Description

Image



Image caption

(1) Manual forging © TiBine at Pixalbay [Public domain] (2) Flashless forged 2-cylinder crankshaft © IPH Hannover at Wikimedia Commons (CC BY 2.0) (3) Forged ornament of a castle gateway © Mh-grafik at Pixalbay [Public

The process

In forging a metal ingot is squeezed to shape by dies that subject it to large plastic deformation. Nearly 90% of all steel products are either forged or rolled. In hot die forging a heated blank is formed between open or closed dies in a single compressive stroke. Often a succession of dies is used to create the final shape. In cold rolling and forging the metal blank is initially cold, although deformation causes some heating.

The greatest precision and shape complexity is given by closed-die forging, illustrated below, but the size of component is limited to about 20 kg. Open-die forging is less precise, but can be applied to much larger components (up to 5000 kg).

Process schematic

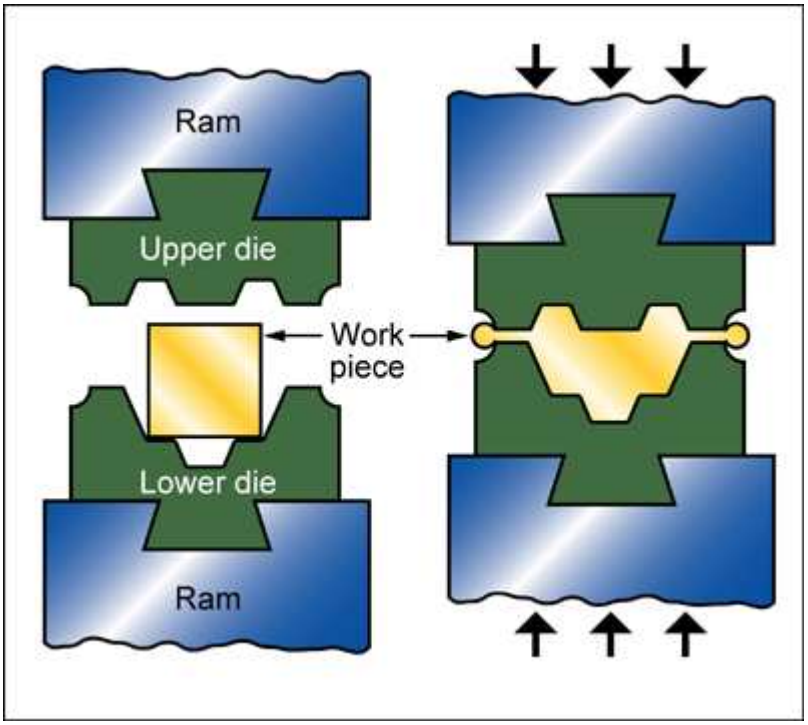


Figure caption

Closed die forging

Material compatibility

Metals - ferrous	✓
Metals - non-ferrous	✓

Shape

Non-circular prismatic	✓
Solid 3-D	✓

Economic compatibility

Relative tooling cost	high			
Relative equipment cost	high			
Labor intensity	low			
Economic batch size (units)	1e3	-	1e5	

Physical and quality attributes

Mass range	0.01	-	5e3	kg
Range of section thickness	3	-	250	mm
Tolerance	0.2	-	1	mm
Roughness	3.2	-	12.5	µm
Surface roughness (A=v. smooth)	A			

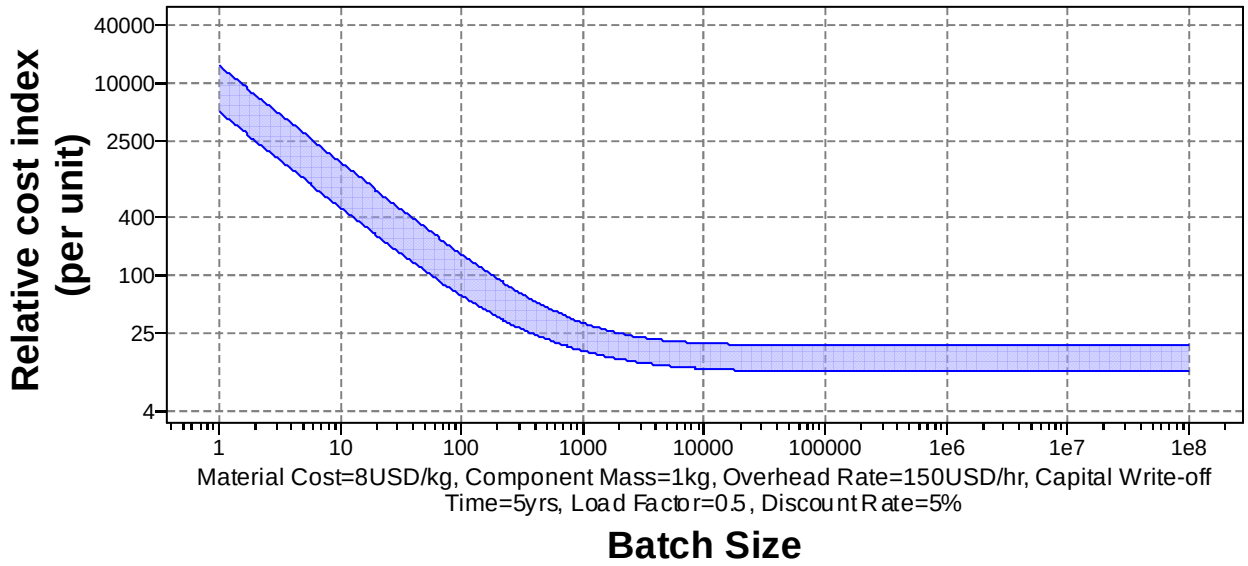
Process characteristics

Primary shaping processes	✓
Discrete	✓

Cost model and defaults

Relative cost index (per unit)	*	16.5	-	32.3

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



Capital cost	3.28e5	-	8.2e5	USD
Material utilization fraction	0.85	-	0.95	
Production rate (units)	100	-	500	/hr
Tooling cost	4.92e3	-	1.48e4	USD
Tool life (units)	* 1e3	-	1e6	

Supporting information

Design guidelines

Forging produces components with particularly good mechanical properties because of the way in which the deformation refines the structure and reduces the porosity. During hot forging the metal recrystallizes, remaining relatively soft, and its surface may oxidize. Cold forging, by contrast, impart a high surface finish and cause extreme work hardening, raising the strength of the product but limiting the extent of deformation. Complex shapes. Re-entrant angles, undercuts and inserts are not possible.

Technical notes

Most metals can be forged, but forgeability varies widely. The most easily forged include aluminum, magnesium, copper alloys and steels. Closed die forging allows more complex shapes and closer tolerances than does open die forging.

Typical uses

Forging is used to shape highly stressed mechanical parts such as aircraft components, connecting rods, crankshafts, gear blanks, hand and machine tools, valve bodies, tube and hose bodies.

The economics

Dies for forging have to be made from exceptionally hard materials and are expensive, meaning that shape rolling and closed die forging are suitable only for large batches.

The environment

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

Links

MaterialUniverse

Reference