Metal Forming Processes (ME5807)

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Metal Forming Processes−ME5807

Module 03

Lect 3.02

Roll Force, Torque, and Power

The roll force, roll torque, and drive power necessary to form the workpiece are some of the important parameters of process information.

(a) Roll Force The roll separating force can be determined if the distribution of normal pressure in the deformation zone is known by the following equation:

$$F = \int_0^L wpdL = w \int_0^L pdL \tag{1}$$

Where,
F = rolling force, N (lb)
w = width of workpiece, mm
p = roll pressure
L = projected arc of contact between roll and workpiece, *mm*

Roll Force

Because, in practice, the arc of contact between the roll and the workpiece is very small compared with the roll radius, So it can be assumed that the force is perpendicular to the plane of the workpiece without causing significant errors in the calculations. Thus, the roll force can be calculated based on the average flow stress experienced by the material in the roll gap from the formula:

$$F = Lw\sigma_{f(m)} \tag{2}$$

Where,

$\sigma_{f(m)}$ = average flow stress, MPa

Lw = roll workpiece contact area, mm^2

Roll Force

L is projected arc of contact between roll and workpiece, *mm* (in.).

$$L = \sqrt{R(h_o - h_f)} = \sqrt{R(\Delta)}$$

Where,

$R =$ roll radius, *mm*.

Roll Force

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$$F = Lw\sigma_{f(m)} \tag{3}$$

Where,

$\sigma_{f(m)}$ = average flow stress, MPa

Lw = roll workpiece contact area, mm^2

Torque

The torque M in flat rolling in the case of the rolls being of equal diameter can be calculated by

$$M = Fa \tag{4}$$

Where,

$a =$ length of lever arm, mm.

If length of lever arm is $a = 0.5L$, then the torque for each roll is

$$M = 05.LF \tag{5}$$

Power

The total power for two rolls in SI units can be calculated by

$$P = \frac{2\pi FLN}{60,000} \tag{6}$$

Where,

$P =$ power, kW,
$F =$ rolling force, N,
$L =$ contact length, m,
$N =$ rotation speed, rev/min.

Shape Rolling

- In shape rolling, the work is deformed into a contoured cross section.
- Products include construction shapes such as I-beams, L-beams, and U-channels; rails for railroad tracks; and round and square bars and rods.
- The process is accomplished by passing the work through rolls that have the reverse of the desired shape.
- Most of the principles that apply in flat rolling are also applicable to shape rolling.
- Shaping rolls are more complicated; and the work, usually starting as a square shape, requires a gradual transformation through several rolls in order to achieve the final cross section.

Shape Rolling Products

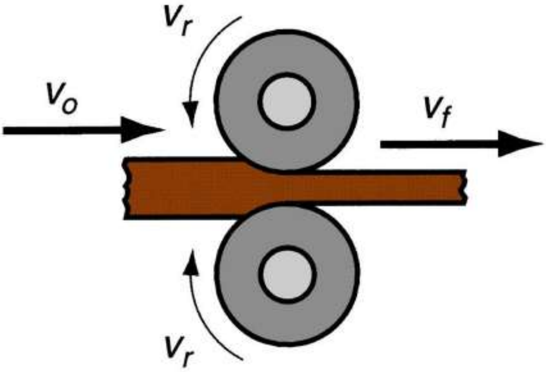
L- beam

U- beam

I- beam

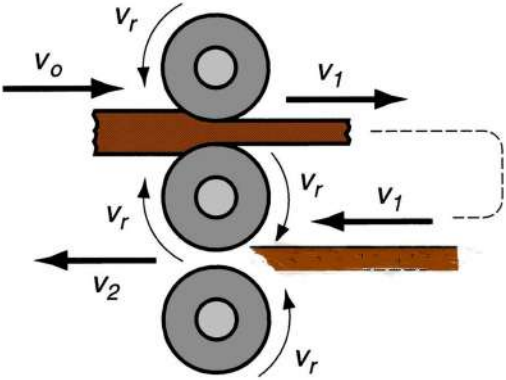
Rolling mill configurations

(a) Two-high consists of two opposing rolls, and the configuration can be either reversing or nonreversing.



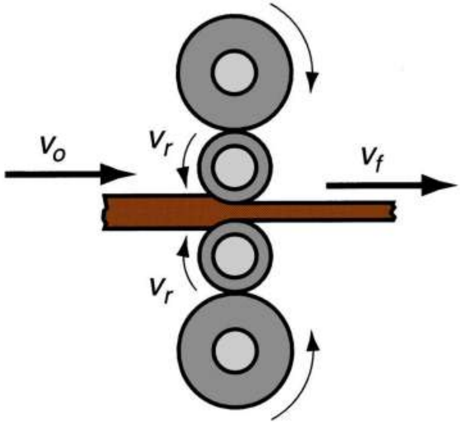
Rolling mill configurations

(b) Three-high three rolls in a vertical column, and the direction of rotation of each roll remains unchanged.



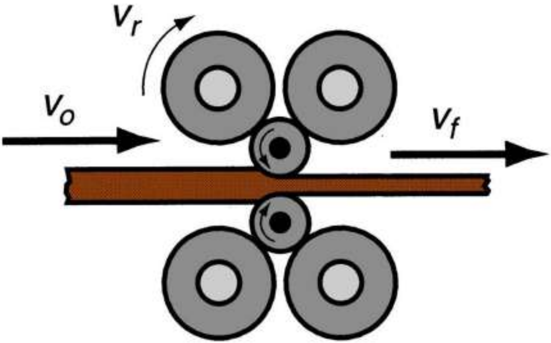
Rolling mill configurations

(c) Four-high uses two smaller-diameter rolls to contact the work and two backing rolls behind them.



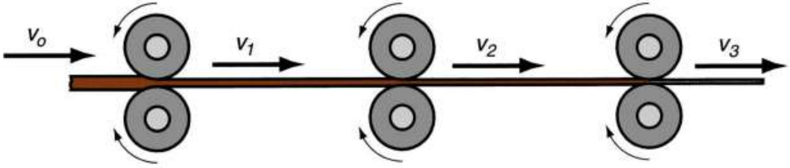
Rolling mill configurations

(d) Cluster mill roll configuration that allows smaller working rolls against the work (smaller than in four-high mills).



Rolling mill configurations

(e) Tandem rolling mill consists of a series of rolling stands, aimed at higher throughput rates.



Thread Rolling

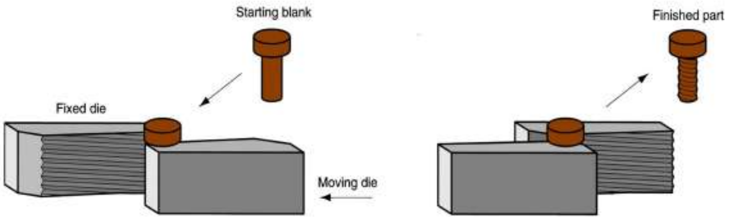


Figure: Thread rolling with flat dies: (1) start, and (2) end of cycle.

Thread Rolling

- Used to form threads on cylindrical parts by rolling them between two dies.
- The most important commercial process for mass producing external threaded components.
- Performed by cold working in thread rolling machines. These are equipped with special dies that determine the size and form of the thread.
- Advantages of thread rolling over thread cutting and rolling include:
  - Higher production rates.
  - Better material utilization.
  - Smoother surface.
  - Stronger threads and better fatigue resistance due to work hardening.

Ring Rolling

Ring Rolling: is a deformation process in which a thick-walled ring of smaller diameter is rolled into a thin-walled ring of larger diameter.

- As the thick-walled ring is compressed, the deformed material elongates, causing the diameter of the ring to be enlarged

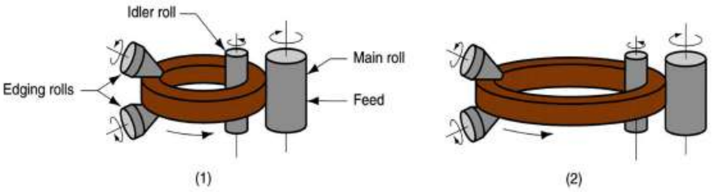


Figure: Ring Rolling

Ring Rolling

- Usually performed as a hot-working process for large rings and as a cold-working process for smaller rings.
- Applications include ball and roller bearing races, steel tires for railroad wheels, and rings for pipes, pressure vessels, and rotating machinery.
- Advantages over processes producing similar products include:
  (1) raw material savings,
  (2) ideal grain orientation for the application, and
  (3) strengthening through cold working.

Roll Piercing

Roll Piercing: a specialized hot working process for making seamless thick-walled tubes.

- Based on the principle that when a solid cylindrical part is compressed on its circumference, high tensile stresses are developed at its center. If compression is high enough, an internal crack is formed.
- Compressive stresses on a solid cylindrical billet are applied by two rolls, whose axes are oriented at slight angles (6^o) from the axis of the billet, so that their rotation tends to pull the billet through the rolls. A mandrel is used to control the size and finish of the hole created by the action.

Roll Piercing

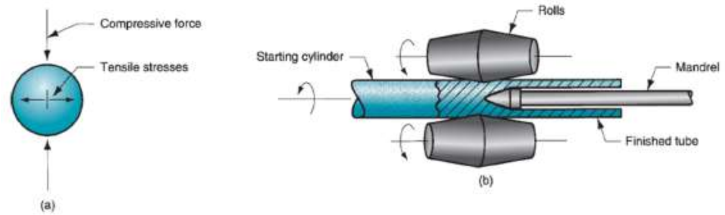


Figure: Roll piercing: (a) formation of internal stresses and cavity by compression of cylindrical part; and (b) setup of Mannesmann roll mill for producing seamless tubing.

Thank You