SKMM 1922

BASIC MANUFACTURING PROCESSES 2

Metal Cutting
Introduction

- Machining is the removal of stock material from an initial form (usually a block or bar of material).

- Traditional or “chip-forming” machining processes remove material by using mechanical energy and are usually referred to as cutting processes (single point or multiple point). The machine used is named Machine Tools.

- The non-traditional or “chip-less” processes use electrical, thermal or chemical energies to remove metal.
Material Removal Classification

Material Removal Processes

Machining
- Circular
  - Turning
  - Drilling
  - Boring
- Other
  - Milling
  - Planing
  - Shaping
  - Broaching
  - Gear Generating

Abrasives
- Bonded
  - Grinding
  - Honing
- Loose
  - Lapping
  - Polishing
  - Buffing

Non-Traditional (NT)
Machining

**Turning**

- Work
- New surface
- Speed motion (work)
- Cutting tool

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**Drilling**

- Speed motion (tool)
- Drill bit
- Work

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**Horizontal Milling**

- Milling cutter
- Speed motion
- New surface
- Work

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**Vertical Milling**

- Milling cutter
- Speed motion
- New surface
- Work
**GRINDING**

**PROCESS**

**Mechanical machining**
Removal of material from a workpiece using tool made from abrasive particles of irregular geometry.

**SHAPE**

3D
Mainly used for solid objects but re-entrant angles possible.

**MATERIALS**

Metals, ceramics
Mainly hard metals and ceramics. Soft and ductile materials difficult.

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**Horizontal spindle, reciprocating table**

**Vertical spindle, rotary table**

**Transverse thread grinding**

**Plunge-cut thread grinding**

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**CYCLE TIME**

Controlled by relative hardness of workpiece and tool, and lubrication/cooling. Reduced by the use of automation.

**QUALITY**

Often used to improve surface texture which is only limited by the time and effort expended.

**FLEXIBILITY**

Good. Form grinding tooling can be expensive.

**MATERIALS UTILIZATION**

Extremely poor. Scrap is difficult and expensive to recycle due to lubricant contamination and changes in microstructure.

**OPERATING COST**

Some tooling dedicated. Machine costs dependent on degree of flexibility and automation.

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RATING 2  RATING 5  RATING 5  RATING 1  RATING 4
Single Point Cutting Tool

(a) Schematic illustration of a right-hand cutting tool. Although these tools have traditionally been produced from solid tool-steel bars, they have been largely replaced by carbide or other inserts of various shapes and sizes, as shown in (b)..

(b) Diagram showing the components of a cutting tool:
- Toolholder
- Insert
- Clamp
- Seat or shim
- Back rake angle, + (BR)
- Cutting edge
- Flank
- Side relief angle
- Side-cutting edge angle (SCEA)
- End-cutting edge angle (ECEA)
- Side rake angle (SR)
- Face
HSS (1-2 hours)

- High T
- High \( \sigma \)
- Friction
- Sliding on cut surface

Inserts
SINGLE POINT CUTTING

PROCESS

Mechanical machining
Processes involving the removal of metal from the workpiece by means of cutting tools which have one major cutting edge.

SHAPE

3D
Mainly used for solid objects but re-entrant angles possible.

MATERIALS

All materials
Most metals and polymers, and some ceramics and composites although tool wear rates may be high.

CYCLE TIME

Controlled by relative hardness of workpiece and tool. Reduced by the use of automation.

QUALITY

Often used to improve surface texture which is only limited by the time and effort expended.

FLEXIBILITY

Very high. Ideal for production of individual articles and very small batches.

MATERIALS UTILIZATION

Extremely poor. Scrap is difficult and expensive to recycle due to lubricant contamination and changes in microstructure.

OPERATING COST

No dedicated tooling. Machine costs dependent on degree of flexibility and automation. Range from low to very high.

RATING 2  RATING 5  RATING 5  RATING 1  RATING 5
MULTI-POINT CUTTING TOOL

Schematic illustration of a (a) horizontal-spindle column-and-knee-type milling machine. (b) a vertical-spindle column-and-knee-type milling machine.
**Multiple Point Cutting**

**Process**
Mechanical machining
Removal of material from a workpiece using cutting tools which have more than one major cutting edge.

**Shape**
3D
Mainly used for solid objects but re-entrant angles possible.

**Materials**
All materials
Most metals and polymers. Some ceramics and composites although tool wear rates may be high.

**Cycle Time**
Controlled by relative hardness of workpiece and tool, and lubrication/cooling. Reduced by the use of automation.

**Quality**
Often used to improve surface texture which is only limited by the time and effort expended.

**Flexibility**
High. Ideal for production of individual articles and very small batches.

**Materials Utilization**
Extremely poor. Scrap is difficult and expensive to recycle due to lubricant contamination and changes in microstructure.

**Operating Cost**
Little dedicated tooling. Machine costs dependent on degree of flexibility and automation.

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Turning Process using Lathe Machine
Components of a Lathe

- Spindle speed selector
- Headstock assembly
- Spindle (with chuck)
- Tool post
- Compound rest
- Cross slide
- Carriage
- Ways
- Dead center
- Tailstock quill
- Tailstock assembly
- Handwheel
- Bed
- Feed selector
- Chip pan
- Apron
- Split-nut
- Clutch
- Lead screw
- Feed rod
- Longitudinal & transverse feed control
Various machining operations using lathe machine

(a) Straight turning

(b) Taper turning

(c) Profiling

(d) Turning and external grooving

(e) Facing

(f) Face grooving

(g) Cutting with a form tool

(h) Boring and internal grooving

(i) Drilling

(j) Cutting off

(k) Threading

(l) Knurling
Lathe tool

a. cutoff
b. boring bars
c. R.H. facing
d. L.H. turning
e. threading tool
Turning parameters
Summary of Turning Parameters & Formulas

\[ N = \text{Rotational speed of the workpiece, rpm} \]
\[ f = \text{Feed, mm/rev or in/rev} \]
\[ v = \text{Feed rate, or linear speed of the tool along workpiece length, mm/min or in/min} \]
\[ = f/N \]
\[ V = \text{Surface speed of workpiece, m/min or ft/min} \]
\[ = p \ D_o \ N \ (\text{for maximum speed}) \]
\[ = p \ D_{avg} \ N \ (\text{for average speed}) \]
\[ l = \text{Length of cut, mm or in.} \]
\[ D_o = \text{Original diameter of workpiece, mm or in.} \]
\[ D_f = \text{Final diameter of workpiece, mm or in.} \]
\[ D_{avg} = \text{Average diameter of workpiece, mm or in.} \]
\[ = \frac{(D_o + D_f)}{2} \]
\[ d = \text{Depth of cut, mm or in.} \]
\[ = \frac{(D_o + D_f)}{2} \]
\[ t = \text{Cutting time, s or min} \]
\[ = l/f N \]
\[ \text{MRR} = \text{mm}^3/\text{min or in}^3/\text{min} \]
\[ = p \ D_{avg} \ d \ f N \]
\[ \text{Torque} = \text{Nm or lb ft} \]
\[ = (F_c)(D_{avg}/2) \]
\[ \text{Power} = \text{kW or hp} \]
\[ = (\text{Torque})(w, \text{ where } w=2\pi \text{ radians/min}) \]

Note: The units given are those that are commonly used; however, appropriate units must be used and checked in the formulas.
Why Machining?

There are commercial and technological reasons which make machining one of the most important manufacturing processes.

- **ACCURACY**
  
  Highest of all manufacturing processes, close tolerances can be achieved.  
  Small amount of materials removed, smooth surface finishes  
  Precise tools, dies, moulds can be made.
Why Machining?

- **HIGHLY FLEXIBLE** –
  variety of work materials
  Shape can be programmed. Regular geometries (flat planes, round holes, cylinders) can be easily machined. Irregular geometries (screw threads, T-slots) can be cut using various tool shapes and tool paths.
  Many different parts can be made on one machine (general purpose).
Any arbitrary shape can be machined by combining several machining operations in sequence.

- **LOW COST TOOLING**
  - Contour is generated by path of tool rather than its shape, in most cases
  - Cutting tools are mass produced in standardized shapes/geometry
  - Economical for small quantity production
Disadvantages of metal cutting

- Removal of material - become scrapped and waste
- Machining is relatively a slow process
- Need highly skilled operators
- High capital cost – machine, cutters, workholders, jigs and fixtures
- Not suitable for high volume production
Thank you