Lendl's equivalent rectangle method PyRoll Plugin

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January 30, 2023

This plugin provides the equivalent method after Lendl for calculation of an equivalent rectangle used for spread calculation.

1 Model approach

A common approach for groove rolling is to calculate some equivalent rectangular profile to be able to use spread models for flat rolling in groove rolling. This method is valid if the groove design is a simple irregular one. For this case, the roll pass is characterized by a change in height that varies across the width, with the caliber having more than one axis of symmetry. Lendl [1, 2, 3] proposed a method for calculation of an equivalent rectangle using the incoming profile of the roll pass and the groove used in the pass.

1.1 Two-Roll Passes

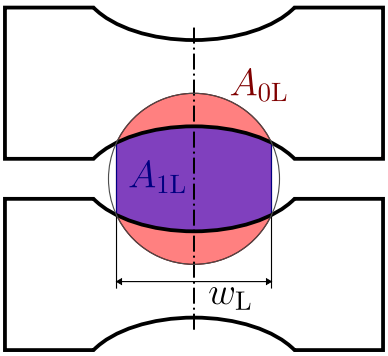

Figure 1: Lendl Areas for a Two-Roll Pass

The original method by Lendl [1, 2, 3] was defined for two-roll passes of classic elongation passes. The basic idea is to define a contact width of incoming profile and rolls by intersection of their contours, as shown in Figure 1. This width is commonly referred to

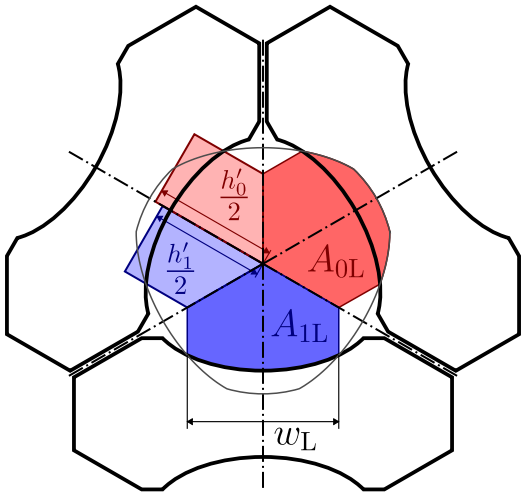

Figure 2: Lendl Areas, Widths and Heights According to [5]

as Lendl's width w_L. Accordingly, the two areas $A_{0\mathrm{L}}$ and $A_{1\mathrm{L}}$ are called Lendl's areas, which are the respective profile cross-sections clipped symmetrically at w_L.

The heights of the equivalent flat pass are defined as

$$h'_i = \frac{A_{i\mathrm{L}}}{w_\mathrm{L}} \tag{1}$$

For the equivalent width Mauk and Kopp [4] suggest to use the maximum width of the profile. This is implemented with this plugin.

1.2 Three-Roll Passes

For roll passes working with a three-roll system, the approach is slightly different due to the 3-fold symmetry as shown in Figure 2. Lendl's method for 3-roll passes was proposed by Overhagen and Mauk [5]. The method shown there is implemented with this plugin, but note the difference to the definition of widths and heights in PyRolL.

The equivalent heights are calculated using

$$h'_i = 2\frac{A_{i\mathrm{L}} + \frac{\sqrt{3}w_\mathrm{L}^2}{12}}{w_\mathrm{L}} \tag{2}$$

2 Usage instructions

The plugin can be loaded under the name `pyroll.lendl_equivalent_method`. The functionality of the plugin should work out of the box without provision of further data on units and incoming profile.

The plugin provides hook functions for `RollPass.Profile.euqivalent_width` and `RollPass.Profile.equivalent_height` using the calculation method above. Two hooks

are defined additionally: `RollPass.lendl_width` representing Lendl's width w_L and `RollPass.Profile.lendl_section` representing the geometry of Lendl's areas $A_{i\mathrm{L}}$. The latter return a `shapely.Polygon` object to be able to access geometric data aside the area itself. Therefore, the name `section` was chosen to distinguish from the pure numeric area value.

References

[1] A. E. Lendl. "Rolled Bars - Part I - Calculation of Spread between non parallel roll surfaces". In: *Iron and Steel* 21.14 (1948), pp. 397–402.

[2] A. E. Lendl. "Rolled Bars - Part II - Application of Spread Calculation to Pass Design". In: *Iron and Steel* 21.14 (1948), pp. 601–604. ISSN: 0021-1532.

[3] A. E. Lendl. "Rolled Bars - Part III - Application of Spread Calculation to Diamond Passes". In: *Iroan and Steel* 22.12 (1949), pp. 499–501. ISSN: 0021-1532.

[4] P. J. Mauk and R. Kopp. "Breitung beim Warmwalzen". In: *Der Kalibreur* 37 (1982).

[5] Christian Overhagen and Paul Josef Mauk. "A New Rolling Model for Three-Roll Rolling Mills". In: *Key Engineering Materials* 622–623 (Sept. 2014), pp. 879–886. DOI: 10.4028/www.scientific.net/KEM.622-623.879.