The Wusatowski Spreading PyRoll Plugin

Max Weiner

March 15, 2022

This plugin provides a spreading modelling approach with Wusatowski's formula for flat rolling, adapted on groove rolling by an equivalent rectangle approach.

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, many different expressions were given by various authors for its value. The original expression by Wusatowski [1] is given in Equation 3, where R is the roll radius.

$$w = 10^{-1.269\left(\frac{h_0}{2R}\right)^{0.56}\frac{b_0}{h_0}} \tag{3}$$

1.2 Equivalent rectangle approach

Wusatowskis spreading model [1] was originally built for flat rolling. A common approach for groove rolling is to calculate some equivalent rectangular profile to be able to use flat rolling models [2, 3]. Figure 1 shows 3 variants of calculating an equivalent rectangle of a profile.

The first variant is to keep the width constant and calculate the height h' so that the cross section A is equal:

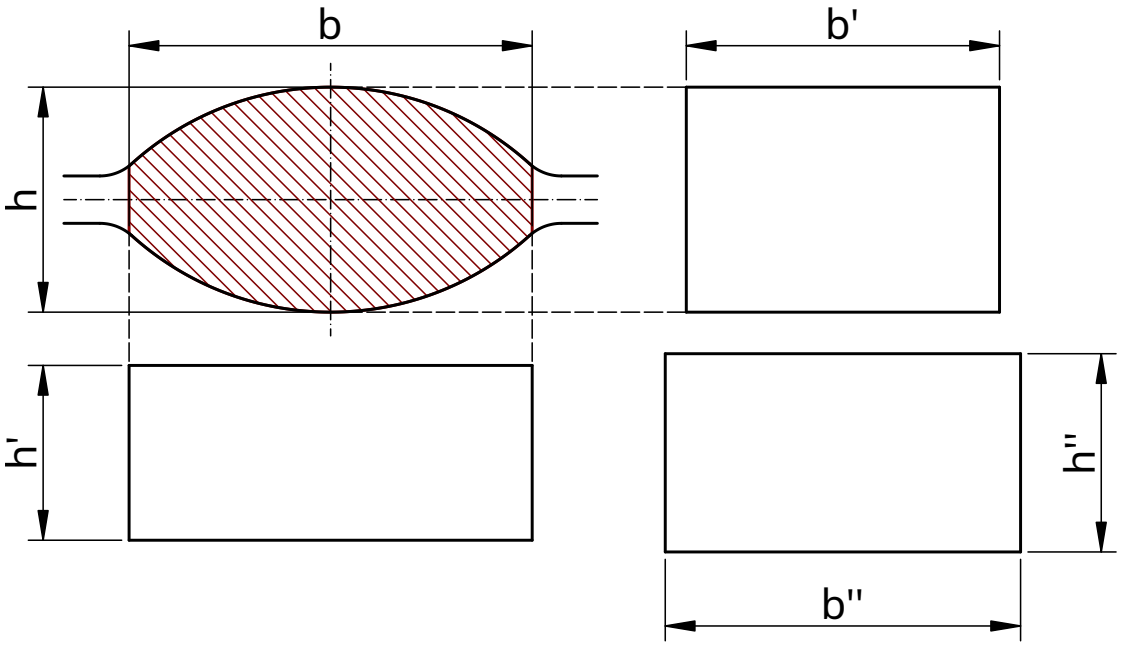

Figure 1: Three methods of defining an equivalent rectangle of an oval groove

$$h' = \frac{A}{b}$$

The second variant is to keep the height constant and calculate the width b' so that the cross section A is equal:

$$b' = \frac{A}{h}$$

Both represent the geometry of the profile poorly. A better way is to keep the aspect ratio equal as propose by Spittel, Eberlein, and Spittel [3]:

$$h'' = \sqrt{\frac{Ah}{b}}$$

$$b'' = \sqrt{\frac{Ab}{h}}$$

This variant is used in the current implementation. So h and b in Wusatowski's model are replaced with h'' and b''. In the end, b_1 can be obtained from b_1'' by:

$$b_1 = \frac{b_1'' h_1}{h_1''}$$

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`	spread exponent w

2 Usage instructions

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

An implementation of the `width_change` 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` and `wusatowski_velocity_coefficient` the equations 3 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] A. Hensel and Th. Spittel. *Kraft- und Arbeitsbedarf bildsamer Formgebungsverfahren*. Deutscher Verlag für Grundstoffindustrie, 1978.

[3] M. Spittel, L. Eberlein, and K. Spittel. "Berechnung des Umformgrads bei irregulären Kalibrierungen". In: *Neue Hütte* 29.7 (1984), pp. 259–262.