The effect of production press stiffness on tablet strain rate

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Introduction:

The deformation of a rotary tablet press and its tooling under typical tableting loads is significant relative to the height of a tablet. The theoretical sine curve of punch movement under the rolls of a press is modified by press and punch elasticity. When simulating the press action on a programmable machine, the punch deformation is common to both machines and therefore can be ignored for control purposes. Deformation of the press however is important and particularly affects the unloading rate when the tablet is stiff. This poster shows the effect of press elasticity on the tablet by using a HB Compaction Simulator with press elasticity simulation.

Discussion:

Difficult powders can generally be formed into robust compacts by using a tri-axial decompression fixture. This shows that uni-axial decompression and ejection from the die is usually the cause of physical tablet failure. The rate of decompression is thought to have a significant effect on the formation of cracks that can lead to capping or chipping of the tablet. Stress relieving mechanisms within the tablet are likely to be time sensitive, so the decompression rate and time to ejection are critical factors to consider. It is probable that small pilot scale rotary presses are less stiff than larger production presses, leading to the danger of tableting problems when scaling up. Tablet press stiffness values are not generally stated by press manufacturers, but the estimated range would be from 10 to 40 microns per kN. Calculated stiffness values are generally over-stated due to imperfections in joints, so the better option is to measure press deflections under load. Alternatively the simulated stiffness can be adjusted until the load trace matches a load trace from the production press.

Punch Elasticity:

Compaction Simulators measure the elasticity of the punches in use so that the true position of the punch tips can be calculated. This is essential for materials properties measurements. This elasticity value can also be used for correction of the control position measurement, and is useful for studying load relaxation at a fixed punch tip separation. However it has not been used for this study. **Figure 1** shows the deformation of the punches during the 25kN test performed. **Figure 2** shows the entire load curve and the corrected punch tip separations for simulations of an infinitely stiff press and one with a 40microns/kN elasticity.

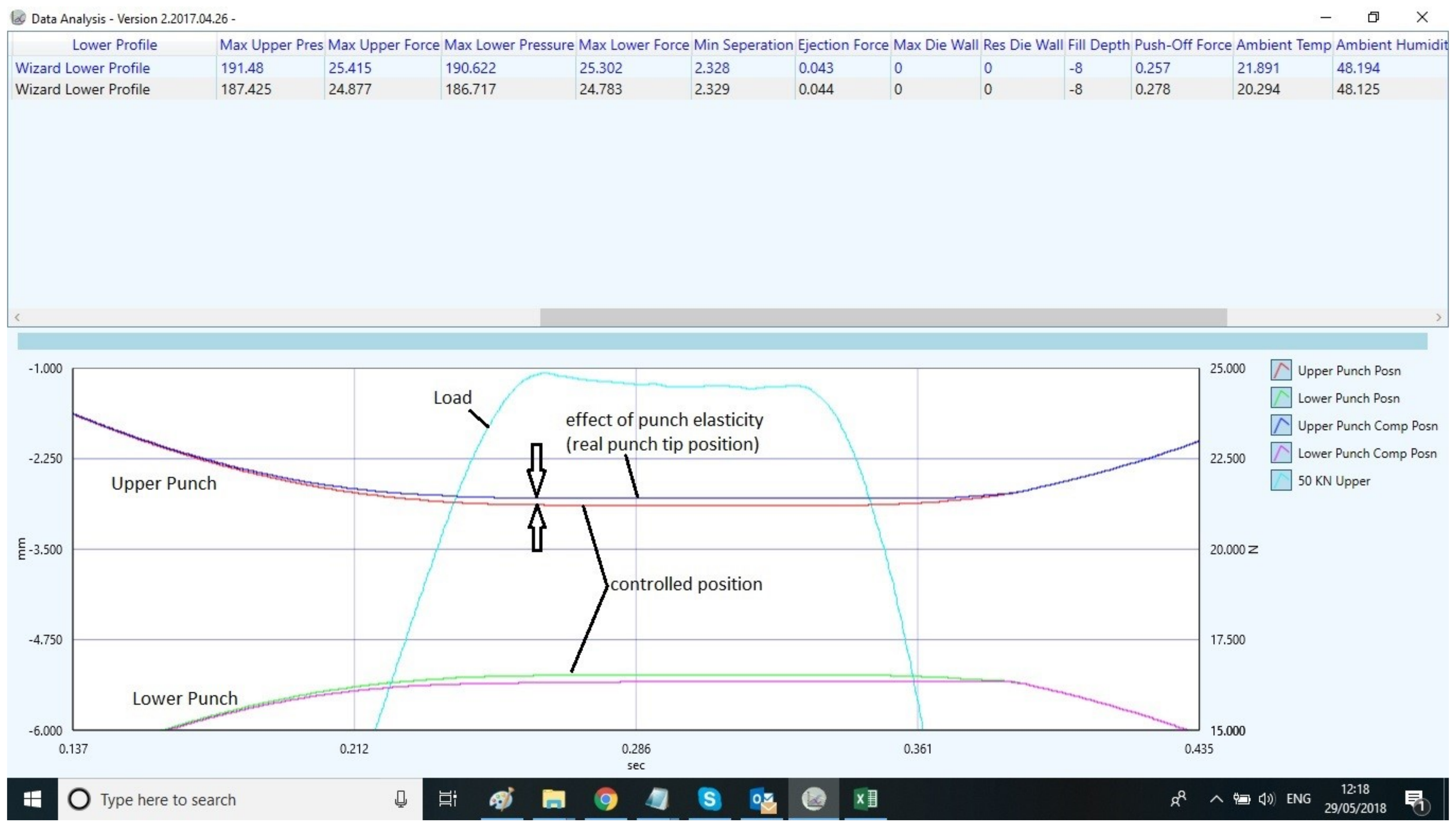


Figure 1.

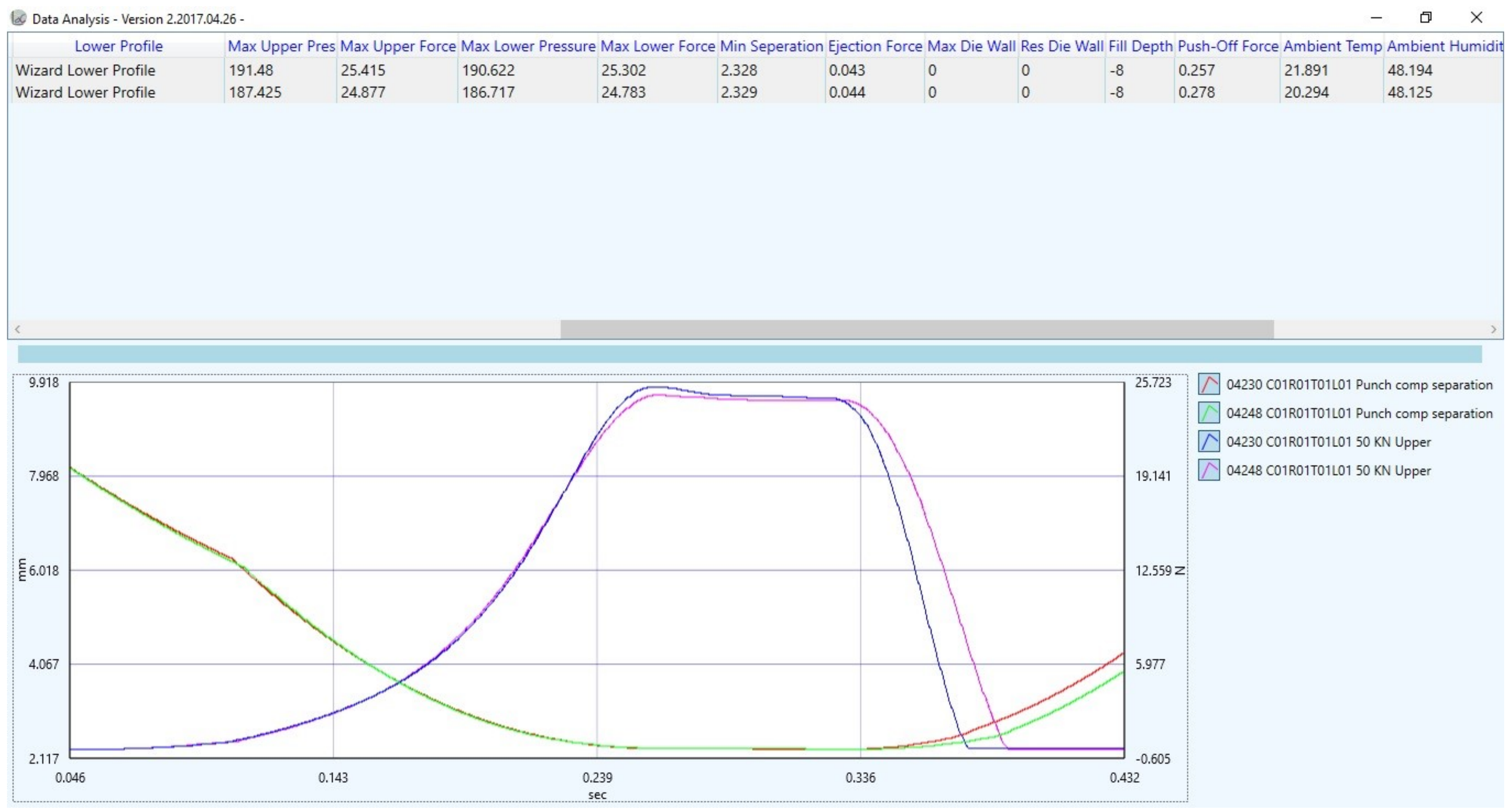


Figure 2.

Figure 3 shows a close up of the decompression section of the compaction curve. This shows that the speed of separation of the punch tips (corrected for punch elasticity) is reduced when an elastic press is simulated. Note that the set punch gap must be reduced to achieve the same tablet thickness and load on the flexible press. A flexible 40 microns/kN press is shown relative to an infinitely stiff one.

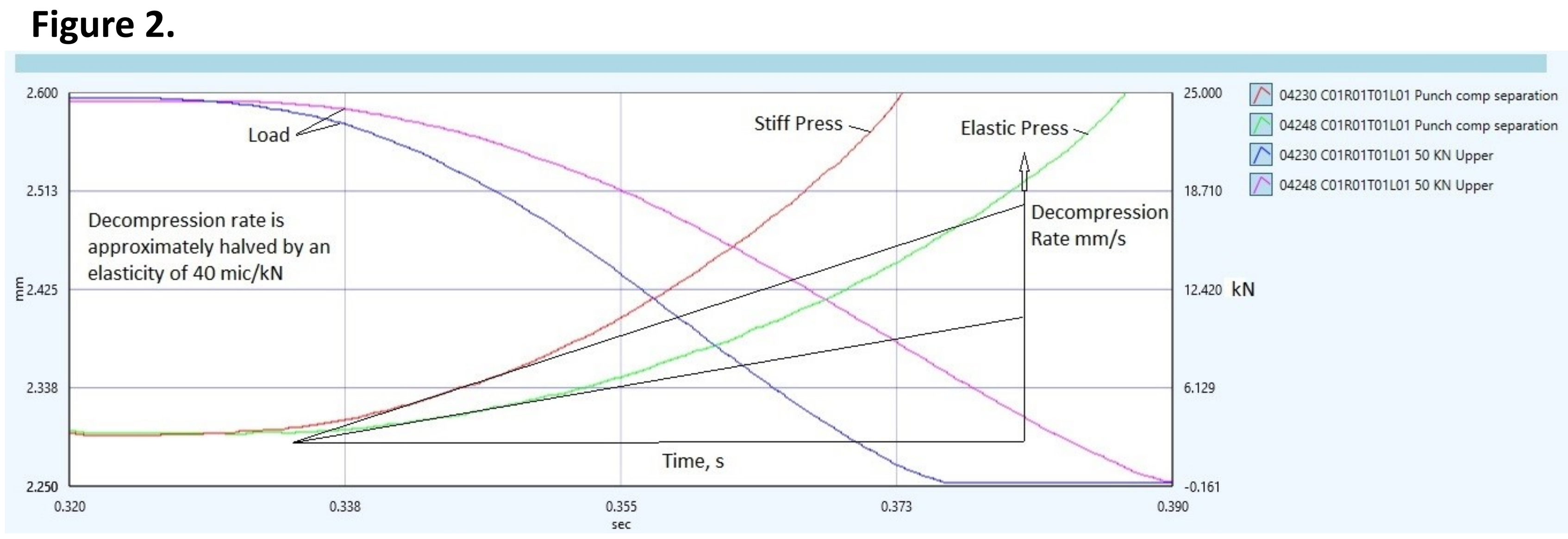


Figure 3

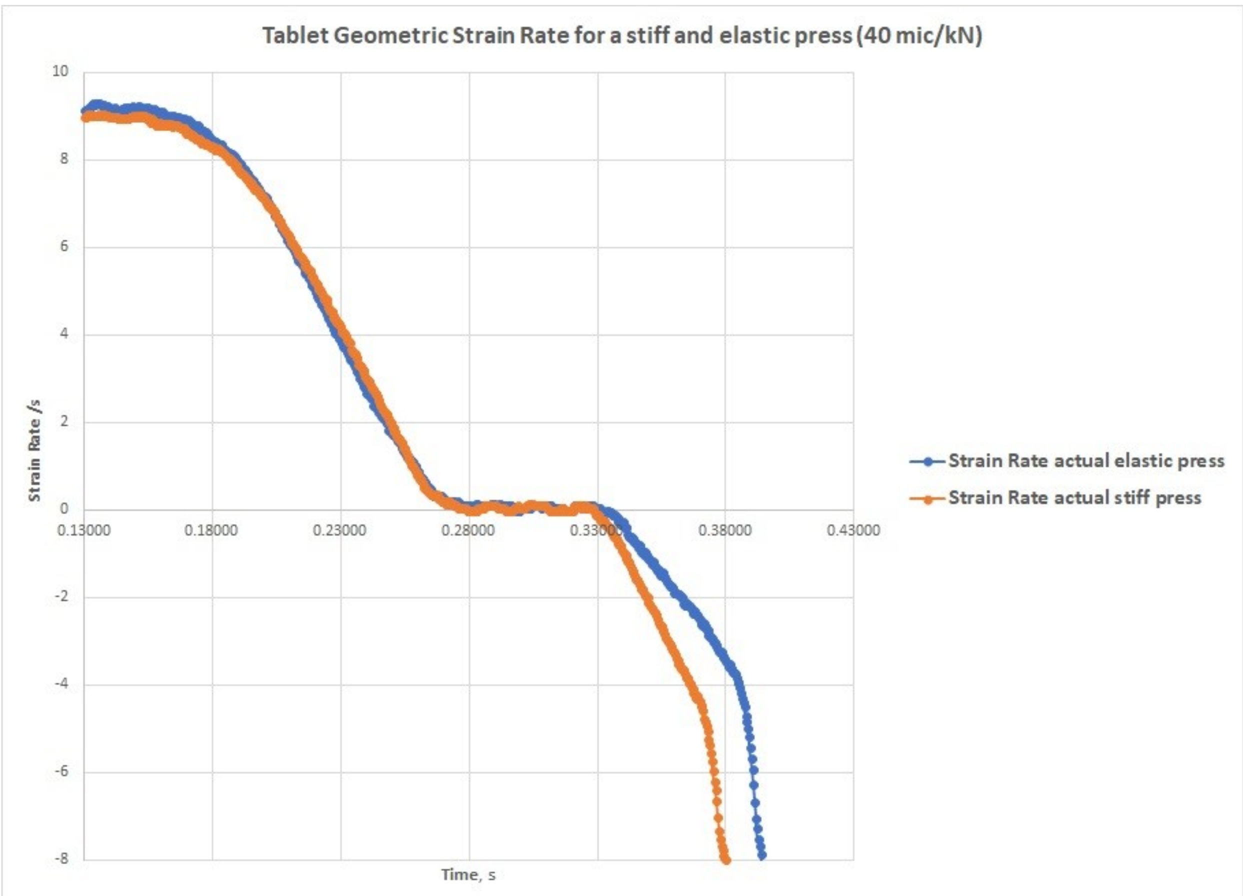


Figure 4

Figure 4 shows the "geometric strain rate" ie; compaction speed divided by tablet height, for the stiff press compared to the 40 microns/kN flexible press.

Figure 5 shows the loading rate in kN/sec for the tablet compressed in the stiff press compared to the flexible press

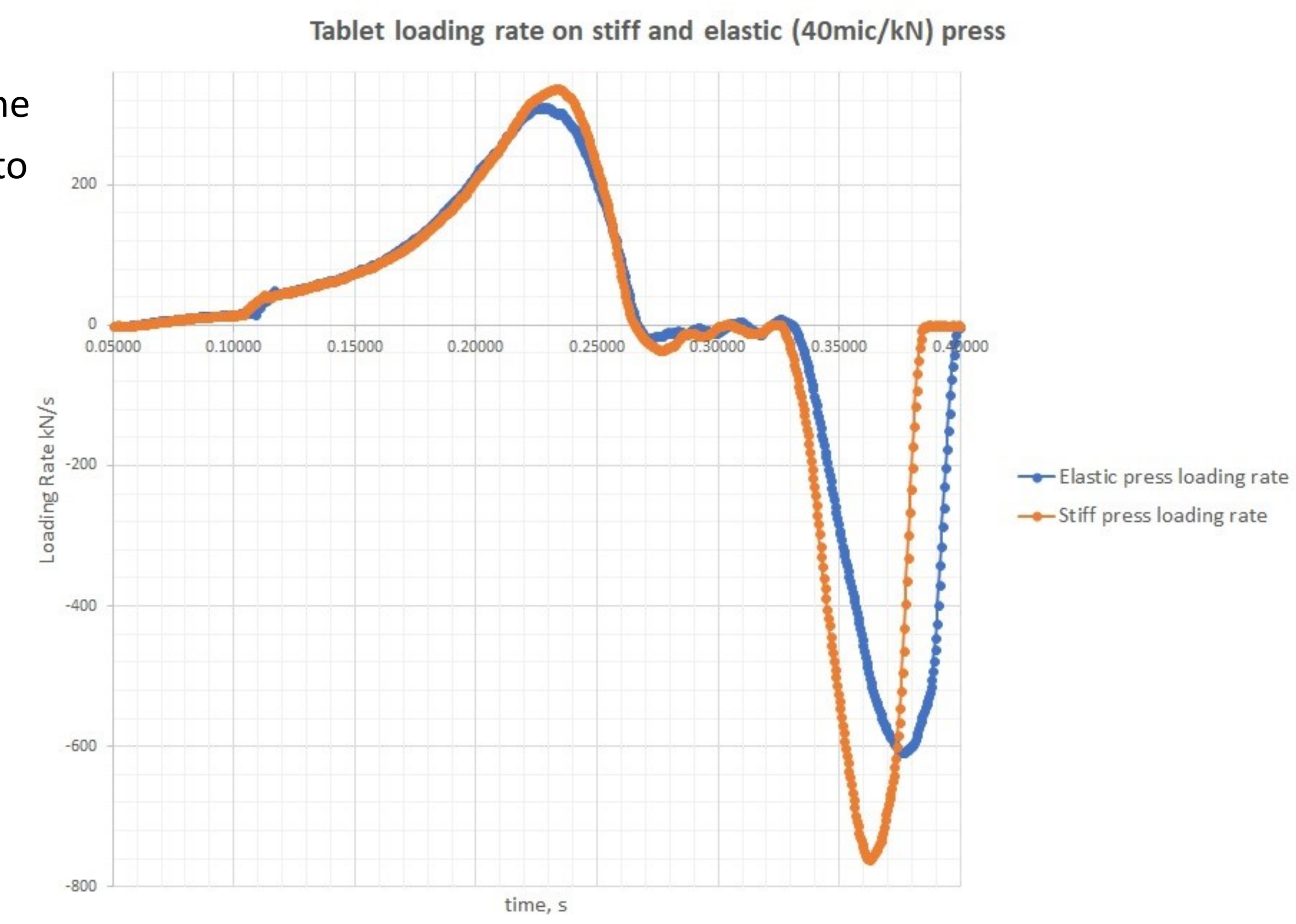


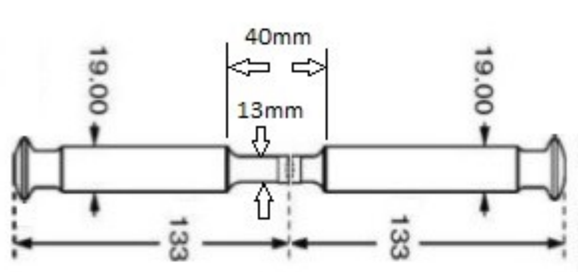
Figure 5

Conclusion:

The inevitable focus in tableting is on the act of compression, but the problems are more likely associated with decompression. The speed of decompression is harder to control and harder to quantify because of the effect of press stiffness and tooling stiffness, and it is much faster. Advanced Compaction Simulators can be used to study the effects of press stiffness by entering measured or estimated values of press stiffness into the simulation software. Differences in stiffness between production and lab scale presses could lead to increased capping tendency when scaling up.

This study only looks at axial loading. Die wall pressure is also important and relaxation before ejection is a critical variable.

Appendix: Punch Stiffness calculations:



"E" steel = 209 kN/mm^2, length 13mm dia. = 40mm, length 19mm dia. = 226mm, Area 13mm dia.= 133mm^2, Area 19mm dia.= 283mm^2

Stiffness, K = E*A/L. K 13mm dia. section = 209*133/40 = 695 kN/mm. K 19mm dia. section = 209*283/226 = 262 kN/mm

Stiffness of punch set is given by 1/K(set) = 1/K (13mm) + 1/K (19mm) = 0.00525

Stiffness of punch set = 1/0.00525 = 190 kN/mm. Then elasticity of the punch set = 1/190 = 0.00526 mm/kN, This is 5.26 microns per kN

Note: due to uneven stresses and deformation of the punch head and anvil, the measured value of elasticity was 7.8 microns/kN.