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A REVIEW ON TABLET PROCESSING PROBLEMS AND ITS REMEDIES

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ABSTRACT

Tablet dosage forms remain one of the most widely used drug delivery systems due to their convenience, stability, and cost-effectiveness. However, the manufacturing of tablets is often challenged by a range of processing problems that can compromise product quality, efficacy, and patient compliance. Common issues include capping, lamination, sticking, picking, mottling, weight variation, hardness inconsistency, and friability. These problems arise from multiple factors such as poor powder flow, inadequate granulation, improper compression force, or unsuitable excipient selection. Environmental conditions like humidity and temperature further exacerbate these defects. Remedies involve a systematic approach that integrates formulation optimization, process control, and equipment calibration. For instance, capping and lamination can be minimized by adjusting compression force, improving binder concentration, or modifying punch design. Sticking and picking are often resolved by using anti-adherent agents, polishing punches, or controlling moisture content. Weight variation and hardness issues demand uniform granulation and precise machine settings, while mottling can be corrected through proper mixing and use of stable colorants. Advances in process analytical technology (PAT), direct compression techniques, and continuous manufacturing have further enhanced the ability to monitor and control these challenges in real time. Ultimately, successful tablet production requires a holistic understanding of material science, process engineering, and quality assurance. This review highlights the major tablet processing problems, their root causes, and practical remedies,

offering insights for pharmaceutical scientists and manufacturers to achieve consistent, high-quality tablet formulations.

KEYWORDS: Tablet processing, Tablet defects, Compression problems, Lamination, Sticking, Picking, Pharmaceutical manufacturing, Quality control remedies.

INTRODUCTION

Tablets are the most common solid oral dosage forms due to ease of administration, accurate dosing, and patient acceptability. Despite their advantages, tablet manufacturing is complex and prone to defects that affect quality, safety, and due to their convenience of administration, accurate dosing, stability, cost-regulatory compliance.

Tablets remain the most widely used solid dosage form in the pharmaceutical industry effectiveness, and patient compliance. The manufacturing of tablets involves a sequence of well-defined unit operations such as powder blending, granulation, drying, lubrication, compression, and coating. Despite advances in formulation science and manufacturing technology, tablet production is frequently challenged by various processing problems that can compromise product quality, performance, and regulatory compliance.

Tablet processing problems may arise at any stage of manufacture and are often reflected as visual defects, mechanical weakness, or performance failures of the final dosage form. Common defects include capping, lamination, sticking, picking, chipping, cracking, mottling, and variation in hardness or weight. These issues not only affect the aesthetic appearance of tablets but can also lead to dose non-uniformity, poor dissolution, reduced bioavailability, and batch rejection, resulting in economic losses and delays in production.

The root causes of tablet defects are multifactorial and may be related to formulation variables (such as excipient properties, particle size, moisture content, and binder concentration), process parameters (compression force, machine speed, and tooling design), or environmental conditions (humidity and temperature). A clear understanding of the interplay between material characteristics and processing conditions is therefore essential for effective troubleshooting and quality assurance.

This review article aims to provide a comprehensive overview of the major tablet processing problems encountered during pharmaceutical manufacturing, along with their underlying causes and practical remedies. By systematically discussing common defects and their

solutions, this review seeks to serve as a valuable reference for students, researchers, and professionals involved in tablet formulation and production, supporting the development of robust and high-quality tablet dosage forms.

Tablet

Definition

- Tablet: A tablet is a solid unit dosage form that contains one or more active pharmaceutical ingredients (APIs) along with suitable excipients.
- It is usually prepared by compression of powders or granules (sometimes by mottling.
- Tablets are among the most widely used dosage forms because they are portable, stable, cost-effective, and allow precise dosing.
- They can be formulated to release drugs immediately, slowly, or at a targeted site depending on therapeutic needs.

Ideal Properties of Tablets

For a tablet to be considered ideal, it should meet the following characteristics:

1. Physical Properties

- Uniform size, shape, and weight for consistency.
- Adequate hardness to withstand handling and packaging without breaking.
- Smooth surface for easy swallowing and aesthetic appeal.
- Stable colour and appearance without mottling or defects.

2. Pharmaceutical Properties

- Accurate dosage: Each tablet must contain the correct amount of drug.
- Rapid disintegration: Should break down quickly in the gastrointestinal tract unless designed for sustained release.
- Proper dissolution rate: Ensures the drug is released and absorbed effectively.
- Chemical and physical stability: Maintains potency and safety throughout its shelf life.

3. Patient-Centric Properties

1. Easy to swallow with no sharp edges.
2. Pleasant taste or coating to mask bitterness.

TABLET	Ideal Characteristics
Physical:	Uniform size/shape, hardness, smooth surface
Pharmaceuticals	Accurate dose, rapid disintegration, proper dissolution, stability

Patient-Centric	Easy swallowing, taste masking, non-irritating, portable

Tablet Compression Defects

- Capping – Separation of the top or bottom layer of a tablet due to air entrapment.
- Lamination – Splitting of a tablet into two or more distinct layers during compression.
- Cracking – Fine surface fractures appearing on tablets because of rapid expansion or contraction.
- Chipping – Breaking of tablet edges caused by improper handling or weak granules.
- Sticking – Tablet material adhering to the punch faces during compression.
- Picking – Small amounts of material sticking specifically to the embossed or engraved punch surface.
- Binding – Excessive friction between tablet and die wall leading to rough edges.
- Mottling – Uneven distribution of colour on the tablet surface.
- Double Impression – Duplicate embossing marks caused by free movement of punches.

A. CAPPING

1. Capping is a common defect observed during tablet compression in which the upper or lower part of a tablet separates from the main body.
2. This defect usually appears during ejection from the die or immediately after compression.
3. The primary reason for capping is trapped air with in granules which expands when compression pressure is released.
4. Factors such as poor binding, low moisture content, excess fine particles, and high compression speed contribute to this problem.
5. Capping reduces tablet strength, appearance, and overall product quality, often resulting in rejection during quality control.

Causes of Capping

- Air entrapment in granules during compression.

- Insufficient binding or improper moisture content.
- Worn tooling (punches/dies).
- Excess fines or poor granulation.
- High compression speed leading to stress release.

Remedies for Capping

- Granulation adjustment: Optimize moisture, particle size, and binder concentration.
- Compression force control: Apply gradual compression to reduce air entrapment.
- Tooling maintenance: Replace worn punches /dies.
- Pre-compression step: Light compression before final pressing to expel trapped air
- Lubrication: Ensure proper lubrication to reduce sticking and stress

Remedies	Advantages	Disadvantages
Granulation optimization	Improves tablet strength & uniformity	Time-consuming, requires trials
Pre-compression step	Reduces air entrapment, minimizes capping	Increases machine cycle time
Tooling replacement	Ensures consistent tablet quality	Costly for manufacturers
Binder adjustment	Enhances cohesion and mechanical strength	Risk of over wetting→ sticking
Lubrication control	Smooth ejection, prevents stress fractures	Excess lubricant may affect dissolution

B. LAMINATION

1. Lamination is a tablet manufacturing defect in which a compressed tablet separates into two or more distinct horizontal layers after compression.
2. The layers split parallel to the tablet face, giving the appearance of the tablet being stratified rather than breaking into fragments.
3. Lamination may occur immediately after ejection from the die or develop later during storage, coating, or handling.
4. The defect results from inadequate bonding between powder particles, leading to failure of the compact under internal stress.
5. Entrapped air within the powder mass and its sudden release during decompression creates internal pressure that promotes layer separation.
6. Elastic recovery of the compressed material causes expansion of the tablet, which exceeds its cohesive strength and leads to lamination.
7. High compression forces and rapid compression speeds increase stress accumulation and worsen the tendency toward lamination.

8. Formulations containing materials with poor plastic deformation or high elasticity are more prone to this defect.
9. Lamination differs from capping in that the tablet separates into multiple layers rather than losing only the top or bottom portion.

Causes Of Lamination

A. Formulation-Related Causes

1. Low binder concentration or ineffective binder.
2. Excessive fines in the granulation.
3. Improper granule size distribution.
4. Low or non-uniform moisture content.

B. Process-Related Causes

1. Excessive compression force.
2. High turret speed resulting in short dwell time.
3. Rapid decompression during ejection.

C. Equipment-Related Causes

1. Worn or poorly designed punches and dies.
2. Inadequate venting of air from the die cavity.

Remedies for Lamination

A. Formulation Adjustments

1. Increase or optimize binder type and concentration.
2. Reduce excessive fines by proper granulation and sieving.
3. Maintain optimal and uniform moisture content.

B. Process Optimization

1. Apply pre-compression to allow gradual air release.
2. Reduce compression force to minimize internal stress.

3. Decrease turret speed to increase dwell time

Advantages

1. Improves mechanical strength and integrity of tablets.
2. Enhances uniformity in dose and drug release.
3. Reduces batch rejection and production losses.

Disadvantages

1. Leads to tablet breakage and loss of structural integrity.
2. Causes dose variation due to layer separation.
3. Affects dissolution and bioavailability of the drug.

C. CRACKING

1. Cracking is a tablet manufacturing defect characterized by the formation of visible fractures or fine splits on the tablet surface, particularly around the edges or crown.
2. The cracks may appear during compression, ejection, or subsequent handling, such as coating, packing, or transportation.
3. Unlike capping or lamination, cracking does not involve complete separation of tablet layers but presents as surface or structural fissures.
4. Cracking occurs due to uneven stress distribution within the tablet during compression and rapid elastic recovery after decompression.
5. Inadequate inter-particulate bonding causes the tablet to fail when subjected to mechanical stress.
6. Tablets with complex shapes, deep score lines, or embossed logos are more susceptible to cracking.
7. Non-uniform density across the tablet mass leads to weak zones that initiate crack formation.
8. Cracking compromises mechanical integrity and may worsen during downstream processes such as coating.

Causes of Cracking

A. Formulation-Related Cause

1. Insufficient binder content or weak binder type.
2. Improper moisture content in granules (too dry or uneven).
3. Poor granule size distribution.

B. Process-Related Causes

1. Excessive compression force.
2. Rapid decompression or ejection.
3. Inadequate pre-compression.

C. Equipment-Related Causes

1. Deep or sharp embossing on punches.
2. Worn or misaligned punches and dies.
3. Improper tablet shape design.

Remedies for Cracking

A. Formulation Adjustments

1. Increase or optimize binder concentration.
2. Maintain optimal and uniform moisture content.
3. Improve granule size uniformity through proper granulation.

B. Process Optimization

1. Reduce compression force to avoid excessive stress.
2. Introduce or optimize pre-compression.
3. Reduce turret speed to allow uniform compression.

C. Equipment Improvements

1. Modify punch design to reduce sharp edges and deep embossing.
2. Replace worn punches and ensure proper alignment.
3. Select tablet shapes that distribute stress evenly.

Advantages

1. improves tablet mechanical strength and durability.
2. Enhances product appearance and patient acceptability.
3. Prevents further defects during coating and packaging.

4. Ensures consistent dose delivery.

Disadvantages

1. Weakens tablet structure, leading to breakage.
2. Causes poor aesthetic quality and reduced consumer confidence.
3. May lead to dose variation due to fragment loss.
4. Affects coating uniformity and stability.

D. CHIPPING

Definition

Tablet chipping is a manufacturing defect in which small portions break off from the edges or surface of a tablet during compression, ejection, handling, coating, or packaging.

1. Tablet chipping is a manufacturing defect in which small fragments break off from the edges or surface of a tablet during compression, ejection, handling, or post-processing.
2. It occurs when the tablet has insufficient mechanical strength to withstand applied mechanical stress.
3. Chipping is mainly caused by weak inter-particle bonding within the tablet matrix.
4. The defect is commonly seen at edges and corners, especially in tablets with sharp or complex shapes.
5. Chipping leads to loss of material, resulting in poor appearance, weight variation, and reduced tablet quality.

Causes of Chipping

1. Formulation related causes

* Inadequate or improper binder concentration
* Brittle granules due to improper moisture content
* Poor granule strength and non-uniform particle size distribution

2. Tablet Design Causes

* Sharp edges and thin tablet sections

* Complex shapes, deep embossing, or logo

3. Process-Related Causes

* Excessive or improper compression force
* Insufficient lubrication leading to high ejection friction
* Improper tablet ejection conditions

Remedies of Chipping

1. Optimize binder type and concentration.
2. Maintain proper moisture content of granules.
3. Adjust compression force appropriately.
4. use rounded tablet designs

Advantages

1. Acts as an indicator of formulation or process problems.
2. Helps in optimizing compression and tooling conditions.

Disadvantages

1. Causes poor appearance and reduced patient acceptability.
2. Leads to weight variation and reduced tablet quality.
3. May result in batch rejection and economic loss.

E. STICKING

1. Tablet sticking is a defect where granules or powder adhere to the punch faces during compression.
2. It leads to imperfect tablet surfaces and unclear or missing embossing.
3. The defect is commonly caused by high moisture content or insufficient lubrication.
4. Sticking interferes with smooth tablet ejection and uniform tablet formation.
5. It indicates formulation or process imbalance in tablet manufacturing.

Causes of Sticking

1. High moisture content in granules or powder blend.
2. Insufficient lubrication or improper lubricant selection.
3. Presence of low-melting, hygroscopic, or sticky ingredients.
4. Rough, worn, or damaged punch faces.

Remedies of Sticking

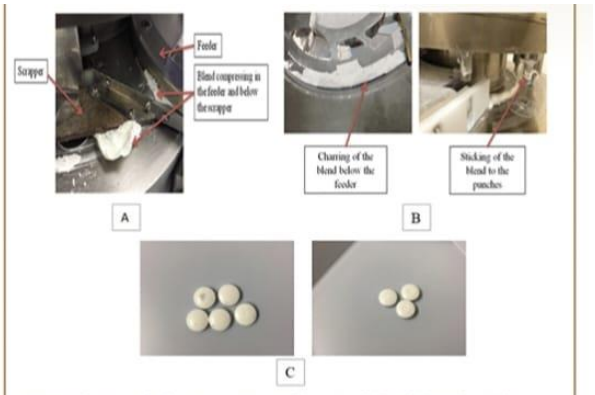
1. Dry granules properly and maintain controlled humidity conditions.
2. Optimize type and concentration of lubricants and anti-adherents.
3. Modify formulation by using suitable excipients or absorbents.
4. Polish, coat, or replace worn punches and dies.

Advantages

1. Acts as an early indicator of formulation or processing problems.
2. Helps in optimizing lubrication and moisture control.
3. Assists in improving punch surface maintenance practices.

Disadvantages

1. Produces rough tablet surfaces and poor appearance.
2. Causes loss of embossing and identification marks.
3. Reduces production efficiency due to frequent machine stoppages.



A: Sticking of the Compound XY tablet blend in the feeder and below the scrapper.
B: Charring of the blend below the feeder and sticking to the punches.
C: Tablets show discoloration on tablet surface and picking in center.

F. PICKING

1. Tablet picking is a defect where small amounts of material are removed from the tablet surface during compression.
2. The removed material adheres to the punch face, especially at engraved or embossed areas.
3. It causes pits or rough marks on the tablet surface.
4. Picking is a localized form of sticking in tablet manufacturing.
5. It indicates formulation or punch-related problems.

Causes of Picking

1. High moisture content in granules or tablet blend.
2. Inadequate lubrication or absence of anti-adherents.
3. Low-melting, sticky, or hygroscopic ingredients in the formulation.
4. Rough, worn, or engraved punch surfaces.
5. Excessive compression force and heat generation

Remedies of Picking

1. Dry granules properly and control environmental humidity.
2. Optimize lubricant and anti-adherent type and concentration.
3. Modify formulation by using suitable excipients or absorbents.
4. Polish, coat, or replace damaged punches.
5. Reduce compression force and adjust machine speed.

Advantages

1. Acts as an early indicator of formulation or tooling issues.
2. Helps in optimizing moisture control and lubrication.
3. Assists in improving punch design and maintenance.

Disadvantages

1. Causes pits, rough surfaces, and poor tablet appearance.
2. Leads to unclear or damaged embossing and identification marks.
3. Reduces production efficiency due to frequent stoppages.
4. May result in batch rejection and economic.

G. BINDING

* Binding is a tablet defect where granules adhere to the die wall during compression.

* It causes difficulty in tablet ejection from the die.
* Common causes include excess binder, high moisture content, and insufficient lubricant.
* It results in scratches, drag marks, or tablet surface damage.
* Binding can be prevented by optimizing binder level, moisture, and lubrication.

Causes of Binding

* Excessive use of binder in the formulation.
* High moisture content in granules.
* Insufficient or improper lubrication.
* Rough or worn die surfaces.

Remedies of Binding

* Reduce the binder concentration.
* Dry granules to an optimal moisture level.
* Add or optimize lubricants (e.g., magnesium stearate)
* Polish or replace damaged dies.

Advantages

* Improves granule cohesion when present in controlled amounts.
* Enhances tablet hardness and mechanical strength.
* Helps maintain tablet integrity during handling.

Disadvantages

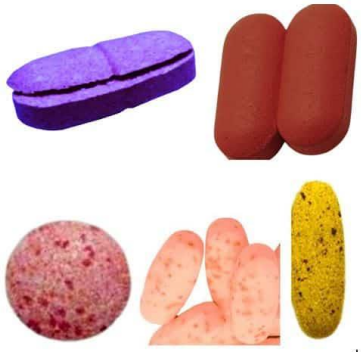
* Causes sticking to die wall and ejection problems.
* Produces scratches, drag marks, or defective tablets.
* May lead to tablet breakage or rejection.

H. MOTTLING

- Mottling is a tablet defect characterized by uneven or patchy distribution of colour on the tablet surface.
- It appears as light and dark areas or spots on a tablet instead of a uniform colour .
- This defect occurs due to non-uniform distribution of colorants or ingredients in the tablet formulation.
- Mottling mainly affects the appearance and aesthetic quality of tablets.
- Although it usually does not alter therapeutic efficacy, it can reduce patient acceptance of the product.

Causes of Mottling

* Improper mixing of colorants
* Difference in particle size of ingredients
* Migration of dye during drying
* Use of coloured drug with white excipients.



Remedies of Mottling

* Use lake pigments instead of dyes
* Ensure proper blending
* Maintain uniform particle size
* Control moisture and drying process

Advantages

* Helps detect processing problems
* Acts as a visual quality indicator
* Does not usually affect drug action

Disadvantages

* Poor tablet appearance
* Lower patient acceptance
* Possible batch rejection.

I. DOUBLE IMPRESSION

1. Double impression is a tablet defect where more than one imprint appears on a single tablet surface.
2. It occurs due to rotation or movement of engraved punches during compression.
3. The defect mainly affects tablets with embossed letters, numbers, or logos.
4. It causes unclear or overlapping markings, affecting tablet appearance and identification.
5. Double impression is a manufacturing defect related to machine or punch instability.

Causes of Double Impression

1. Rotation or movement of engraved punches during compression.
2. Loose or worn punches and high machine speed.

Remedies of Double Impression

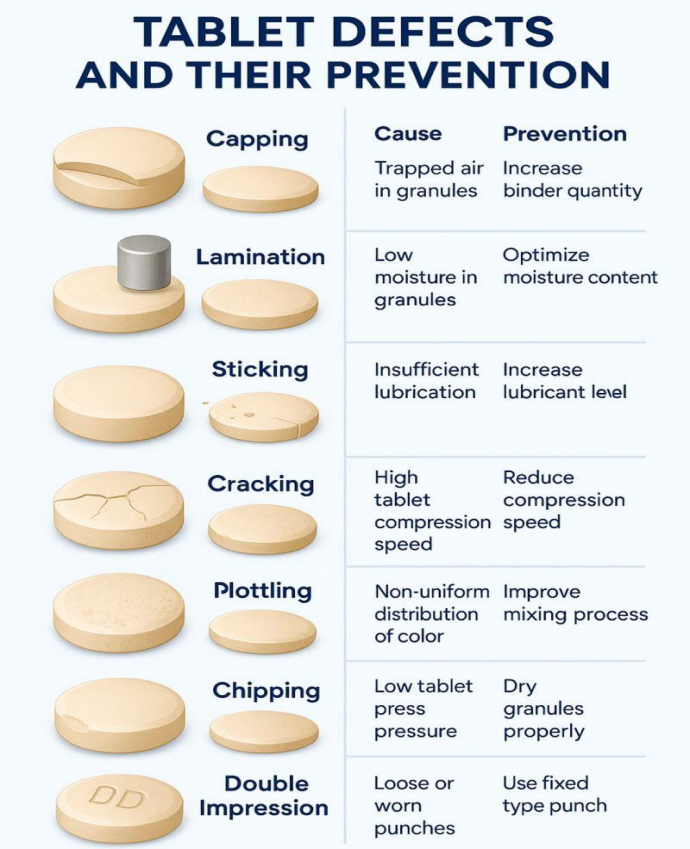
1. Use anti-rotation or keyed punches.
2. Proper punch fixing and machine maintenance.

Advantages

1. Does not affect tablet dose or strength.
2. Helps identify machine-related problems.

Disadvantages

1. Poor tablet appearance and unclear imprint.
2. May lead to rejection due to quality issues.



CONCLUSION

Tablet processing problems are a major concern in pharmaceutical manufacturing as they directly influence product quality, patient acceptability, and regulatory compliance. Defects such as capping, lamination, sticking, mottling, chipping, and weight variation mainly arise from inappropriate formulation design, poor flow and compression characteristics, and suboptimal processing conditions. A thorough understanding of the underlying causes of these problems is essential for effective control. Appropriate selection of excipients, optimization of granulation methods, proper tooling design, and careful adjustment of processing parameters can significantly reduce tablet defects. Implementing preventive strategies during formulation development and scale-up ensures consistent tablet quality, enhances manufacturing efficiency, and minimizes production losses. Overall, systematic identification and timely correction of tablet processing issues play a crucial role in achieving robust, safe, and high-quality solid dosage forms.

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