

## Description

### Image



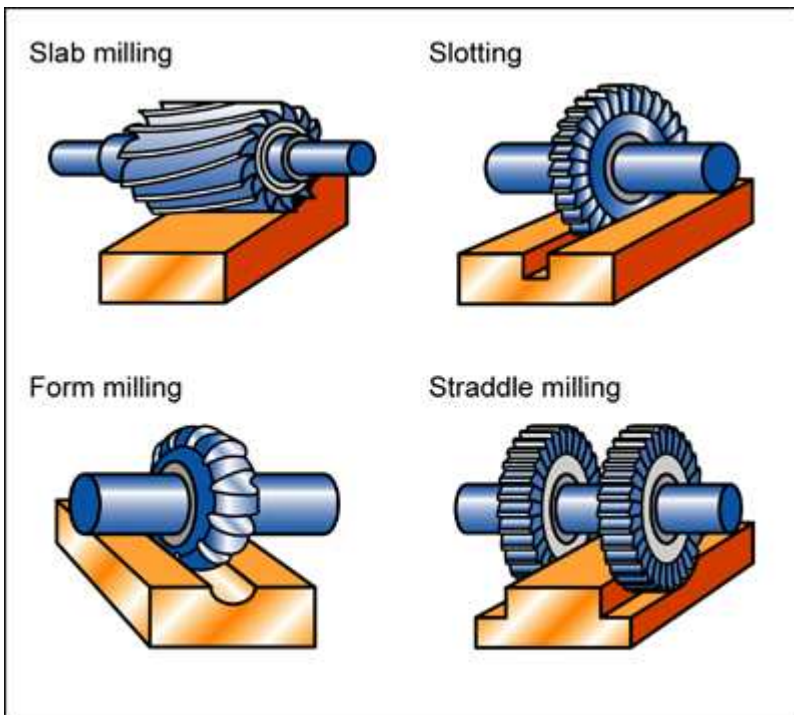
### Image caption

(1) Hot rolling of bar stock for milling © Deutsche Fotothek at Wikimedia Commons (CC BY 3.0) (2) Milling tools © Blickpixel at Pixabay [Public domain] (3) Milling a gear © Heller at Wikimedia Commons (CC BY 3.0)

## The process

In MILLING metal is removed by a rotating multiple-tooth cutter; each tooth removes a small amount of metal with each revolution of the spindle. Because both workpiece and cutter can be moved in more than one direction at the same time, surfaces having almost any orientation can be machined.

## Process schematic



### Figure caption

Milling techniques.

## Material compatibility

Composites	✓
Metals - ferrous	✓
Metals - non-ferrous	✓
Polymers - thermoplastics	✓
Polymers - thermosets	✓

## Shape

Circular prismatic	✓
Non-circular prismatic	✓
Flat sheet	✓
Dished sheet	✓
Solid 3-D	✓

## Economic compatibility

Relative tooling cost	low
Relative equipment cost	high
Labor intensity	medium
Economic batch size (units)	1 - 1e7

## Physical and quality attributes

Mass range	0.001 - 1e3 kg
Range of section thickness	0.2 - 500 mm
Tolerance	0.02 - 0.5 mm
Roughness	1 - 25 $\mu$ m
Surface roughness (A=v. smooth)	B

## Process characteristics

Primary shaping processes	✗
Machining processes	✓
Discrete	✓
Prototyping	✓

## Supporting information

### Design guidelines

All polymers and all but the hardest metals can be machined by milling. Ceramics and glasses can be drilled and cut, but require diamond or carbide-tipped tools. Very intricate shapes, high precision and finish are possible, but at a cost.

### Typical uses

The profiling of metals with hardness below Rockwell 45 Rc, and some plastics and

### The economics

Any production quantity is economic. Equipment varies from manual millers for small quantities to multiple-spindle numerically controlled systems for very high production levels.

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**The environment**

Lubricants and cutting fluids can pose an environmental problem. Special precautions are essential when machining composites because of glass or carbon dust, and when machining toxic materials such as beryllium

**Links**

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[MaterialUniverse](#)

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[Reference](#)

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