TURNING – BORING


FACING: Single point tool, radial feed.
TYPES OF OPERATIONS

1. Cylindrical turning

2. Taper turning

3. Facing
4. FORM TURNING: CYLINDRICAL, CONICAL, BARREL & IRREGULAR SURFACES of limited length can be performed using special shape tools which are fed against the work axis.

5. Internal cylindrical surfaces – Internal turning

6. Drilling and reaming
FIGURE 23.2  Basic turning machines can rotate the work and feed the tool longitudinally for turning and can perform other operations by feeding transversely. Depending on what direction the tool is fed and on what portion of the rotating workpiece is being machined, the operations have different names. The arrows indicate the tool motion relative to the workpiece.
FIGURE 23-1  Standard engine lathe performing a turning operation, shown in inset.
MACHINE TOOLS – LATHES: primarily for turning, facing, boring.

-a basic machine tool, heavy and rigid (to avoid deformations and vibrations)

**BED:** Normalised (aged) cast iron – a support for the parts.

Two longitudinal ways (For tail stock and carriage).
HEAD STOCK assembly:

- Transmission
  - Multiple V-belts (8-18 speeds)
  - hollow spindle on precise bearings
  - transmission gears
  - electronic clutch and brake
TAILSTOCK assembly can move along the way to accommodate different length of work-pieces.

Lower Casting

Upper Casting

Tailstock quill (hollow, Morse taper, graduated)

FIGURE 23-8 Method of turning tapers by offsetting the tailstock.

\[
Q_f = \frac{1}{2} \frac{(D - d) L_w}{L_t} = \text{Offset}
\]

\begin{align*}
D &= \text{Large diameter} \\
\bar{d} &= \text{Small diameter} \\
L_w &= \text{Length of work} \\
L_t &= \text{Length of taper}
\end{align*}
CARRIAGE ASSEMBLY: To mount and move the cutting tool

Rests and moves on outer set of the ways

- It has a cross slide mounted on transverse box that can be moved by feed screw along an axis normal to the axis of rotation.
- Compound rest can be installed on cross slide on a rotating base attached to the carriage assembly.
• manual and the powered motion for the carriage and for the cross side.

• **manual motion** → pinion and hand wheel

• **Powered motion** – a feed rod that pushes through two reversing level pinion and keyed to there forward and reverse motions.

• Clutch → connects either the rack-pinion for longitudinal motion and the cross slide screw for transverse motion.

• A lead screw is used for thread cutting → inter-relates feed with RPM

• 48 feed step (0.05 – 3 mm/rev ), leads (1.5 to 92 TPI)
SIZES DESIGNATION OF LATHES

1. **SWING**: Max Dia. Of the job that can be turned, twice of the distance between the center and nearest point on the ways. 300 mm lathe swing → max dia 300 mm

2. **Distance between the centers**: maximum length between centers.

3. **Size of the hole**: Determined by the hollow spindle providing the bar-stock for machining
1. **Speed lathes** ➔ SIMPLE & LIGHT
   - Headstock, tailstock and hand – adjustable cross-slide for tool support on the carriage
   - 3-4 speeds up to 4000 RPM
   - used for wood turning, polishing and metal spinning

2. **Engine lathes** ➔ production machine tool, power drive for all the movements.
   - many features for controlling the spindle and the feed speed (large no. of speeds and feeds)
   - used in manufacturing – small series
   - 12-24” swing and 24 – 28 in size capacity, 50-100HP
   - chip panels and cooling system and filters

3. **Bench lathes** ➔ very precise
   - max swing 10” – same to engine lathes

4. **Tool room lathes** ➔ Universal engine lathes, meant for small parts.
   - wider range of speeds and feeds
   - designed for greater versatility, greater accuracy
   - Shorter and very rigid -> high accuracy
   - Have large number of accessories

5. **Special purpose lathes** ➔ extra swing or size capacity
   - ex.: for railroad wheel
TURRET LATHES: Automated machines for quantity production

- need non-skilled operators

- turrets are provided with several tools for consecutive operations (setup in the proper sequence) → high skill to set up the machine is needed

- workpiece, bar-stock that is positioned automatically

Construction

* 6-8 sided vertical turret is placed instead of the tail stock – MAIN TURRET

* 4 sided turret is placed instead of the cross slide tool post – AUXILIARY TURRET

* bar stock material feeds the chuck after finishing one piece.

* the turrets can be rotated and indexed and reciprocated along the main axis
HORIZONTAL TURRET LATHE

- The most popular two configurations:

1. RAM Type turret lathe
   - The turret is placed on a guide or slide (RAM) which moves forth and back on a saddle clamped to the lathe bed → easy movement of turret → low inertia – recommended for bar and light duty chucking work-piece
   - The saddle does not move during the operation of the turret
   - A set of stop screws can be adjusted to control the inward travel of the slide (one stop for each face on the turret)
2. **SADDLE type turret lathe** – much heavier
   * the turret mounted on the saddle which moves back and forth with the turret
   * the stroke is much longer → long pieces
   * the turret is slower (because the inertia)
## Difference between turret and engine lathes

<table>
<thead>
<tr>
<th>Turret Lathe</th>
<th>Engine Lathes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality Production</td>
<td>general jobs</td>
</tr>
<tr>
<td>automatic operation</td>
<td>manual operation</td>
</tr>
<tr>
<td>qualified setter</td>
<td>qualified operation</td>
</tr>
<tr>
<td>rapid shifting between two spindle speeds (brake)</td>
<td>slow shift between two speeds</td>
</tr>
<tr>
<td>chuck- a spring collet (feed during rotation)</td>
<td>all the other system</td>
</tr>
<tr>
<td></td>
<td>(feed – by hand)</td>
</tr>
</tbody>
</table>
VERTICAL TURRET LATHE

- Large and heavy pieces dia 600 – 1200 mm
- cross slide can carry two turrets

**Other types of lathe**

- Automatic Turret Lathe
- Single Spindle Automatic Screw Machines (vertical type mounting of turrets)
- Multi-spindle Automatic Screw Machines
- Swiss Type Screw Machine (vertical type mounting of turrets)
**Turning (Rotational)**

\[ v = \frac{\pi D_1 \text{RPM}}{12}, \text{ } f/\text{min}, \text{ } D \text{ in inches} \]

\[ \text{DOC} = \frac{D_1 - D_2}{2}, \text{ in} \]

\[ v = \pi D_1 \text{RPM}, \text{ } m/\text{min}, \text{ } D_1 \text{ in } m \]

**Speed**, stated in surface feet per minute, (sfpm) is the peripheral speed at the cutting edge. To convert rpm into sfpm, use the following:

\[ V = (\pi \times D_1 \times N_s)/12 \text{ (converting D to ft.)}. \text{ This applies to milling, drilling turning and all rotary operations.} \]

**Feed per revolution** in turning (and drilling) is a geared feed driven from the main spindle.

\[ f_r: \text{ m/rev}, \text{ } f_m: \text{ m/min} \]
CUTTING PARAMETERS

\[\begin{align*}
CT &= \frac{L + A}{f_r \times RPM} \\
MRR &= \frac{\pi(D_i^2 - D_f^2) \times L}{4 \times L / f_r \times RPM} \approx Vf_r d \\
where \quad d &= (D_i - D_f) / 2
\end{align*}\]

FACING
- flat surface – feed across the end of the work, Right – hand tool is mostly used
- the cross carriage must be clamped during each facing in order to prevent axial movement of the tool

SPECIAL OPERATIONS
Drilling
- The drill is held in the tail stock quill and fed against the spinning work-piece, fixed in the chuck.
- the drills are fixed in chucks in the quill of the tailstock
- feeding – by hand
- the drill is withdrawn several times to clean the hole from chips
Reaming - the same mode as for drilling direction of the axis cannot be changed

Boring - enlarging of an existing hole initiated by boring
- the hole may be redressed, making it to be concentric to the axis of rotation
- geometric deviation can be solved
- work-piece held in the chuck.

Tools * larger relief angles are used to prevent rubbing of the tool
* less loaded (smaller feeds)

Knurling: chip-less – cold forming process – special tool
EQUIPMENT FOR LATHES (ACCESSORIES)

A. Work-piece supporting equipment

1. Between centers
2. In chuck
3. In collet
4. On a face plate
5. On the carriage, on the tailstock
6. Mandrels - for pieces that have “dish shape”

   – to be machined from both directions.

   a. solid mandrel 1:2000 taper → pressed on mandrel
   b. gang or drill mandrels – for cylindrical surface
   c. cone mandrels → for pieces with different hole sizes

FIGURE 23-35 Three types of mandrels.
Lubrication of dead center needed at the tailstock

Dog plate needed for driving the work

Need for center drills
Morse taper on one side and 60deg taper on other side.

Dead center is more accurate

- Lubrication of dead center needed at the tailstock
- Dog plate needed for driving the work
Chucks: Three jaws, self centering clutch

- a spiral cone is rotated by means of a bevel gear, accuracy: 0.025 mm (25um)

* four jaws independent jaws. Motion by special screws

- their fastening is time consuming

Special productions: chucks actuated by fluid or by air
- The work can be kept more accurately

- Thin tubular bushing, very accurately split into three segments

- External surface is a taper fits with internal taper - collet pulled inward into the spindle by mean of the draw bar

- the piece is squeezed.
  
  • Accurate centering ~ 10um precision

  • Condition: the collet is 0.1 mm from the normal size of the work-piece

  • a large class of collets to cover the dimensions of the stock round bars.
Other possible operation and types of fixing the non-circular jobs.

Face plates

- for irregular work-pieces or eccentric work

- work-pieces are bolted or clamped directly on the face plate

- an auxiliary fixture can be used

- fixture is bolted on the face plate
STEADY AND FOLLOW RESTS

• For long and not rigid works ➔ deflection
  - a steady rest clamped on the lathe ways can be used ➔ three movable fingers to align the bar and to support it.
  - can be used for both holds
  - between centers
  - in the clutch

• the follow rest is attached to carriage and is moving with it ➔ two contact fingers to align the bar and to support it.

Cutting a thread on a long, slender work-piece, using a follow rest (left) and a steady rest (right) on an engine lathe. Note the use of a dog and face plate to drive the work-piece.
TOOLS FOR LATHES

* mainly single point cutting tools are used

* right-hand, left-hand turning and facing tools are cutting by the side where the side rake angle is of primary importance → deep cuts

* cut off tools, round nose threading tools the back rake angle is of importance, light depths of cut can be applied.

FIGURE 23-27 Common types of forged tool holders: (a) cutoff; (b) boring bars; (c) right-hand facing; (d) left-hand turning; (e) threading. (Courtesy of Armstrong Brothers Tool Company.)
special heavy tool holders and cutting carbide tip are used – for heavy-duty work.

- tool holders, **forged** - are clamped with minimum of overhang

- When the tool is not rigid → elastic → vibrations and poor surface finish may result

- For changing the tool → quick – change tool holders are used → individual tools are preset in their holders to interchange in few seconds.

The tool nose must be set exactly at the same height as axis of rotation of the work – actually, **few thous higher**

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<table>
<thead>
<tr>
<th>Insert shape</th>
<th>Available cutting edges</th>
<th>Typical insert holder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Round</td>
<td>4–10 on a side 8–20 total</td>
<td>15° Square insert</td>
</tr>
<tr>
<td>80°/100° diamond</td>
<td>4 on a side 8 total</td>
<td>0° Triangular insert</td>
</tr>
<tr>
<td>Square</td>
<td>4 on a side 8 total</td>
<td></td>
</tr>
<tr>
<td>Triangle</td>
<td>3 on a side 6 total</td>
<td></td>
</tr>
<tr>
<td>55° diamond</td>
<td>2 on a side 4 total</td>
<td>35° diamond</td>
</tr>
<tr>
<td>35° diamond</td>
<td>2 on a side 4 total</td>
<td></td>
</tr>
</tbody>
</table>

*FIGURE 23-28 Typical insert shapes, available cutting edges per insert and insert holders for throwaway insert cutting tools. (Adapted from Turning Handbook of High Efficiency Metal Cutting, courtesy of General Electric Company.)*
FIGURE 23-29 Quick-change tool post and accompanying toolholders. (Courtesy of Armstrong Brothers Tool Company.)

FIGURE 23-30 Circular and block types of form tools. (Courtesy of Speedi Tool Company, Incorporated.)

FIGURE 23-6 (a) Knurling in a lathe, using a forming-type tool, and showing the resulting pattern on the workpiece; (b) knurling tool with forming rolls. (Courtesy of Armstrong Brothers Tool Company.)
LATHE OPERATORS

CYLINDRICAL TURNING

• For a work-piece between centers, a right hand tool should be used to create the cutting force directed towards the headstock (is rigid).

• For good finish – two cuts (ex.: depth ~2mm)
  
  1. A roughing cut feed - 0.5 mm/rev
  
  2. A finish cut after this – less than 0.1 mm/rev

• for work with hardened surface, the cut should be deep enough to remove the hardened layer.

• If the surface is unusually hard, RPM must be reduced

FIGURE 23-26 Schematic of common single-point lathe tools for showing how they can be used.
• finishing cuts – light depth. ~0.4 mm and very fine feed
• finishing cut – can be done with the same tool as the roughing one
• special quality → diamond tool.
Main Concerns: Too wear (increases roughness, dimension, cutting force, deflection).
To reduce built up edge, increase cutting speed higher than roughening operation.
Taper Turning - Morse tapers 5.208%
- 4.166% Brown and Shape taper – milling machines
- 5% Jarno and Reep taper – used in lathes
- 2.083% Taper pins – as fasteners

Methods:
1. Taper turning attachment – bolted on the back of the lathe → a guide bar can be set at desired angle or taper (for tapers < 1:2) - External and Internal

FIGURE 23-7 Rear view of carriage of an engine lathe. Taper attachment moves cross slide transversely when carriage moves, but only if the bed clamp is fastened.
2. Compound rest method → the circular base of the carriage is swiveled to the desired angle. The tool is fed by hand – for short tapers - External and Internal
3. The setting over **(SETOVER METHOD)** - the tailstock is moved out from the alignment by $\frac{1}{4}'' \Rightarrow$ cylinder of 12 in long will have $\frac{1}{2}''$ per foot taper. If the cylinder of 6'' long $\Rightarrow 1''$/foot

![Diagram](image)

**FIGURE 23-8** Method of turning tapers by offsetting the tailstock.
BORING: Process of enlarging an existing hole obtained with drilling/casting and redressing its shape

• Rotating tool – tools feed axially

• Rotating work piece

Advantages
- concentric to the axis of rotation
- done on different machines
  * lathes, drilling and milling machines
  * special boring mills.

The boring configuration gives the size of the hole

for rotating tool → is the radial distance from the
tip of the boring bar and
axis of rotation

for rotating work → the radial distance from the
tip of the tool and the axis
of the hole and work
**HORIZONTAL BORING MACHINES (Mills)**

-they perform drilling, boring and milling

-used for large works

Consists of

* table with two co-ordinates

* headstock with vertical movement

* rotating spindle with horizontal feed

* support for boring bar

The tool is a single cutting point.

But spindle can accept drill/mill tools.

Heavy load bearings – can accept large drills

Special devices are used to reduce the time of tool changing - turret head

**SIZE** of horizontal boring machines – designated by the diameter of the spindle + the size of the table and the distance between the spindle on the column + table size.
Boring tool configuration

- **stud** – type boring bar

- **long line type boring bar with its end supported**

- **More accurate**

  Change the offset radius

  Adjustable tool bar
Boring with centering tool

- For long holes.
- Corrects the misalignment.
For production machines:

Multiple heads and spindles
VERTICAL BORING MACHINES (Mill)

- boring and facing → large sizes up to 40”
- rotating table
- very similar to vertical turret lathes but they have two main tool heads instead of a turret
- used for heavy pieces that can’t be spun about horizontal axis and circular hole > 12”
- two tool heads mounted on a cross rail
- feed – horizontal and vertical
  • Side tool head is also available → more cuts can be done simultaneously (turning, facing, boring, finishing).
  • SIZE – designated by the size of the table

FIGURE 23-20 Block diagram of a vertical boring and turning machine.
AUTOMATIC VERTICAL BORING MACHINES
- used to bore the cylinder block of the engine
- bore holes simultaneously.

JIG BORERS - to bore jig and fixtures in the tool room
- are equipped with co-ordinate controlling devices.
- Very precise spindle and bearings.
- operated by numerical controls.
- expensive ➔ accurate

Boring operations;
- the same principles in drilling ➔ small depth and feeds are sometimes necessary because of the dia.

Boring tools
- multiple cutter boring tool – like milling cutter ➔ for cylindrical internal surfaces similar to reaming