The Roux Spreading PyRoll Plugin

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

1 Model approach

1.1 Roux's spread equation

proposed Equation 3 for estimation of spreading in flat rolling. Where h and b are height and width of the workpiece with the indices 0 and 1 denoting the incoming respectively the outgoing profile. C_1 and C_2 are parameters introduced by Roux. R is the roll radius.

$$C_1 = \left(1 + 5\left(0.35 - \frac{\Delta h}{h_0}\right)^2\right)\sqrt{\frac{h_0}{\Delta h}} - 1 \tag{1}$$

$$C_2 = \left(\frac{b_0}{h_0} - 1\right)\left(\frac{b_0}{h_0}\right)^{\frac{2}{3}} \tag{2}$$

$$b_1 = b_0 + (h_0 - h_1)\,\frac{1}{\left(1 - \frac{\Delta h}{h_0}\right) + \frac{3C_1}{\left(2\frac{R}{h_0}\right)^{\frac{3}{4}}}}\,\frac{\frac{b_0}{h_0}}{1 + 0.57C_2} \tag{3}$$

1.2 Equivalent rectangle approach

Roux's 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:

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

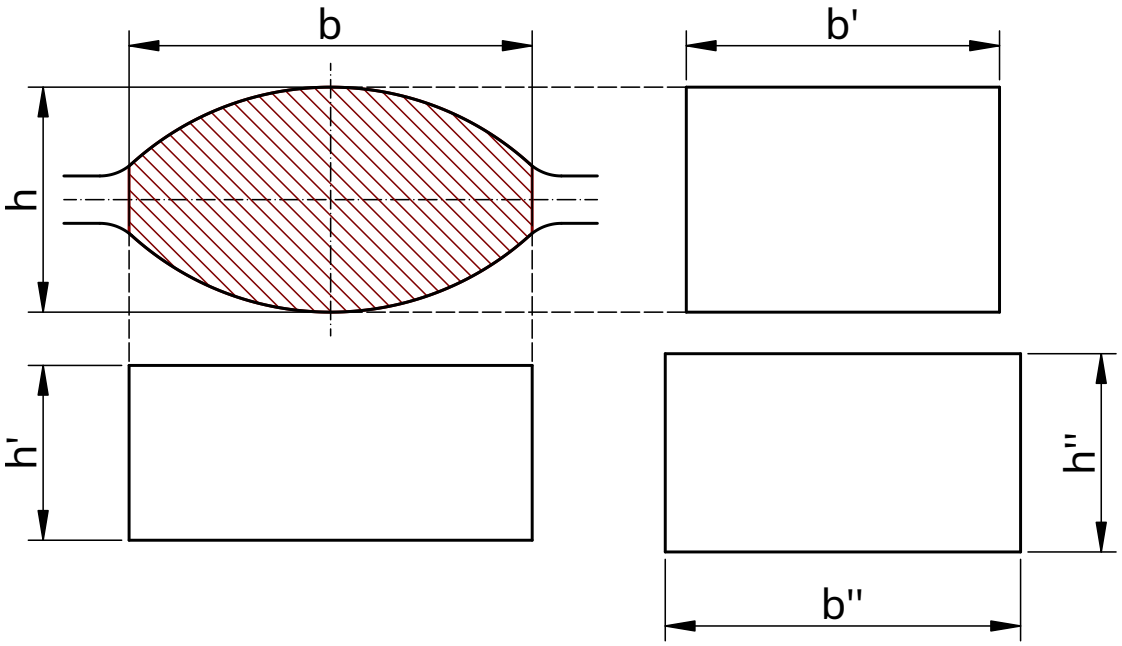

Figure 1: Three methods of defining an equivalent rectangle of an oval groove

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 Roux's model are replaced with h'' and b''. In the end, b_1 can be obtained from b_1'' by:

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

2 Usage instructions

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

Table 1: Hooks specified by this plugin. Symbols as in Equation 3.

Hook name	Meaning
`roux_parameter_c1`	Parameter C_1 of Roux's spreading equation
`roux_parameter_c2`	Parameter C_2 of Roux's spreading equation

An implementation of the `width_change` hook on `RollPass` is provided, calculating the spread using the equivalent rectangle approach and Roux'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 `roux_parameter_c1` and `roux_parameter_c2` the equations 1 and 2 are implemented. Friction coefficient can be adjusted individually. Provide your own hook implementations or set attributes on the `RollPass` instances to alter the spreading behavior.

References

[1] M. J. Roux. "Étude sur le phénomène de l'élargissement dans les laminoirs". In: *Rev. Metall* 36.6 (1939), pp. 257–270.

[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.