Tension spreading interaction PyRolL Plugin

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The PyRolL plugin pyroll-tension-spreading-interaction calculates the tension influenced spread of the rolled profile. The model was published by Dobler [1] and Mauk and Dobler [2] using data from Nikkilä [3] and Treis [4].

1 Model approach

To incorporate the effect of longitudinal tensions into the process of groove rolling, Dobler [1] developed an empirical model derived from different measurements by Nikkilä [3] and Treis [4]. The model is applied by defining a "tension free logarithmic elongation" as well as a "tension influenced logarithmic elongation". Both values are combined using superposition according to Equation 1

$$\varphi_l = \varphi_{l,\sigma=0} + \Delta\varphi_{l,\sigma} \tag{1}$$

The tension influenced logarithmic elongation $\Delta\varphi_{l,\sigma}$ is treated as a function of the mean flow stress ($k_{f,m}$), the acting tension stresses ($\sigma_{l,0}$,$\sigma_{l,1}$) as well as cross-section change. $\sigma_{l,0}$ is the acting mean back tension and $\sigma_{l,1}$ the mean front tension. Another influencing parameter which is treated indirectly is the strain rate $\dot{\varphi}$. This value is incorporated by the flow stress. Therefore,to achieve better calculative results a flow stress model incorporating the strain rate should be chosen. The influence of friction is incorporated by the drought ϵ_h as well as the roll gap ratio $\frac{b_0}{h_0}$ as well as the ratio of contact area and mean profile cross-section $\frac{A_d}{A_m}$.

Table 1: Coefficients for calculation of the tension influenced elongation $\varphi_{l,\sigma}$.

i	$m_{i,1}$	$m_{i,2}$	$m_{i,3}$
1	1.05502	0.100816	-0.591029
2	-0.886507	-0.00258613	0.159971
3	-0.347681	-0.0457338	0.0525161

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

$$x_0 = \frac{\sigma_{l,0}}{k_{f,m}} \tag{3}$$

$$x_1 = \frac{\sigma_{l,1}}{k_{f,m}} \tag{4}$$

$$A_m = \frac{A_0 + 2A_1}{3} \tag{5}$$

$$\Delta\varphi_{l,\sigma} = f\left(x_0, x_1, \epsilon_h, \frac{b_0}{h_0} m \frac{A_d}{A_m}\right) \tag{6}$$

From measurements by Nikkilä [3] and Treis [4], Dobler [1] came to the conclusion that the backward tension x_0 has a quadratic influence and the influence of the front tension x_1 could be model by a linear approach. He therefore published the following equation for calculation of the tension influenced elongation:

$$\Delta\varphi_{l,\sigma} = k_1 x_0^2 + k_2 x_0 + k_3 x_1 \tag{7}$$

The coefficients included in this formula are functions of the geometric parameters and are calculated by a linear relationship.

$$k_i = m_{i,1}\epsilon_h + m_{i,2}\frac{b_0}{h_0} + m_3\frac{A_d}{A_m} \tag{8}$$

The values for the coefficients $m_{i,j}$ where calculated by Dobler [1] using an equilibrium calculation for overdetermined linear systems of equations.

The statistical evaluation of calculated and measured forming influenced elongations shows a determination of 92.91%.

2 Usage instructions

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

An implementation of the `log_elongation` hook on `RollPass` is provided. Furthermore, an implementation of the `width` hook on `RollPass.OutProfile` is provided.

Additionally, hooks on `RollPass` are defined, which are used in the calculation, as listed in Table 2.

Table 2: Hooks specified by this plugin.

Hook name	Meaning
`tension_model`	Tension model of Dobler and Mauk
`log_elongation_with_tension`	Mean back tension of the roll pass $\varphi_{l,\sigma}$

References

[1] Andreas Dobler. "Modellierung des dynamischen Zusammenwirkens der Einflußgrößen des Walzvorgangs auf die Endtoleranz in Hochgeschwindigkeits-Walzmaschinen". de. Diplomarbeit. Duisburg: Universität Duisburg-Essen, 1998.

[2] P. J. Mauk and A. Dobler. "Die Einflussgrößen des Walzvorganges und ihre Auswirkungen auf die Toleranzen der Endquerschnitte bei Stabstahl und Walzdraht". de. In: *Der Kalibreur* 60 (1999), pp. 21–36.

[3] Kalevi Nikkilä. "On the Effects of Front and Back Tensions on Wire Rod Rolling". PhD Thesis. Helsinki University of Technology, 1977.

[4] H. Treis. "Ermittlung der Formänderungsverhältnisse beim Warmwalzen auf der Flachbahn ohne und mit äusserem Langszug". de. PhD Thesis. RWTH Aachen, 1968.