The Wusatowski Spreading PyRoll Plugin

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This plugin provides a spreading modelling approach with Wusatowski's formula for flat rolling.

1 Model approach

1.1 Wusatowski's spread equation

Wusatowski [1] proposed Equation 1 for estimation of spreading in flat rolling, where $\gamma = \frac{h_1}{h_0}$ is the compression. h and b are height and width of the workpiece with the indices 0 and 1 denoting the incoming respectively the outgoing profile. a, c, d and f are correction coefficients for temperature, velocity, material and friction, respectively.

$$\beta = \frac{b_1}{b_0} = a \times c \times d \times f \times \gamma^{-w} \tag{1}$$

The velocity coefficient c can be assumed as below in dependence on the velocity v.

$$c = (-0.002958 + 0.00341\gamma)\, v + 1.07168 - 0.10431\gamma \tag{2}$$

w is the spread exponent. As for strains ϵ smaller than 50%, Wusatowski [1] proposed Equation 3a. For strains higher than 50% Wusatowski [1] used a adjusted version of the exponent w_{high}. The origin of this equation was first given by Hill [2] which derived the equation from plastic stress-strain equations from Mises [3]. In the following expressions, R is the roll radius.

$$w_{low} = 10^{-1.269\left(\frac{h_0}{2R}\right)^{0.556}\frac{b_0}{h_0}} \tag{3a}$$

$$w_{high} = 10^{-3.457\left(\frac{h_0}{2R}\right)^{0.958}\frac{b_0}{h_0}} \tag{3b}$$

2 Usage instructions

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

Table 1: Hooks specified by this plugin. Symbols as in Equation 1.

Hook name	Meaning
`wusatowski_temperature_coefficient`	temperature correction coefficient a
`wusatowski_velocity_coefficient`	velocity correction coefficient c
`wusatowski_material_coefficient`	material correction coefficient d
`wusatowski_friction_coefficient`	friction correction coefficient f
`wusatowski_exponent_low`	spread exponent w_{low}
`wusatowski_exponent_high`	spread exponent w_{high}

An implementation of the `spread` hook on `RollPass` is provided, calculating the spread using the equivalent rectangle approach and Wusatowski's model.

Several additional hooks on `RollPass` are defined, which are used in spread calculation, as listed in Table 1. Base implementations of them are provided, so it should work out of the box. For `wusatowski_exponent_low`, `wusatowski_exponent_high` and `wusatowski_velocity_coefficient` the equations 3a, 3b and 2 are implemented. The others default to 1. Provide your own hook implementations or set attributes on the `RollPass` instances to alter the spreading behavior.

References

[1] Z. Wusatowski. *Fundamentals of Rolling*. Pergamon Press, 1969.

[2] R. Hill. *Letter to A. W. McCrum*. eng. 1955.

[3] Richard von Mises. "Mechanik der festen Körper im plastisch-deformablen Zustand". In: *Nachrichten von der Gesellschaft der Wissenschaften zu Göttingen* (1913).