tablet press operation

Preventing and fixing weight and hardness defects: Strategies for production personnel

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Tablet specifications are tight, and the list of possible defects is long: Variable weight, sticking, picking, black spots, streaks, capping, lamination, variable hardness, among others. This article focuses on variations in tablet weight and tablet hardness. It pinpoints the possible causes of these defects and offers advice on preventing and fixing the source of the problems. It also discusses the problems of formulations with too many fines.

Every product behaves differently on a tablet press, even if it's the same product run on a different day. The variation often stems from changes in the properties of the raw materials—active ingredients and excipients—from batch to batch. Naturally, the goal is to minimize these changes. Tablet press operators, however, don't have any control over formulation and granulation. They have to work with what they're given, and their employers expect them to make good tablets day in, day out.

Tablet weight: Sources of variation

If you're a tablet press operator, the exchange below may have a familiar ring to it.

Tablet press operator: It says right here that if the operator cannot maintain target weights within acceptable quality limits that I must report to you, my supervisor. So what should I do?

Supervisor: You're the operator. How'd you do it last time? It worked fine on the last batch, right?

Operator: I didn't do anything differently. It must be the product. So what do you want me do?

Supervisor: Let's pull out the checklist and review the options.

So the two of them scan the checklist on weight control, which tells them that tablet weights are mainly affected by

1. Product variation
2. Machine condition
3. Tooling condition
4. Flow of powder on the machine

Let's look at each of these factors.

Product variation. Sources of product variation include inconsistent powder density and particle size distribution. While you may think that density variations originate with your colleagues in formulation and granulation, density can also change on the press, often because of overfilling of the die and re-circulation of the powder on the tablet press. The particle size distribution can change when the product becomes "unblended" during transfer or because of static electricity. It might also change because the product can't withstand the handling and the mechanical stress it undergoes before reaching the tablet press.

Machine condition. The problems caused by a tablet press that is poorly prepared or operated are legion. Look at the die table. Have you inspected its runout? The up and down motion under load on a new die table should be within 0.003 inch of the setting. You must also ensure that the pressure rolls and cams are in very good condition.

Tooling condition. There is quite a bit of information available on tooling, but in a discussion of weight variation, the punch working length is the property that you must know. Working length is the key factor in how punches affect tablet weight. New tools are made to a tolerance of one-thousandth of an inch, which is equal to the thickness of one page in this magazine. Make sure the length of each punch is correct and identical.

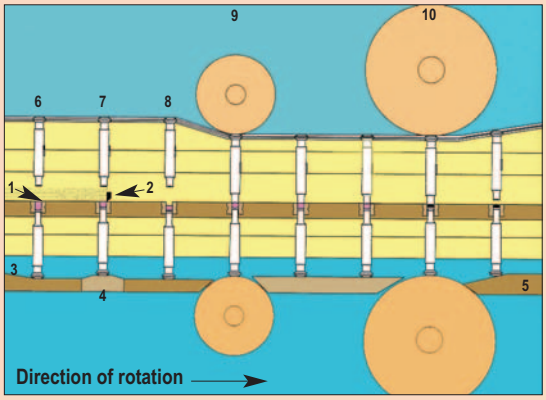
Powder flow and feed-rates. Many of the defects related to powder flow and feed-rates stem from the formulation you're given, not the operation of the tablet press. Since the focus of this article is resolving problems at the tablet press, I won't go into the many problems that may be related to the granulation process or the formulation itself except to say that too many fines is bad. I address fines in more detail at the end of the article and in the sidebar on page 42.

Tablet press adjustments

As the tablet press operator, your job is to make good tablets, no matter how poorly the product works on the tablet press. Here are some things you can adjust on the tablet press to overcome weight variations. Refer to Figure 1.

FIGURE 1

An illustration of the compression cycle



Courtesy of the American Pharmaceutical Association

1. Product in feeder
2. Scraper
3. Fill cam (partial view)
4. Weight adjustment cam
5. Ejection cam
6. Fill position
7. Weight adjustment position
8. Pull-down position
9. Pre-compression
10. Main compression

Head pressure. This factor is related to the amount of product in the overhead feed system or hopper. The more product present, the greater the head pressure, and vice versa. When the pressure varies, so does the weight of the tablets.

Hopper level. To keep the head pressure consistent, you need to maintain the product in the hopper at a consistent level. Maintaining the level within a narrow range will reduce the potential for weight changes. Every operator knows that tablets produced at the end of a run weigh less than those made at the start. That's because the hopper level (and thus head pressure) decreases during the run. If you determine that variations in the hopper level are linked to variations in tablet weight, you must monitor the weights more often and adjust your equipment so the level is more consistent.

Feeder clearance. Generally speaking, you should set the clearance between the feeder and the die table according to the product's particle size. The smaller the particle size, the smaller the clearance between the feeder base and the die table, and vice versa. That's the *general* rule, but there's a big "if" involved here: If the powder is waxy or very moist, a feeder that is incorrectly set may compact, or "pack" the powder on the die table. In such

cases, the only way to determine the best setting is to experiment with different clearances.

Feeder speed. The feeder delivers powder from the hopper to the die table, and the rotating paddles in the feeder are intended to match the powder flow rate to the rotational speed of the press. The feeder can also unmix blended powders, and the paddles can break friable granules and compact highly moist powders. The best strategy is to run the feeder as slowly as possible while maintaining proper tablet weight. Running the feeder too fast can also cause the product to segregate. See Figure 2.

Fill cam. The fill cam allows the die cavity to be overfilled. The excess is then pushed up and out of the die when it reaches the weight adjustment cam so that the scraper blade can remove the excess as the die passes by. Most modern tablet presses include a "pull-down" position after the weight adjustment step. I discuss this feature later in the article. Thin tablets require a shallow fill cam, and thick tablets need a deep fill cam. It's typically necessary to overfill the cam by 10 to 30 percent to maintain consistent tablet weights.

Scraper blade condition and adjustment. The scraper blade is a wear part. It's worn by die table rotation and product abrasion. The more abrasive the product, the faster the scraper's edge will wear. So inspect the blade frequently and replace it as needed. When the blade is in bad condition or set up incorrectly, it won't scrape the die table clean, and you'll have problems with weight control.

Re-circulation. After the scraper blade levels the powder in the die, it guides the excess powder into a re-circulation channel. This allows the powder to travel on the turret until it returns to the feeder. If the fill cam is set too deep, there may be "an excess of excess" powder in the re-circulation channel. When that happens, the powder will not flow well. It may even back up, spill, compact, or leak, all of which can reduce yield and alter the characteristics of the re-circulated powder. Poor re-circulation produces a powder that is overworked, compacted, unmixed, or otherwise damaged.

To see what's happening on the press, use a strobe light. It lets you see how well the product flows, how well the scraper blade works, and how well the die and punches are functioning. See Figure 3.

Figure 2

Removing the feeder from this tablet press reveals segregated powder, which ultimately leads to weight fluctuations. Running the feeder too fast is one cause of segregation.

Figure 3

A strobe light can reveal how well a product flows, how well the scraper blade works, and how well the die and punches are functioning.

More on weight variation

Those are some of the machine-related variables that can affect tablet weight. But what if the weight problem is related to the product, not the machine? In some cases, you'll be tempted to return the problematic product to the granulating department. More likely, you'll be asked to consult your supervisor.

Operator: So are you going to answer my question? What do I do?

Supervisor: Hmm. Isn't the next shift going to be here soon? Just joking!

In the real world, we have to solve the problems, not pass them along to the next shift. The first point to remember: Change one (and only one!) variable at a time. The next step is to define the extent of the problem by checking the tablets closely. Is there a pattern to the weight variation among individual tablets? Is the variation consistent? Does it come and go? Is the trend toward overweight or underweight tablets or does it go both ways?

At some point you might think, "But I've got automatic weight control on my tablet press! Why is this happening in the first place?" Well, you have to understand that "automatic weight control" works by allowing the tablet press to make weight adjustments based on variations in compression force. When the compression force is below the limit, an electronic signal tells the tablet press to fine-tune the weight adjustment cam to increase the fill volume. When the compression force increases, another signal tells the tablet press to fine-tune the weight cam to reduce the volume of fill. That's all weight control is, nothing more. In short, you must make incremental adjustments to the weight cam to attain accurate volumetric change, which—given a known and fixed product density—relates precisely to gravimetric change.

If you've gotten this far and the tablet weights still vary too much, look closely at how well the machine keeps the product in the die before it's compressed into a tablet. Light, fluffy powders may "splash" out of the die, or the centrifugal force of the rotating turret may cause the powder to come out. Either way, the tablet will be underweight. The best defense against splashing is to use the "pull-down" feature offered on most tablet presses nowadays. This feature pulls the lower cam down, allowing the column of powder to drop into the die after filling , thus preventing under-filling. It can also prevent the powder from splashing.

Reducing machine speed is another good strategy. Naturally, you'd prefer to move the powder through the tablet press as fast as possible, but the formulation dictates the speed of the press. I know companies that purchased a new press hoping to make their tablets faster, only to find that the formulation couldn't match the performance of the press. If you want good tablets instead of just fast tablets, you can only run the press as fast as the product will allow. I've never seen a formulation that could outrun the machine.

Variations in tablet hardness

Hardness variation is a defect, and hardness varies according to how well you control tablet weight, powder density, dwell time, tablet thickness, and the working length of the tooling.

Increasing the tablet weight can increase the tablet hardness, but your supervisor may forbid that because it "just gives product away." Instead, you'll be encouraged to exhaust the other options. Changing the powder density is likely impossible, unless it's a machine-induced density problem, as described earlier.

You can increase dwell time to increase hardness, but longer dwell times typically require you to slow the machine, and that's not usually an option. Instead, I recommend that you first decrease tablet thickness by adjusting main compression. Or, if you are already at the target weight, then decrease the thickness and increase the pressure at pre-compression. If you make that change and you're still achieving your target weight—that is, the tablet hardness increases and decreases rapidly but the weights are consistent—then you have what is known as a dwell-sensitive granulation. Finally, as mentioned earlier, you must know that the tooling is in good condition. If the diameter of the tooling head flat is inconsistent within the set of punches, then hardness will be inconsistent.

To summarize: If you have trouble controlling hardness, first check for consistent weights. If the weights are consistent, then check the thickness. If the thickness is consistent and on target, then reduce the thickness at pre-compression. Only increase the weight or reduce machine speed when you have determined that there are no other options.

A word on particle size

I'm often asked to define the optimum particle size distribution for making the perfect tablet. That's a tough question. A particle size distribution within the right range produces a good-looking tablet, but the nature of that distribution depends on the tablet size. If the powder contained only large particles, like granular sugar, you'd be making a porous sugar cube. Conversely, if all the particles were superfine, you'd have other problems with compression. We need a range of particle sizes that is in harmony with the tablet size.

Generally speaking, the smaller the tablet, the smaller the particle size. Likewise, the bigger the tablet, the bigger the particle size. Particles smaller than 200 mesh (74 microns) are generally a problem for compression. Particles larger than 18 mesh (1,000 microns) can cause weight fluctuations and create a textured appearance. This is true for the most common sizes of pharmaceutical and health-supplement tablets. Tablet shape is also a consideration. If the tablet has small sharp corners, then the particles must be small enough to flow and fit into those tight corners. However, if you're making a round or caplet-shaped tablet, larger particles work better.

Disintegration and dissolution times are generally better for tablets made with a fine dust-like powder than they are for tablets made with large-particle powders. Finding a happy medium—a formulation that disintegrates and dissolves well and that also compresses well—requires some true formulating skills. I think that formulators too often err on the fine-particle side of the issue and don't consider all the issues of tablet making. In short, fines affect yields, punch lubrication, compressibility, and can cause the tablets to cap, laminate, or show other defects. Fines also increase

My gripe with formulators and granulation staff: fines!

I wonder if any formulators out there have ever run a tablet press, really run a press. And I'm not talking about a wimpy run that lasts 5 minutes, either. In fact, I know that no formulators have ever run a tablet press under production conditions. If they had, I doubt whether they'd be formulators.

Having run a press for years, I think the only folks more misguided than formulators are people who think they know how to granulate. Maybe we could put these would-be formulators in a room with the mill operators, throw in a few supervisors, and lock the door. Then I'd gather the people who run the tablet press and make some real products. There won't be any of this superfine stuff that doesn't disintegrate for 3 weeks, the stuff that you must press so hard that it could be used as ammo in your shotgun. Hey, now there's an idea. Maybe these formulators could go into making artillery rounds, and maybe they could hire some of their buddies from the granulation department to go with them.

By the way, while I'm at it, I've never, ever met a supervisor who knows anything more than how to deliver a stack of paperwork. When it comes time to fix a problem, they become politicians: "Well what do you think the problem is?" they ask. It's never said, but the press operators must be thinking: "You have got to be kidding! Why does the handbook say I must consult you, the boss, when you don't have a clue about what to do?"

But back to my to my real beef: There are too many fines everywhere. Why do companies spend so much time working powders and granulating them when they end up on the press as a pile of dust?

I'd like you formulator and granulator guys to get out there and look at the issues. The fines are everywhere, and it's really a problem. Think about it: You guys cannot be making a good product when 30 to 50 percent of it is dust. I know, the formulators will say that the fines help disintegration. And I'll reply, "Baloney!" The fines are killing the press run, they don't compress well, and there is no benefit to fines. You call yourself a formulator, but anyone—you don't need an advanced degree—can grind powders into a pile of dust. **M.T.**

tabletting run times and cleaning frequency. Table 1 repeats these points.

If I were allowed just one statement on particle size distribution, it would be this: Most formulations contain too many fines, and by "most," I mean about 95 percent of them. If the people responsible for formulation understood compression, they would never make a product's particle smaller than what's necessary to achieve the target dissolution rate. If more products had better particle size distribution (fewer fines), the press would run better and longer with less cleaning and fewer defects. **T&C**

TABLE 1

Excessive fines can

- Remove the oil from punches, leading to tight punches that leave black specks in the tablets
- Reduce the effectiveness of the formulation's powdered lubricant, increasing the required ejection force
- Decrease yields while increasing the amount of dust collected and the frequency of cleaning
- Cause capping and lamination
- Decrease content uniformity and impede product flow

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