NATOLI
YOU DEMAND. WE DELIVER.

WHITEPAPER

EXTENDED HEAD FLATS INCREASE DWELL TIME

A variety of options are available for punches and dies to help compress difficult drug products. One commonly overlooked punch modification, the extended head flat, increases the diameter of the flat area atop the punch head. Typically, this option doesn't require any modifications to the press, and you can use it with cam tracks that meet Tableting Specification Manual (TSM) or European Union (EU) standards.

The extended head flat offers multiple benefits, including a longer dwell time—the time the head flat spends in contact with the pressure roll—at a given press speed to better compact poorly compressible products. The longer dwell time may even reduce the amount of force required to attain a specific tablet hardness.

Although, extending the head flat is beneficial in many situations, it is important to note that extended head flats and the resulting extended dwell time is not always the ideal way to mitigate common tableting issues such as capping for all products. Recent studies, sponsored by Natoli Engineering, have shown that for some products reducing the head flat or even eliminating the head flat entirely (thus reducing or eliminating the dwell time) can be beneficial in some circumstances. In some cases, the reduced or eliminated head flats have been shown to reduce ejection forces and can be beneficial in solving capping issues. Studies on these relatively new head profiles are currently being finished at the Natoli Institue at Long Island University and the data and study results will be available soon.

Extended head flat vs. standard head flat

NATOLI
YOU DEMAND. WE DELIVER.

Dwell time is dependent on press speed, the pitch circle diameter of the turret, and the head flat's diameter (figure 1).

Increasing the diameter of the head flat is the easiest way to prolong dwell time without switching to a press with a smaller turret pitch circle and generally with fewer stations, or, without decreasing the turret speed, both of which would decrease production. For example, a Fette 2090 press has a pitch-circle diameter of 410 millimeters, and assuming an operating speed of 50 rpm, a standard B-type punch, TSM domed head flat of 9.525mm (0.375 in) would have a dwell time of 8.88 milliseconds.

Dwell time (ms)

$$dt = \frac{Dhf}{Dpc \; x \; \pi \; x \; rpm}(60)(1000)$$

Where:

dt=dwell time (milliseconds)

Dhf=head flat diameter (millimeters)

Dpc=pitch circle diameter of turret (millimeters)

rpm=revolutions per minute (turret speed)

FIGURE 1

Meanwhile on that same press, a B-type punch with TSM domed head with extended head flat (15.0mm, 0.591in) would have a dwell time of 13.98 milliseconds (Figure 2). Figure 3 illustrates the differences in dimensions between a standard B-type, TSM domed head and a Natoli B-type, TSM domed head with extended head flat punch. The larger head flat increases dwell time by more than 50 percent without reducing the turret speed.

The extended head flat punch can also reduce the amount of compression force needed to form a tablet at a given breaking force, also known as hardness. Tablet hardness and density are related to both compression force and dwell time. If the amount of time spent under compression increases, the amount of force necessary to maintain the same tablet hardness may decrease. The reduction in required compression force depends on the characteristics of the granulation being compressed.

Figure 2.

Fette 2090 with Pitch-Circle Diameter of 410mm

B-TYPE TOOLING	ROTATION SPEED	DWELL TIME
TSM Domed Head Flat 9.525mm (0.375")	50 RPM	8.88ms
Natoli TSM Domed Head Flat Extended Head Flat 15.00mm (0.591")	50 RPM	13.98ms

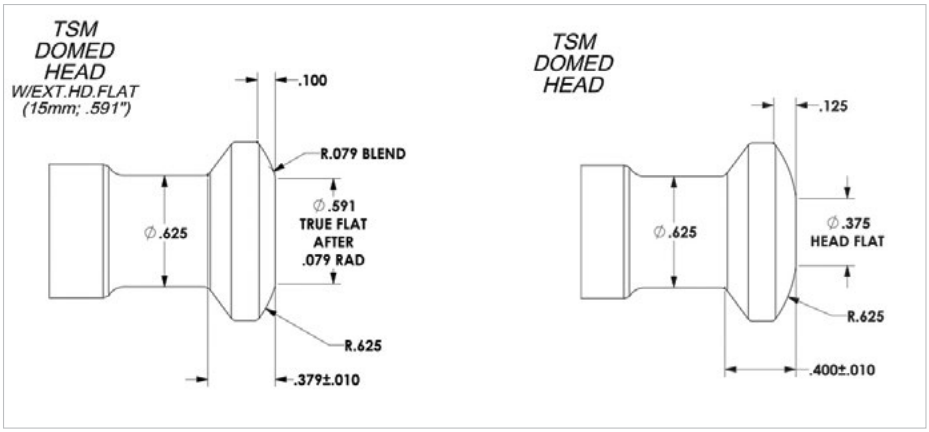


Figure 3.

Because the required compression force is dependent on the product being compressed, it's impossible to predict accurately how much an increase in dwell time will decrease compression force. The effect of dwell time on compression force can best be quantified during the research and development stage, and understanding the relationship of dwell time to compression force can mitigate issues that commonly arise during scale-up to large production presses.

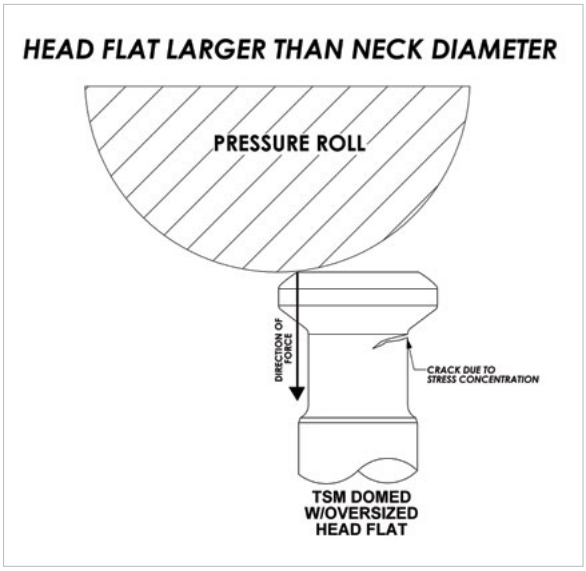
Geometrically, the design of the extended head flat differs only slightly from a TSM domed head or an EU head. Other than the increased head flat, one notable difference is a reduction in the head's thickness to allow the larger flat to fit through the same cam profile as that of a standard TSM domed or EU head. It's this slightly thinner head that allows extended head flats to traverse the standard cams without modifications to the cam tracks or press. The head flat can even be customized to achieve a specific dwell time on a given press.

The limiting factor in the head flat's size is the neck diameter of the punch. The neck transfers the force from the head to the barrel and tip and then to the granulation. As you can see in Figure 4, if the head flat gets larger than the neck's diameter, it won't have the support required to transfer the force generated when it contacts the pressure roll, which can cause the head or neck to fail.

Extended head flats can also be oval or elliptically shaped. Although this design extends the dwell time exactly as a round extended head flat does, it has some drawbacks. The primary drawback is that the oval head flat can pass under the pressure rolls only in one direction along the major axis of the oval or ellipse to extend dwell time. For that reason, punches with an oval head flat must

NATOLI
YOU DEMAND. WE DELIVER.

be keyed on the upper AND lower punches, even when round, to prevent them from rotating as they pass under or over the pressure rolls. With upper and lower punches requiring keys for oval or elliptical head flats, punch heads can experience accelerated wear because of repeated contact between the punch head and the compression roller at the same spot and no punch rotation.



Additionally, if a turret doesn't have lower key slots, then round tooling with an oval head cannot be used because the benefit of the extended head flat will be lost if the lower punch rotates. Another limitation is that if two presses have turrets with key slots of different angles, you can't interchange the oval head flat's punches because the different angle will alter the orientation of the head flat with respect to the pressure rolls.

Punch head profiles and the resulting dwell time play an important role in the compaction characteristics of many drug products. Using extended head flat punches can provide a quick and reliable way to increase dwell times and in some cases reduce compression force without the need to modify the tablet press or cam tracks. Round, extended head flat punches don't require keyed tooling for round shapes, as oval ones do, and that allows them on many makes and models of tablet presses interchangeably. Furthermore, Natoli Engineering exclusively offers a unique set of tooling that allows you to maintain turret RPM, punch velocity and powder flow while easily changing out head flats from no head flat to an extended head flat with no required tools.

Don't be deceived by sales tactics that lack data representing head flats. Working with a knowledgeable tool vendor like Natoli Engineering early in the development process to examine the role of dwell time and head flats can eliminate any misconceptions. Examining the role of dwell time in the R&D stages of product development will allow for the determination of which head flat (standard, extended or even reduced/eliminated) is ideal for specific products. That early work can help minimize compression-related issues that could ultimately limit production.