Sample Calculation for Predicting Roll Separating Force for 1 Pass through the Rolling Mill

Note: The calculations shown below are based on the following data, starting from a 4.70 mm (.185 inch) thick 6061-T0 aluminum plate (your calculations should use your data from the Rolling Lab):

Previous Pass:

\[ t_i = 2.41 \text{ mm}; \quad L = 582 \text{ mm}; \quad w = 99 \text{ mm}; \quad F_{\text{act}} = 121 \text{ kN}; \quad \sigma_{yf} = 195 \text{ MPa} \]

Current Pass:

\[ t_o = 2.03 \text{ mm}; \quad L = 680 \text{ mm}; \quad w = 99 \text{ mm}; \quad F_{\text{act}} = 134 \text{ kN} \]

Calculations:

\[ \Delta t = t_o - t_i = 0.38 \text{ mm} \]
\[ L_R = \sqrt{R \Delta t} = \sqrt{\left(\frac{133}{2} \text{ mm}\right)(.38 \text{ mm})} = 5.03 \text{ mm} \]
\[ \epsilon_{1,\text{total}} = \ln \left( \frac{t_{\text{init}}}{t_o} \right) = \ln \left( \frac{4.70 \text{ mm}}{2.03 \text{ mm}} \right) = 0.840 \]
\[ \epsilon_e = \frac{2}{\sqrt{3}} \epsilon_{1,\text{total}} = .969 \]
\[ K = 205 \text{ MPa}; \quad n = 0.20 \quad \text{(K&S Table 2.3)} \]
\[ \sigma_{yf} = K \epsilon_e^n = (205 \text{ MPa})(.969)^{0.20} = 204 \text{ MPa} \]
\[ Y \approx \frac{1}{2}(195 \text{ MPa} + 204 \text{ MPa}) = 200 \text{ MPa} \]
\[ \sigma_3 = -\frac{2}{\sqrt{3}} Y = -231 \text{ MPa} \]
\[ |F| = L_R w |\sigma_3| = (5.03 \times 10^{-3} \text{ m})(99 \times 10^{-3} \text{ m})(231 \times 10^6 \text{ Pa}) = 115 \text{ kN} \]
\[ \frac{134 \text{ kN} - 115 \text{ kN}}{134 \text{ kN}} = 14\% \]

Therefore, the predicted roll separating force is within 14% of the actual value for this pass. This is a reasonable result, considering all of our modeling assumptions.

For all data points that I analyzed for this example, the results were best in the middle and “so-so” at the ends. However, the order of magnitude of the forces was correct even at the extremes.