mean thickness

Where: $\dot{\xi}_x \equiv (\delta V_{x1} - \delta V_{x2})/V$ and $\dot{\xi} \equiv (\delta V_{y1} - \delta V_{y2})/V$ are the creep rations γ is the non-dimensional spin parameter, $(\omega_{x1} - \omega_{x2})cV$, and $c = (ab)^{\frac{1}{2}}$.

In a stick region:

$$\dot{x}_x = \dot{x}_y = 0$$

In additional, the resultant tangential traction must not exceed its limiting value:

$$|q(x,y)| \langle \mu p(x,y) \tag{10}$$

And, the direction of q must oppose the velocity:

$$\frac{q(x,y)}{|q(x,y)|} = \frac{\dot{s}(x,y)}{|\dot{s}(x,y)|} \tag{11}$$

If there is no slip equation (11) reduces to:

$$\frac{\partial u_{x1}}{\partial x} - \frac{\partial u_{x2}}{\partial x} = -\xi \tag{12}$$

Where: ξ is the creep ratio $(V_1 - V_2)/V_2$ of the strip relative, to the periphery of the rollers. The longitudinal strain in a roller within the contact arc is given by equation.

$$\frac{\partial u_{x1}}{\partial x} = \frac{1-\nu_1^2}{E_1}\left(\sigma_x + \frac{\nu_1}{1-\nu_1} p(x)\right) \tag{13}$$

The integral equation (10) is satisfied by the traction:

$$q(x) = (1 - \frac{4\beta}{1+\alpha})\frac{b}{2a} p_o \frac{x}{(a^2 - x^2)^{\frac{1}{2}}} \tag{14}$$

Where: β is defined by the equation:

$$\beta = \frac{1}{2}\left[\frac{(1-2\nu_1)/G_1 - (1-2\nu_2)/G_2}{(1-\nu_1)/G_1 + (1-\nu_2)/G_2}\right] \tag{15}$$

The distribution of traction and also the stress difference (σ_x-σ_y) ţon the centre plane of the strip are show in fig.2.

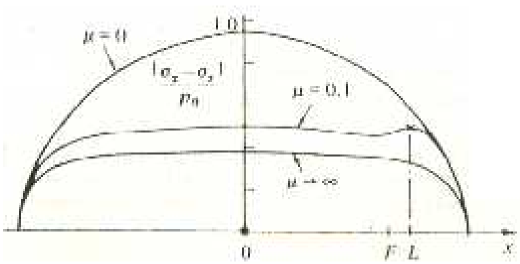

Figure 2

2. CONCLUSION

The paper explains through the theory of contact mechanics how are the elastic contact stress and deformation between rigid plastic in contact, influence by surface deformation and stress in the roughing process.

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