Description

Image

Image caption

(1) Working space a thread rolling machine with two round dies © Arne Höltich at Wikimedia Commons [Public domain] (2) Rolling mill for cold rolling metals like this brass sheet © Skatebiker at Wikimedia Commons [Public domain] (3) Coiled magnesium sheets and magnesium ingots © Mark Fergus at Wikimedia Commons (CC BY 3.0)

The process

In rolling a metal ingot is squeezed to shape by massive rolls that subject it to large plastic deformation. Nearly 90% of all steel products are rolled or forged. Billet and sheet are made by plane rolling, I-beams and other such continuous sections are made by shape rolling. In hot rolling, the ingot, heated to about 2/3 of its melting temperature, is forced through a series of rolls that progressively shape the profile.

Process schematic

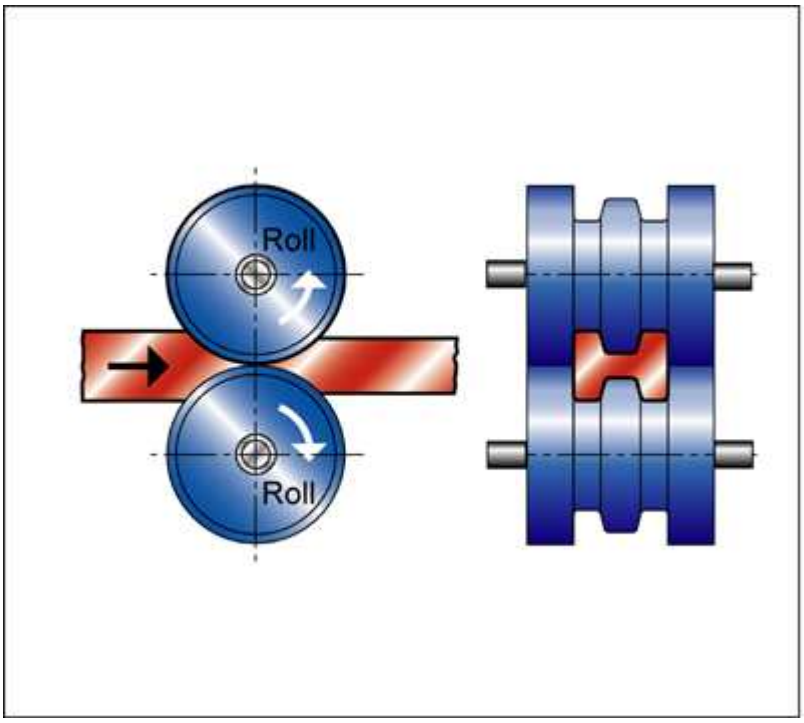

Figure caption

Shape rolling -- the rolls have profile. Flat sheet used cylindrical rolls.

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Material compatibility

Metals - ferrous	✓
Metals - non-ferrous	✓

Shape

Circular prismatic	✓
Non-circular prismatic	✓

Economic compatibility

Relative tooling cost	high			
Relative equipment cost	high			
Labor intensity	low			
Economic batch size (units)	100	-	1e4	

Physical and quality attributes

Mass range	0.1	-	2e3	kg
Range of section thickness	2	-	250	mm
Tolerance	0.1	-	0.5	mm
Roughness	3.2	-	12.5	µm
Surface roughness (A=v. smooth)	B			

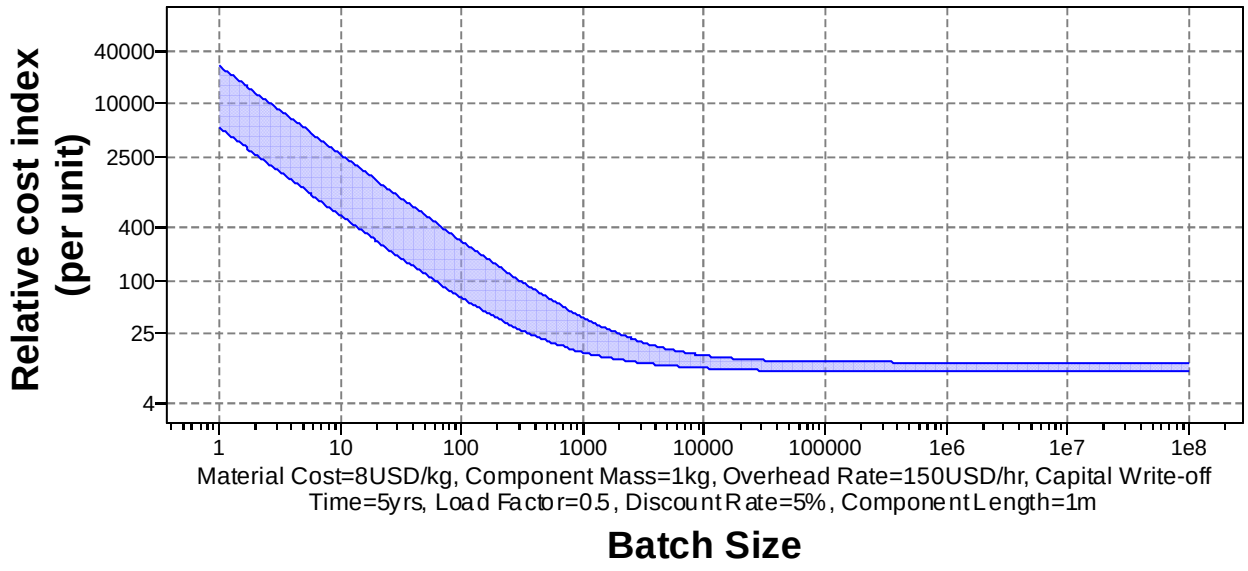
Process characteristics

Primary shaping processes	✓
Continuous	✓

Cost model and defaults

Relative cost index (per unit)	15.4	-	38.2	

Parameters: Material Cost = 8USD/kg, Component Mass = 1kg, Batch Size = 1e3, Component Length = 1m, Overhead Rate = 150USD/hr, Discount Rate = 5%, Capital Write-off Time = 5yrs, Load Factor = 0.5



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Capital cost	2.69e5	-	2.69e6	USD
Material utilization fraction	0.9	-	1	
Production rate (length)	0.02	-	10	m/s
Tooling cost	5.37e3	-	2.69e4	USD
Tool life (length)	1e4	-	1e6	m

Supporting information

Design guidelines

Rolling produces components with particularly good mechanical properties because of the way in which the deformation refines the structure and reduces the porosity. During hot rolling the metal recrystallizes, remaining relatively soft, and its surface may oxidize. Cold rolling , by contrast, impart a high surface finish and cause extreme work hardening, raising the strength of the product but limiting the extent of deformation.

Technical notes

Most metals can be rolled, but the extent of deformation that is possible varies widely. Those best suited are the range of aluminum and magnesium alloys designed for deformation processing (the 'wrought' grades), copper alloys and steels.

Typical uses

Rolling is used to make semi-finished products such as continuous rods, square sections, I-beams and other prismatic sections.

The economics

For metals, rolling is more economical for simple shapes and large product runs; for polymers, the tooling costs are relatively low although capital costs are high and secondary processing is often required (from cutting to size or re-melting and injection molding).

The environment

The lubricants used in rolling and forging generate oil mist, and unpleasant vapors, requiring good ventilation.

Links

MaterialUniverse

Reference

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