Compression and Compaction

Physics of Tablet Compression

Meaning / Definition of Tablet Compression

- **Tablet compression** is the process of converting powder or granules into solid tablets by applying mechanical pressure using a tablet compression machine (tablet press).



- During compression, powder particles are forced together, causing them to adhere to each other and form a solid compact mass called a tablet.
- The scientific study of how particles behave during compression is known as the physics of tablet compression.

Purpose of Tablet Compression

- **Tablet compression is performed to:**
  - Convert loose powder into a stable and strong tablet form.
  - Ensure uniform dosage of the drug.
  - Produce tablets with proper shape and adequate hardness.
  - Maintain uniform weight of tablets.
  - Achieve desired dissolution and disintegration properties.
  - Improve handling, packaging, transportation, and patient convenience.
  - Ensure tablets remain stable during storage and handling.

Basic Principles of Tablet Compression

- Tablet compression is based on the application of mechanical force to a powder bed inside a die cavity.
- **When pressure is applied:**

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- Powder particles move closer together.
- Air spaces decrease.
- Inter-particle bonds are formed.
- The powder bed becomes a solid compact tablet.

Basic Mechanism of Tablet Compression

During compression, several physical processes occur:

1. Particle Rearrangement

- At the beginning of compression, particles rearrange themselves to occupy empty spaces.
- Large void spaces between particles become smaller.
- The powder bed becomes denser and more compact.
- **Example:**
  - Small particles fill the gaps between larger particles.

2. Particle Deformation

- During compression, particles change their shape.
- **Elastic Deformation**
  - Particles temporarily change shape under pressure.
  - When pressure is removed, particles return to their original shape.
- **Plastic Deformation**
  - Particles permanently change their shape.
  - This helps particles stick together and form strong bonds.

3. Fragmentation

- Some particles break into smaller fragments during compression.
- These fragments create new surfaces for bonding.
- This increases inter-particle bonding and tablet strength.
- **Example:**
  - Brittle materials such as lactose tend to fragment during compression.

4. Bond Formation

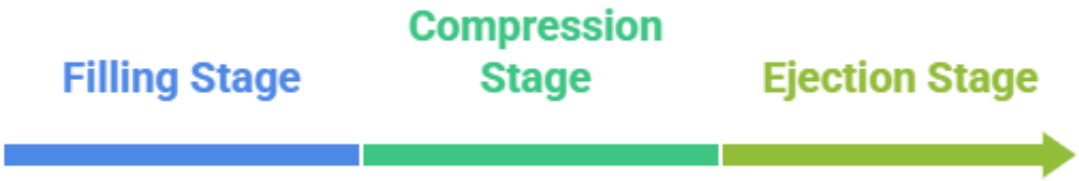
- **During compression, particles form different types of bonds such as:**
  - Mechanical interlocking
  - Van der Waals forces
  - Electrostatic forces

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- Solid bridges

➢ These bonds give the tablet mechanical strength and integrity.

Stages of Tablet Compression



A. Filling Stage

➢ Powder or granules enter the die cavity of the tablet press.

B. Compression Stage

➢ Upper and lower punches apply pressure to the powder inside the die.

➢ The powder particles are compressed into a solid tablet.

C. Ejection Stage

➢ The lower punch pushes the compressed tablet out of the die cavity.

Forces Involved in Tablet Compression

- During compression, forces are transmitted through:
  - Upper punch
  - Powder bed
  - Lower punch
  - Die wall

Factors Affecting Tablet Compression

- Particle size
- Moisture content
- Type of excipients used
- Compression force
- Speed of compression machine

Importance of Understanding Compression Physics

- **Understanding the physics of tablet compression helps to:**
  - Design tablets with proper hardness and disintegration properties.
- **Preventing manufacturing defects such as:**
  - Capping
  - Lamination

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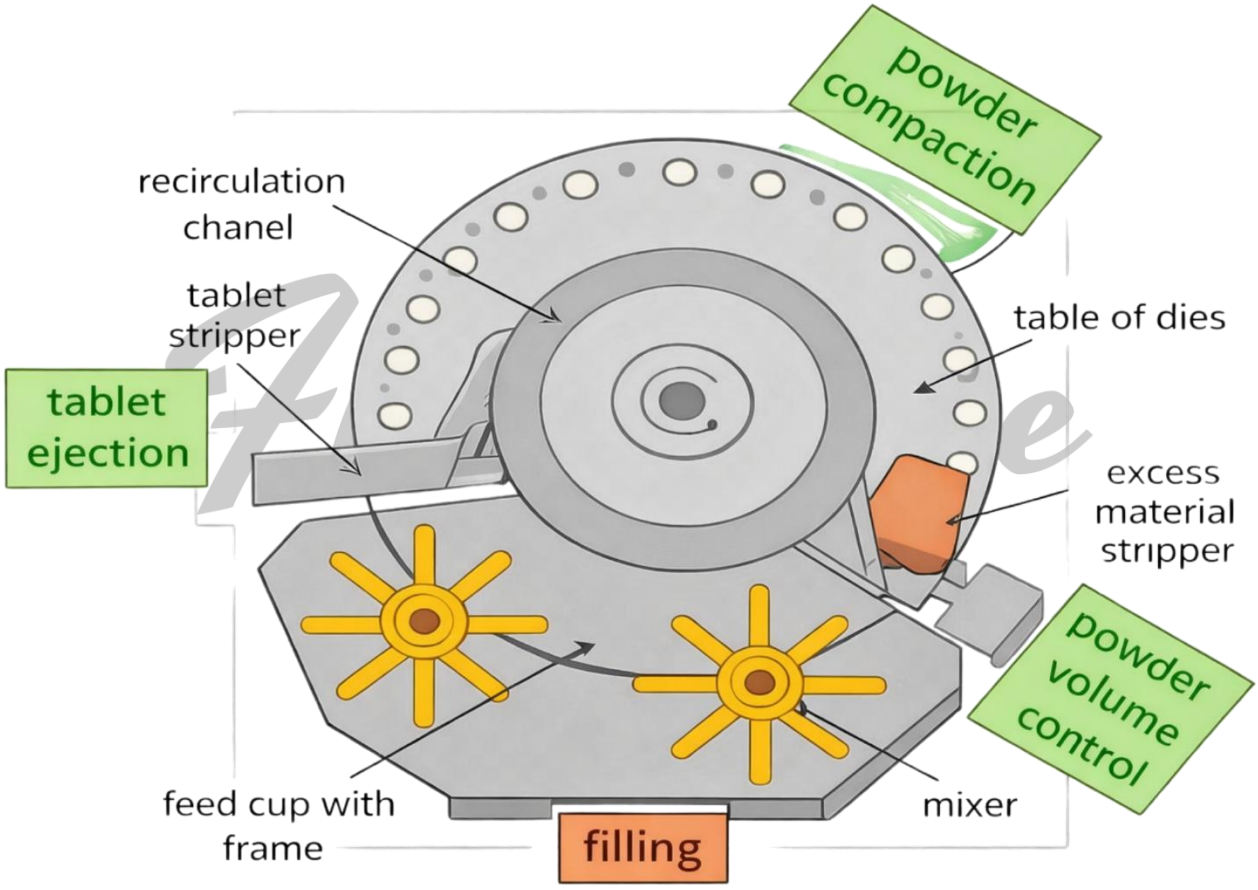
- Cracking

- Improve tablet quality and manufacturing efficiency.

Compression (Tablet Compression)

Definition / Meaning of Compression

- Compression is the application of mechanical force or pressure to powder or granules to reduce their volume and form a compact tablet.
- It is one of the most important steps in tablet manufacturing.
- During compression, powder particles are forced together to produce a solid and stable tablet.



Purpose of Compression

- Convert loose powder into a stable and mechanically strong tablet.
- Produce tablets that can withstand handling, packaging, and transportation.
- Ensure tablet uniformity and structural integrity.

Equipment Used in Compression

- **Compression is performed using tablet compression machines, such as:**
  - Single punch tablet press
  - Rotary tablet press

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- **Main parts of tablet compression machines:**
  - Upper punch
  - Lower punch
  - Die cavity

Process of Compression

The compression process occurs in several steps:



1. Die Filling

- Powder or granules are fed into the die cavity of the tablet press.

2. Pre-Compression

- A small pressure is applied to the powder bed.
- **Purpose:**
  - Removes air from the powder bed
  - Improves tablet strength
  - Prevents tablet defects

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3. Main Compression

- The main compression force is applied by the upper and lower punches.
- Powder particles are compressed into a solid compact tablet.

4. Tablet Ejection

- The lower punch pushes the tablet out of the die cavity.

Compression Mechanism

During compression, several physical changes occur in the powder bed:

1. Particle Rearrangement

- At the beginning of compression, particles move and rearrange themselves.
- Empty spaces between particles decrease.
- The powder bed becomes denser and more compact.

2. Particle Deformation

- As pressure increases, particles change their shape.
- **Elastic Deformation:**

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