METAL FORMING
METHODS

METAL WORKING
• Mechanical: To bring the metal into desired shape, generally by hammering
• Chemical: To change the surface appearance or to join pieces as in soldering.
• Embossing: To increase the surface by hammering the metal into thin sheet and covering the modeled object made of clay or carved wood.

SHAPING OF METAL
• Copper and its alloys can be shaped by repeated hammering and annealing. It can be hammered both hot or cold.
• Iron and its alloys can be forged only when hot. Cooling rate is very critical for the strength of the alloy.

MECHANICAL SHAPING OF SHEET COPPER
METAL FORMING BY HAMMERING

ANCIENT LATHE

Used in shaping Bronze vessels by mechanical Application of force by using a lathe (torna)
SHEET METAL DECORATION

FORGING HAMMERS

CASTING METALS
- Open molds
- Piece molds
- Hollow casting
- Lost wax casting
OPEN MOLD CASTING

PREPARATION OF COPPER BEFORE CASTING

- Blister copper is remelted in a crucible to keep surface area minimum and avoid contact with air.
- Residual inclusions float to the surface and are removed off as a dross.
- The molten metal is polled by unseasoned wood to reduce copper oxide that may have formed during melting back to metal.

MOLD

- Can be made from stone, refractory clay or metal.
- It has to be perfectly dry, otherwise vapors evolved may blow holes in the metal.
- Mold faces are given a dressing of soot, wood ash, flour or animal fat to ensure a good surface to the casting.
EGYPTIAN CASTING OF TEMPLE DOORS

Temple door
Cu Ingot
Sn Ingot

Text:
Ex. 133. Drawing from part of an Egyptian tomb painting of about 1500 B.C. showing foundrymen casting bronze doors.

OPEN MOLDS FROM TARSUS

AXE SAMPLES CAST BY OPEN MOLD

OBJECTS THAT CAN BE MADE BY OPEN MOLD CASTING
PIECE MOLD CASTING

CASTING A SPEAR HEAD BY USING PIECE MOLD

EXAMPLES OF PIECE MOLD CASTING

CASTING AN AXE WITH A SHAFT HOLE

Fig. 8 "Open" and flared-cored moulds. "Open" mould (1) for casting an axe (2), Section through mould and core (3). Flared-cored piece-mould (4) with core, bosses cup and chaplets (5). Section through mould and core (6) and casting (7) with chaplets and bosses removed.
CASTING SHAFT HOLE AXE

FATIH’S CANNONS
HOLLOW CASTING BY PIECE MOLDS

1. The figure is modelled in clay
2. A piece-mould is built up around it
3. The model is removed, shaved down to provide the core around which the mould pieces and mother moulds are assembled.

Post to hold clay for model
Clay builds up
Approximate shape is reached

Rigid profile gives the final form
The clay model dries and hardens
The outer mold is made in sections. They are fired and reassembled after shaving the surface to allow space for the metal.
Molten bronze is poured into a mold. It generally contains about 3% lead. The outer mold and the inner core is removed after half hour.

Metal Casting of China’s Shang Dynasty (17-11th century BC)

PIECE
MOLD
CASTING
CASTING BY PIECE MOLD

CHINESE BRONZES
LOST WAX CASTING

FIG. 10 Lost wax casting. Clay core with protruding chaplet (1). Over this is modelled the wax figure (2). This is invested with clay and then heated to render the wax (3) and fired. Bronze is cast into the space occupied originally by the wax (4). Heads and chaplets are later removed.
HOLLOW LOST WAX CASTING

1. Original wax model.

2. Wax is poured into the master mold, and then left to cool and harden.

3. Wax is removed from the mold to create a casting cavity.

4. Bronze is poured into the casting cavity, filling the mold.

5. Finished wax working model with fingernails marked, clay core poured inside, and metal channels stuck through wax into core.

6. Cross-section of wax working model with wax foundry gate, and sand attached.

7. Cross-section of investment mold inserted for baking, with yellow tubes where wax working mold and gate system have been burned out.

8. Bronze has been poured, investment mold partially broken away.
9. Cast bronze hand with core and clamped gate system.

10. Additional bronze has been poured to create a second cast joint between hand and arm.

GRANULATION

BRAZING
Gold can be beaten to a foil 50 - 100 nm ($10^{-9}$ m) (about 250 - 500 atoms in thickness. Strip of gold 2 mm in thickness can be elongated to about 186,000 times reduction in size (99.9996 %).
MERCURY GUILDING

- Mix Gold or silver with mercury to form an amalgam
- Apply the amalgam on the surface of copper object
- Heat the object to evaporate the mercury
- Thin layer of gold or silver coat will remain on copper object.

INDUSTRIAL BRONZE CASTING