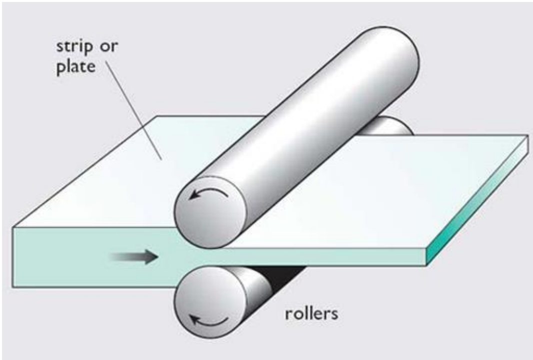
**Assignment # 4, Module 8, Metal Bulk Deformation**

Please submit on Canvas by Saturday, Nov $9^{th}$ ,11:59 PM

**Q1)** An Aluminum alloy strip (width $W = 300mm$, thickness $t_0 = 25mm$) is formed through a rolling mill, each roll radius $R = 250mm$.

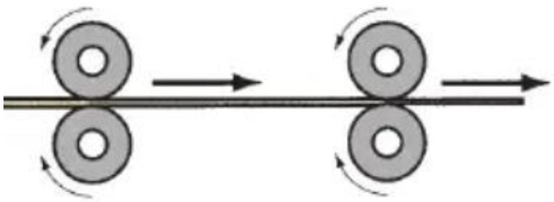
The strength coefficient of the material is $K = 275\ MPa$, and the strain hardening exponent $n = 0.15$ , the process is a warm rolling and the friction coefficient between each roller and the plate is approximated as $\mu = 0.12$

The rollers speed is $N = 50\ RPM$. In this process, the plate thickness needs to be reduced to $20mm$.




**Part 1.** check if the rolling process to reduce the thickness to 20mm can be achieved in one path?

**Part 2.** The engineer, in charge of designing the process, decides to conduct the process in two passes; in each pass, the plate thickness is to be reduced 2.5mm. Calculate the required power (for each roller set)? Note that the width of the plate changes after the first pass (Assume 10% slippage between the rollers and the plate)



**Part 3.** Optimize the process in terms of power consumption by configuring the thickness reduction in each pass? (i.e. Does the thickness reduction of 2.5mm and 2.5mm in each step requires the minimum power for each roller sets, or the initial thickness reduction must be higher or less than the second step thickness reduction?) (Assume 10% slippage between the rollers and the plate)

**Hint:** assume a thickness reduction in the first step to be x, then the reduction of next step is 5-x; with 10% slippage, and constant volume flow rate, the width change can be calculated as $25 \times 300 = 1.1 \times (new\ width) \times (25 - x)$. Calculate required power for step 1 (thickness reduction from 25 to 25-x), and required power for step 2 (thickness reduction from 25-x to 20). The total power requirement is sum of each step; find x which minimize the total power.

**Q2)** In an open forging operation, the starting piece is a cylindrical ingot of 75mm in height and 50mm in diameter. The goal is to reduce the height to 36mm. The ingot material is a low Carbon steel with strength coefficient K=350 MPa, and strain hardening exponent of n=0.17; the coefficient of friction is $\mu = 0.1$

Determine the force as the process begins, at intermediate heights of 62mm, 49mm, and at the final height of 36mm? Using these values, plot the load-stroke curve (a graph of force F as a function of height reduction $h_0 - h$)