How to Avoid Sticky Situations

Sticking is often described as the Achilles' heel of tablet production. It is one of the most common tablet tooling problems and can have a profound effect on production, leading to reduced output and increased costs. This article explains why sticking occurs and proposes several solutions.

Sticking can be confused with picking, which is another common manufacturing problem. However, they are fundamentally different. Sticking is when granule builds up on the punch tip face or die bore. Picking is compressed granule that has adhered to the embossing detail on the punch face, resulting in the "picking out" of parts from the tablet face.

Both issues have a negative effect on tablet appearance and can become so serious that production is interrupted. In extreme cases, punches need to be removed and cleaned. This is disruptive, labour intensive, reduces output and increases production costs.

There are many reasons why sticking can occur, and while it can feel like a challenge to resolve, there are solutions available.

Why Does Sticking Occur?
There is no simple answer to this question. It can be due to any number of reasons, from the physiochemical properties of the formulation to the surface characteristics of the punch face. It can also be related to the machinery, for example the compression force and speed, as well as the environmental conditions like temperature and humidity.

Sticky Granule: Problem
The granule within a formulation can be highly influential when it comes to sticking. Simply put, sticking is the battle between the cohesive forces holding a tablet together and the adhesive forces between the ingredients in the formulation. When the difference in force is significant and adhesive forces are higher, sticking occurs. There are three factors to consider when understanding the cohesive forces. The first is Van der Waals. This is the attraction of intermolecular forces between molecules and is affected by surface roughness and the effective contact area. Essentially, molecules can attract each other at moderate distances and repel at close range. Although these forces are very small, in mass they combine not only increasing cohesive forces within a tablet but also creating adhesive forces (when interacting with the elements in the tools steel or coating), which can cause sticking.

Capillary action is the second cohesive force created when moisture condenses into the gap between a particle and the surface, causing a capillary bridge. The strength of these forces can depend upon relative humidity, gap geometry and surface chemical condition. Capillary bridges increase the cohesive forces that bind a tablet together, and like Van der Waals, they can also be detrimental by increasing the adhesion forces between the granule and the punch tip faces, causing sticking. This is why it's important to control the environment in all areas of tablet production and reduce humidity.

The third cohesive force is electrostatic. This is when tribo-charging occurs between contacting materials. It forms static electricity and is evident when the granule is very dry. The resulting force can be fairly strong and long-ranged, creating cohesive and adhesive forces. The environment is the biggest influence on adhesive forces causing sticking between the formulation and punch tip faces. Temperature can affect some active pharmaceutical ingredients (APIs). A good example of this is Ibuprofen, which has a very low melting point. For this reason, it is important to control the temperature in any area where the tabletting process takes place. Keeping the temperature at a constant low level will reduce sticking.

Humidity is also a problem. Moisture within a tablet can strengthen the adhesive force. This occurs with an increase in capillary action between the tooling surface and the granule. Capillary bridges form, causing high adhesion areas, creating sticking. Moisture can enter the process during wet granulation or from excess humidity in the compression chamber in a non-environmentally controlled area – the latter can even affect direct compression formulations.

Deformation Mechanics
Deformation Mechanics are another adhesive force that can cause sticking. The physical properties of the granule being compressed are either elastic or plastic. When under compression, a particle will either remain deformed or return to its original shape. Formulations with more time dependent consolidation behaviour will need a longer dwell time to form strong bonds between the particles. Extended dwell time at main compression is, therefore, more important for formulations with predominantly elastic deformation behaviour, rather than brittle fracture behaviour. In these instances, extended dwell flat tooling will enable a suitable compression dwell time for a formulation without the disadvantage of slowing the press.

Sticky Granule: Solution
Overcoming sticky granule problems can be a complex task. A good starting point is to optimise the environment in which tablet compression takes place and areas where tooling and granule are stored with the correct temperature and humidity controls.

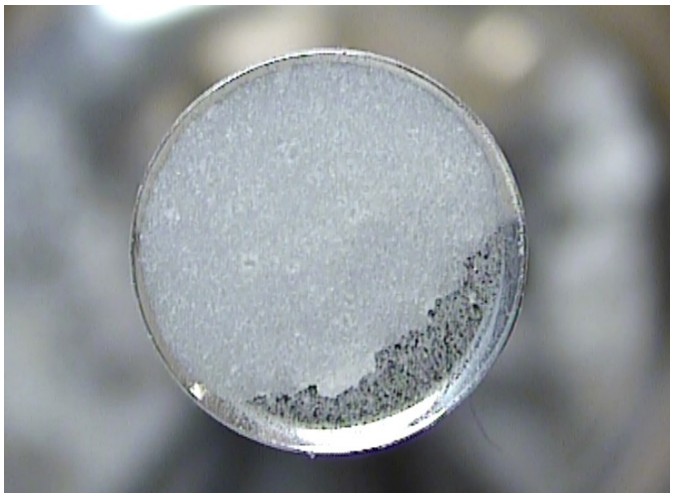
Consider your tablet tool coating. Choosing an anti-stick coating is essential, as conductive or non-conductive tool coatings or treatments can also influence cohesive and adhesive forces.

Specialised punch and die coatings can have a huge impact on the productivity of tablet manufacture. When used in conjunction with high-quality tooling steel, they allow for better tableting efficiency and output.

Surface Finish: Problem
The morphology or surface roughness of a punch tip can affect tablet production. While there is the perception that polishing the punch tip face to a mirror finish will prevent sticking, this is not the case. Research on the interaction

of different surface textures has shown that the standard specification for tablet punch tip faces can include a range of surfaces, which interact with formulations in different ways.

The required standard surface for a punch tip is between 0.1 to 0.025Ra (roughness average). This variance can have a huge effect on sticking. Each coating's surface condition works differently because of the surface roughness. In order to prevent sticking, it's important to understand the effect on the interaction between granule and surface finish.



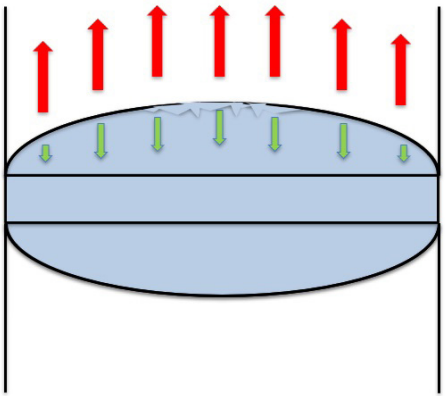
Surface Finish: Solution
The punch surface can be determined in a number of ways, such as:

- Measuring the surface roughness after polishing using optical surface profilometry
- Using scanning electron microscopy to study the structure of the steels and coatings
- Measuring adhesion forces to create a nanoscale map of the surface.

By investigating the surface condition, the correct coating can be applied.

Tool maintenance should also be addressed. Assessing and polishing tooling are crucial steps to ensure that any tooling defects can be dealt with early. Automated polishing using a MF polishing machine is the best method to ensure a suitable surface will be maintained. This also repairs small areas of damage and abrasion that occur during production.

ADHESIVE FORCES > COHESIVE FORCES



By restoring the optimum finish of the tooling, problems like sticking or picking can be prevented.

Poor Tablet Design: Problem
Insufficient tablet compaction is another cause of sticking. In a tablet with decreased hardness, the cohesive force can be less than the adhesive force to the tooling surface. This is a common problem with effervescent tablets as they require a lower hardness to help increase the dissolution rate. Tablet design also has an influence on sticking. A typical indicator is when sticking is found around a tablet's core. However, it can occur in other parts of the tablet as well.

The principal reason for insufficient tablet compaction is an uneven distribution of compaction forces across the tablet. This is usually due to the shape of the tablet and how concave it is. With a concave tablet profile, the core can be lower in hardness, causing sticking to the centre of the punch face. This occurs because a concave punch tip profile compresses

the formulation around the edge of the tablet more than in the centre due to the tablet profile.

Poor Tablet Design: Solution
Specially designed tooling with an elliptical head is one way to increase the dwell time, helping the granule to consolidate during compaction without automatically increasing tablet hardness. Dwell time is defined as the amount of time each individual punch head flat is in contact with the compression roller of a rotary tablet press when the compression force applied to form the tablet is above 90% of its peak value.

Adding either a coating or a polymer insert will also help to reduce the adhesive force.

A tablet design with a flatter profile and changing from a deep single radius to a double radius, reduces the soft area

in the centre of the tablet with the lowest cohesive force. This results in an even tablet hardness, helping to decrease sticking issues by increasing the cohesive forces.

Changing the profile to a double radius can also be beneficial because an even coating thickness is easier to achieve and branding or required markings like break-lines can be accommodated.

Sticking – An Ongoing Struggle
Sticking is detrimental to tablet production. The knock-on effect is costly as tablet press downtime and reduced productivity is inevitable. Sticking must be resolved in order to mass produce quality tablets. There can be many reasons for the cause of sticking from Van der Waals forces to capillary action associated with high moisture content, or conversely, from static electricity generated in very dry conditions. Because the physical properties of any sticky formulation are unique, there is no one-size-fits-all anti-stick solution.

It is important to contact an experienced tooling manufacturer who understands the science behind tablet production and can introduce innovative solutions to tabletting problems, therefore, maximising production capabilities.

Rob Blanchard

Since joining I Holland in 2004 Rob has been instrumental in the development of I Holland's PharmaCote® range of surface treatments and coatings for tablet compression tooling designed to improve properties such as wear resistance, corrosion resistance and antistick characteristics. He was also part of the Eurostandard steering committee and responsible for I Holland's registration to ISO 9001:2008. Rob holds multiple patents linked to solid dose manufacture. Rob also co-ordinates I Holland's close collaboration with various respected.