Abridged version

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Steel Pipe

Three-Dimensional Analysis of Flat Rolling of Rectangular Stock by a Numerical Method Based on Upper Bound Theory

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Synopsis :

Three-dimensional rolling of rectangular bar is analyzed. This analysis is based on the upper bound theorem. The total energy dissipation rate is minimized by the simplex method which is one of the direct methods of nonlinear optimization. It is assumed that kinematically admissible velocity is a cubic function of the distance from the entry plane and the cross section of rolled stock keeps plane in the roll gap. Though the velocity field is simple, the calculation results of the spread and rolling torque agree well with leadmodel experiments. From these results, deformation energy efficiency in case of flat rolling of the rectangular bar becomes maximum in the rolling condition of Ld/Hm=1.

The body can be viewed from the next page.

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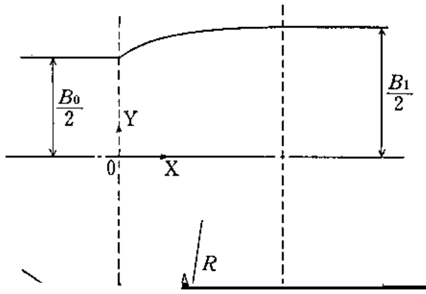


Since $w = B_0$ at $x = 0$, $w = B_1$ at $x = L_d$, and $dw/dx = 0$ at $x = L_d$, the external shape is given by the following equation:

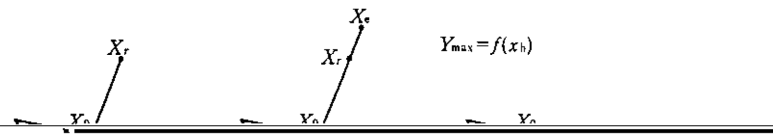
$$w(x) = B_0 + C_0 x + (3 \cdot w_0 \cdot B_0 - 2C_0 L_d)\left(\frac{x}{L_d}\right)^2 + (C_0 L_d - 2w_0 B_0)\left(\frac{x}{L_d}\right)^3 \quad \cdots\cdots\cdots\cdots (2)$$

$$\dot{\varepsilon}_{ij} = \frac{1}{2}\left(\frac{\partial v_i}{\partial x_j} + \frac{\partial v_j}{\partial x_i}\right) \qquad \cdots\cdots(8)$$

$$\dot{\varepsilon}_{eq} = \sqrt{\frac{2}{3} \sum_{ij=1}^{3} \dot{\varepsilon}_{ij}\dot{\varepsilon}_{ij}}$$

The velocity field nearest to the true value can be obtained if a stationary condition for the total energy dissipation rate Φ and the steady condition, in which the velocity field after the satisfaction of this stationary condition coincides with the initially assumed velocity field are both satisfied by appropriately selecting these

reflection, expansion, and contraction of the simplexes, as shown in **Fig. 2**. When the number of degrees of freedom is small, the convergence characteristic is usually good, making this an effective calculation method. The flow of calculation is schematically shown in **Fig. 3**.



3 Experimental Method

A comparison was made between results of an analysis by the upper bound technique and those of lead-model experiments[9] using a stock of almost the same [redacted]

rolling of a rectangular bar corresponds to grooveless [redacted]

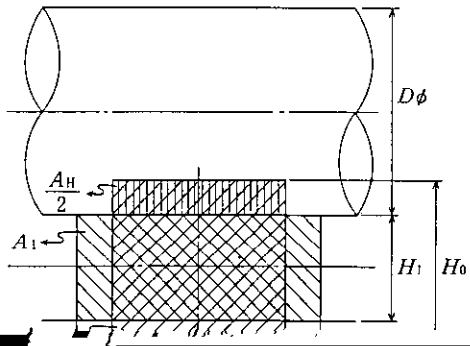
rough rolling method for wire rods and bars. Conditions [redacted]

4 Comparison between Experiment and Calculation Results; Discussion

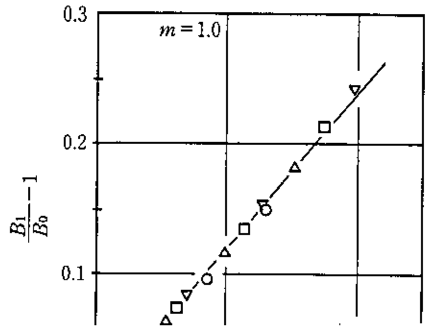
The relationship between the spread ratio and reduction determined from the average width is shown in [redacted]

width and thickness as in this experiment, the width [redacted]

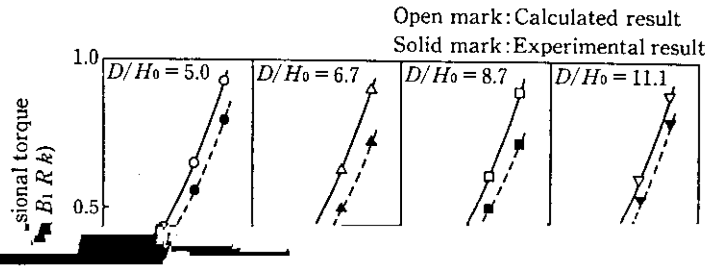
reduction, as already reported[11]; the smaller the stock [redacted]



$D\phi$
$\frac{A_H}{2}$
A_1
H_1
H_0

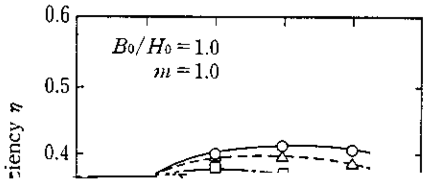


0.3
0.2
0.1
$m=1.0$
$\frac{B_1}{B_0}-1$

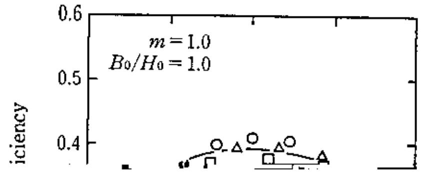


Reduction

Fig. 9 Accuracy of calculation results of rolling torque



0.6
$B_0/H_0 = 1.0$
$m = 1.0$
0.5
iciency η
0.4



0.6
$m = 1.0$
$B_0/H_0 = 1.0$
0.5
iciency
0.4

[illegible]