Casting & Welding Engineering (IE 203)

Second Year,
Industrial Engineering Dept.,
Faculty of Engineering,
Fayoum University

Dr. Ahmed Salah Abou Taleb
Sand Casting
Cores
Cores in the Mold Cavity

• The **mold cavity** provides the **external surfaces** of the cast part

• In addition, a casting may have **internal surfaces**, determined by a **core**, placed inside the mould cavity to define the **interior geometry** of part

• In sand casting, cores are generally made of sand.
Core Definition

A core is a device used in casting process to produce internal cavities and reentrant angles.

The core is normally a disposable item that is destroyed to get it out of the piece.

They are most commonly used in sand casting.
Cores and Core Making

• **Complex internal cavities** can be produced with cores
• Cores can be used to **improve** casting **design**
• Cores may have relatively **low strength**
• If **long cores** are used, **machining** may need to be done afterwards
• **Green sand cores** are not an option for more complex shapes
Cores Requirements

1. In the **green condition (green strength)**, there must be strong enough to retain shape till it goes for baking.
2. In the **hardened state (dry strength)**, it must be strong enough to handle the forces (pressure) of casting.
3. Good **refractoriness** is required as the core is usually surrounded by hot metal during casting or molding.
4. **Permeability** must be very high to allow for the escape of gases.
5. **Collapsibility**, As the casting or molding cools the core must be able to decrease in size as the material shrinks.
6. **Friability**, they must be easy to remove during shakeout.
7. **Smoothness**, a smooth surface finish.
8. **Low gas emission**, a minimum generation of gases during metal pouring.
Casting Core Characteristics

• Sufficient **strength** before hardening
• Sufficient **hardness** and **strength** after hardening
• **Smooth surface**
• **Minimum** generation of **gases**
• Adequate **permeability**
• Adequate **refractoriness**
• Good **collapsibility**
Core Prints
Core Prints

- The core prints are provided so that the core are securely positioned in the mould cavity.
- The design of the core print is such as to take care of the weight of the core before pouring.
- Stand against the upward pressure after pouring.
- Ensure that the core is not shifted during the entry of the metal into the mould cavity.

\[ P = V \left( \rho - 1.65 \times 10^{-2} \right) \]

- **P**: Buoyant Force, N
- **V**: Volume of the core in cavity, cm\(^3\) \( V = 0.25 \pi D^2 h \)
- **D**: Core diameter, cm
- **h**: core length inside cavity, cm
- **\( \rho \)**: Weight density of the molten metal, N/cm\(^3\)
# Core Prints

<table>
<thead>
<tr>
<th>Material</th>
<th>Density, N/cm³</th>
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<tbody>
<tr>
<td>Aluminum</td>
<td>0.0265</td>
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<tr>
<td>Copper</td>
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<tr>
<td>Magnesium</td>
<td>0.0171</td>
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<tr>
<td>Zinc</td>
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<tr>
<td>Lead</td>
<td>0.1113</td>
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<tr>
<td>Carbon steel</td>
<td>0.0771</td>
</tr>
<tr>
<td>Gray cast iron</td>
<td>0.0686 – 0.0735</td>
</tr>
<tr>
<td>White cast iron</td>
<td>0.0755</td>
</tr>
</tbody>
</table>
Core Prints

To keep core in position, it is empirically suggested that:

\[ P \leq 3.5 \, A \]

\( A: \) Core print surface area, \( cm^2 \)

After find “A” one can get the print length from equation

\[ A \geq 1.65 \times 10^{-2} \times V / \sigma \]

\( V: \) Total volume of the core include the core prints, \( cm^3 \)

\( \sigma: \) Compression strength of the moulding sand, \( N/ cm^2 \)

= \( (0.6 \, N/ cm^2) \).
Cores Types

There are essentially **two types of cores** available. The selection of the correct type of core depends on:

1. Production quantity,
2. Production rate,
3. Required precision,
4. Required surface finish, and
5. Type of metal being used.

For example, certain metals are sensitive to **gases** that are given off by certain types of core sands; other metals have **too low of a melting point** to properly break down the binder for removal during the shakeout.
Cores Types (Cont.)

Green Sand Core:

*Green-sand cores* are **not** a typical type of core in that it is part of the **cope and drag**, but still form an internal feature. Their major **disadvantage** is their **lack of strength**, which makes casting **long narrow** features **difficult or impossible**. Even for long features that can be cast it still **leave much material to be machined**.

A typical application is a **through hole** in a casting.
Cores Types (Cont.)

Dry Sand Core:

• Produced separate from the remainder of the mold
• Inserted into core prints that hold the cores in position
Dry-Sand Cores

Figure 12-21 V-8 engine block (bottom center) and the five dry-sand cores that are used in the construction of its mold. (Courtesy of General Motors Corporation, Detroit, MI.)
Core Box
**Types of Core Boxes**

**Half core box:** When the shape of the core required is such that it can be prepared in **identical halves**, a **half core box should be used** to produced each half, then they drayed and pasted together to form the complete core.

**Dump core box:** similar to half core but **make a full core at a time**. The core produced by the core box does not require any pasting.
Types of Core Boxes (Cont.)

**Split core box:** When the core box is in **two parts** and **complete cores** results in **single ramming**, the box is split core box. For alignment of two parts, dowel pins are fixed in one part and corresponding holes are made in the other.

**Left and right core box:** When the core is required in **two parts** and they are **not identical**, two different core boxes of the half core type have to be provided for each part of the core. Such boxes are called right handed and left handed core boxes.
Strickle core box: This is used when the core is required to have an irregular shape, which cannot be rammed by other methods. In this case, the desired irregular shape is achieved by striking off the core sand from the top of the core box with a piece of wood called strickle board. The strickle is cut to correspond exactly to the contour of the required core.
Loose piece core box:
In case where two parts of the core are not identical they can be prepared from a single core box with the help of loose pieces. One part of the core is processed by placing the loose piece in the left-hand recess, and the other part by shifting the loose piece to the right-hand recess.
Cores Types (Cont.)

Dry Sand Core:

The most simple way to make dry-sand cores is in a dump core box, in which sand is packed into the box and scraped level with the top. A wood or metal plate is then placed over the box, and then the two are flipped over and the core segment falls out of the core box. The core segment is then baked or hardened. Multiple core segments are then hot glued together or attached by some other means. Any rough spots are filed or sanded down. Finally, the core is lightly coated with graphite, silica, or mica to give a smoother surface finish and greater resistance to heat.
Additional Core Methods

(Left) Four methods of making a hole in a cast pulley. Three involve the use of a core.

Right) Upper Right; A dump-type core box; (bottom) core halves for baking; and (upper left) a completed core made by gluing two opposing halves together.
Lost Cores

Core are used for complex **injection moldings** in the **fusible core injection molding** process.

First, a core is made from a **fusible alloy** or low melting temperature **polymer**.

It is then placed inside the injection mould's dies and the plastic is shot into the mold. The molding is then removed from the mold with the core still in it.

Finally, the core is melted or washed out of the molding in a hot bath.
Binders

Special **binders** are introduced into core sands to add strength.

- **Core-oil process:**
  
  The oldest binder was **vegetable oil**, however now **synthetic oil** is used, in conjunction with **cereal** or **clay**.
  
  – Sand is blended with oil to develop strength
  
  – Wet sand is blown or rammed into a simple core box
  
  – In convection ovens at 200 – 260 °C for curing. The heat causes the binder to **cross-link** or **polymerize**.
  
  – While this process is simple, the dimensional accuracy is low.
Binders (Cont.)

• **Hot-box method**

  which uses a **thermoset** and **catalyst** for a binder.
  
  – Sand is blended with a thermosetting binder into a core box.
  
  – Heat to 230°C for curing
  
  – The binder that touches the hot surface of the core box begins to **cure** within 10 to 30 seconds.
Binders (Cont.)

• Cold-box method

which uses a binder that is hardened through the use of special gases.

– The binder coated sand is packed into a core box and then sealed so that a curing gas can be introduced.

– These gases are often toxic (amine gas) or odorous (SO\(_2\)), so special handling systems must be used.

– because high temperatures are not required the core box can be made from metal, wood, or plastic.

– An added benefit is that hollow core can be formed if the gas is introduced via holes in the core surface which cause only the surface of the core to harden; the remaining sand is then just dumped out to be used again.
Techniques to Enhance Core Properties

• Addition of internal **wires** or **rods**
• **Vent holes** formed by small wire into core
• Cores can be connected to the outer surfaces of the mold cavity
  – Core prints
• **Chaplets**- small metal supports that are placed between the cores and the mold cavity surfaces and become integral to the final casting
Chaplets

(Left) Typical chaplets. (Right) Method of supporting a core by use of chaplets (relative size of the chaplets is exaggerated).
Chaplets

- Cores are usually supported by **two core prints** in the mold.
- There are situations where a core only uses **one core print** so other means are required to support the **cantilevered end**. These are usually supplied in the form of **chaplets**.
- These are small metal supports that **bridge** the gap between the mold surface and the core, but because of this become **part of the casting**.
- The chaplets **must be of the same or similar material** as the metal being cast.
Chaplets (Cont.)

- Their **design** must be **optimized** because if they are too **small** they will completely melt and allow the core to move, but if they are too **big** then their whole surface cannot melt and fuse with the poured metal.

- Their use should also be **minimized** because they can cause **casting defects** or create a **weak spot** in the casting.

- It is usually more critical to ensure the **upper** chaplets are **stronger** than the **lower** ones because the core will want to float up in the molten metal.
Examples of Sand Cores and Chaplets

Examples of sand cores showing core prints and chaplets to support cores.
Mold Modifications

• Cheeks are second parting lines that allow parts to be cast in a mold with withdrawable patterns
• Inset cores can be used to improve productivity

(Right) Molding an inset section using a dry-sand core.

(Left) Method of making a reentrant angle or inset section by using a three-piece flask.
Removal of Core Methods

- Hydraulic cleaning
- Sand blasting
- Caustic bath / mechanical agitation
- Caustic autoclave
- Molten caustic
- Ultrasonics
Removal of Core Methods

- **Hydraulic cleaning:**
  
  **Description:**
  High pressure water jets erode core particles then re-circulate within machine
  
  **Advantages:**
  ✓ Good method for simple core geometry.
  ✓ Low health and safety issues.

  **Disadvantages:**
  ✗ Can be difficult
  ✗ Time consuming to remove the core.
Sand blasting:

Description:
Grit or shot is fired at the core passage within a cabinet either by compressed air or an impeller.

Advantages:
✓ Effective at removing large cores with low complexity.
✓ Low health and safety issues.
✓ Good casting finish

Disadvantages:
X High level of dust.
X High possibility of casting wear.
Advantages:
- Low cost,
- Simple method for removing cores.
- Minimises erosion of casting.

Disadvantages:
- Can take long time for large or complex cores.
- High level of health, safety and environmental risks.

**Caustic bath / mechanical agitation:**

**Description:**
Sodium or potassium hydroxide solution (35 – 50%) in a tank at room or elevated temp. Parts placed into solution and left for liquid to break down the core material. Mechanical or air agitation may be added.

**Advantages:**
- Low cost,
- Simple method for removing cores.
- Minimises erosion of casting.

**Disadvantages:**
- Can take long time for large or complex core
- High level of health, safety and environmental risks
Removal of Core Methods (Cont.)

- Ultrasonics:

  Description:
  Use of ultrasonic rays to break down macroscopic structures.

  Advantages:
  ✓ Speeds up the process
  ✓ Non contact

  Disadvantages:
  X Early development of the process.
  X Untested.
Removal of Core Methods (Cont.)

- **Caustic autoclave:**

  Best practice:
  - NaOH or KOH
    - Speed, recycle
  - Concentration
    - High / low, temperature
  - Component orientation
    - Up or down, horizontal
  - Cycle parameters
    - Dwell, vent, mid way break
  - Recycle caustic
    - Cost, efficiency
  - Post leach operations
    - Water wash
Removal of Core Methods (Cont.)

- **Molten caustic:**

  **Description:**
  Bath of molten concentrated caustic. Castings placed inside

  **Advantages:**
  ✓ Quick and effective at removing cores.

  **Disadvantages:**
  X Many health and safety issues.
  X Likely to attack the casting alloy surface