The Lippmann - Mahrenholz Power and Labour PyRolL Plugin

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This plugin provides the roll force and roll torque model developed by Lippmann and Mahrenholtz [1]. The basic equations are derived from classic strip theory with simplifications suitable for hot rolling. For the presented plugin, the specific roll torque at the upper work roll is calculated. Usage of the equations for groove rolling is only valid, when using an equivalent rectangle approach. Furthermore, the used variable h is the height of the equivalent flat workpiece and b_m it's mean width, $k_{f,m}$ represents the mean flow stress of the material and ϵ the relative drought of the pass. The indices 0 and 1 denote the incoming and exiting states and L_d is the contact length of the pass.

1 Model approach

To calculate the roll force in hot rolling, the following equation was developed:

$$F_{Roll} = A_d k_{f,m} Q_F \tag{1}$$

The function Q_{Force} is the inverse forming efficiency and is calculated using equation (2a). This function depends on the neutral line angle β_n, which is calculated through equation (2b). σ_R and σ_V are the forward and backward tension applied to the pass.

$$Q_F = \frac{\sigma_R}{k_{f,m}} + 2\sqrt{\frac{1-|\epsilon|}{|\epsilon|}} \arctan\left(\sqrt{\frac{|\epsilon|}{1-|\epsilon|}}\right) - 1 + \sqrt{\frac{R}{h_1}}\sqrt{\frac{1-|\epsilon|}{|\epsilon|}} \log\left(\frac{\sqrt{1-|\epsilon|}}{1-|\epsilon|(1-\beta_n^2)}\right) \tag{2a}$$

$$\beta_n = \sqrt{\frac{1-|\epsilon|}{|\epsilon|}} \tan\left(\frac{1}{2}\sqrt{\frac{h_1}{R}}\left[\frac{\sigma_R - \sigma_V}{k_{f,m}} + \log(1-|\epsilon|)\right] + \frac{1}{2}\arctan\sqrt{\frac{|\epsilon|}{1-|\epsilon|}}\right) \tag{2b}$$

$$k_{f,m} = \frac{k_{f,0} + 2k_{f,1}}{3} \tag{2c}$$

As for the roll torque M_{roll} at a single roll, Lippmann and Mahrenholz developed a similar equation.

$$M_{roll} = b_m R k_{f,m} Q_M \Delta h \tag{3a}$$

$$Q_M = \sqrt{\frac{R}{h_1}} \sqrt{\frac{1-|\epsilon|}{|\epsilon|}} \left(\frac{1}{2} - \beta_n \right) \tag{3b}$$

2 Usage instructions

The plugin can be loaded under the name `pyroll_lippmann_mahrenholz__power_and_labour`.

An implementation of the `roll_force` and `roll_torque` hook on `RollPass` and `RollPass.Roll` is provided, calculating the roll force and torque using (1) and (3a). Values for the `mean_front_tension` as well as `mean_back_tension` have to be provided by the user for the `RollPass`. For the hook `mean_neutral_line_angle` on `RollPass` Equation 2b is implemented.

References

[1] Horst Lippmann and Oskar Mahrenholtz. *Plastomechanik der Umformung metallischer Werkstoffe*. de. Citation Key: Lippmann1967. Berlin, Heidelberg: Springer Berlin Heidelberg, 1967. ISBN: 978-3-642-87885-5. DOI: 10.1007/978-3-642-87884-8. URL: http://link.springer.com/10.1007/978-3-642-87884-8.