

The Sander Spreading PyRoll Plugin

Christoph Renzing

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

1 Model approach

1.1 Sanders's spread equation

Sander [1, 2] 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.

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

w is the spread exponent, by Sander [1] is given in Equation 2, where R is the roll radius.

$$w = 10^{-0.76 \left(\frac{h_0}{b_0} \right)^{0.39} \left(\frac{b_0}{\sqrt{R \Delta h}} \right)^{0.12} \left(\frac{b_0}{R} \right)^{0.59}} \quad (2)$$

The temperature coefficient a is implement using the below condition for various temperature ranges.

$$a = \begin{cases} 1.005 & \text{if } 700^\circ\text{C} \leq \vartheta \leq 950^\circ\text{C} \\ 1 & \text{otherwise} \end{cases} \quad (3)$$

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

$$c = 1 - 0.0033v \left(1 - \frac{1}{\beta} \right) \quad (4)$$

The origin of this equation was first given by Hill [3] which derived the equation from plastic stress-strain equations from Mises [4].

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

Hook name	Meaning
<code>sander_temperature_coefficient</code>	temperature correction coefficient a
<code>sander_velocity_coefficient</code>	velocity correction coefficient c
<code>sander_material_coefficient</code>	material correction coefficient d
<code>sander_friction_coefficient</code>	friction correction coefficient f
<code>sander_exponent</code>	spread exponent w

2 Usage instructions

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

An implementation of the `width` hook on `RollPass.out_profile` is provided, calculating the width using the equivalent rectangle approach and Sander’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 `sander_exponent`, `sander_temperature_coefficient` and `sander_velocity_coefficient` the equations 2, 3 and 4 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] U. Sander. “Ein Beitrag zur Schaffung eines mathematischen Modells für die Berechnung der Breitung, der Walzkräfte, der Umformmomente, des Temperaturverlaufs und der Streckgrade beim Warmwalzen in Streckkalibern”. de. Diss. Magdeburg: TH Otto von Guericke Magdeburg, Oct. 1976.
- [2] U. Sander. “Beitrag zur Schaffung eines mathematischen Modells für die Berechnung der Breitung der Walzkräfte, des Umformmomentes, des Temperaturverlaufs und des Streckgrades beim Warmwalzen in Streckkaliberreihen”. In: *Neue Hütte* 23.1 (1978), pp. 36–37.
- [3] R. Hill. *Letter to A. W. McCrum*. eng. 1955.
- [4] Richard von Mises. “Mechanik der festen Körper im plastisch-deformablen Zustand”. In: *Nachrichten von der Gesellschaft der Wissenschaften zu Göttingen* (1913).