Monitoring the roll compaction process via ribbon stiffness measurement.

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Figure 1. The ribbon structure from Gerteis AG compactor here; SCF 11,2 kN/cm

Introduction

Dry granulation by roll compaction is a particle size-enlargement technique. A primary/feed powder with low flowability and homogeneity is densified into a ribbon [intermediate product]. The ribbon is converted into granules [larger particle agglomerates] with fine powders, afterwards. The granules with improved flow properties, content uniformity and adequate material compact-ability should undergo further forming processes as tableting or capsule filling.

One of the most important characteristic of the ribbons coming out of a roller compactor is their solid fraction. Solid fraction is defined as the ratio of apparent or envelope density of a [ribbon, Figure 1.] sample to true density of the material. It is being increased as the primary powder gets compacted and depends on several processing factors including hydraulic roll pressure, screw speed to roll speed ratio and gap width. Mechanical properties such as tensile strength, hardness and elasticity of compacted powders depend on the solid fraction. By maintaining comparable ribbon solid fractions across different scales from pilot to production, it is expected to achieve similar tensile strengths and subsequently similar particle size distribution when milled under same conditions.

Since the ribbon apparent density is difficult to measure, the objective of this work is using the ribbon stiffness parameter [k, >> k-MEAN, [N/mm]] and other properties of granulate to monitor the compaction process performance.
This poster describes the relationship between the measured ribbon stiffness and critical process parameters.

Materials

API
Atorvastatin calcium trihydrate in crystalline form; two experimental formulation [Figure 2.]

Excipient
Calcium carbonate is the main excipient [in these formulations] possessing brittle material behaviour.

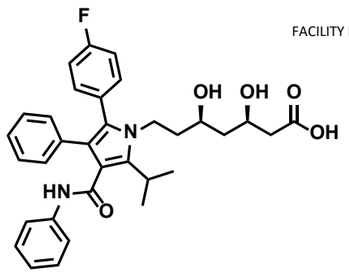

Figure 2. Atorvastatin, ChemDraw 20.0

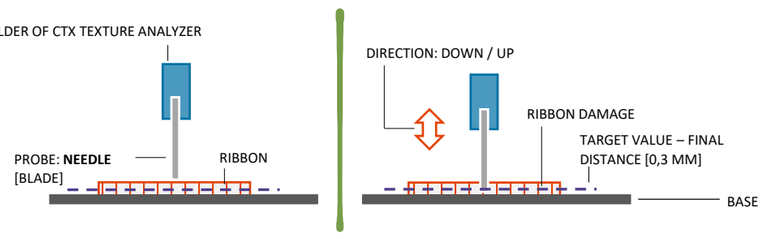

Figure 3.,4. The ribbon texture analysis by CTX Texture Analyzer [compression test method; FD 0,3mm]. The ribbon sample after its texture analysis.

Experimental Instrumentation

The design of experiments had been furnished using two different compactor types; Alexanderwerk AG [WP 200 PHARMA, large scale]; Gerteis Maschinen and Processengineering AG [MINI-PACTOR, small scale]. The primary/feed powder was compacted inside fully automated mode with three specific settings on each facility. The primary particle loading is being expressed by the specific compaction force [SCF, kN/cm; Gerteis AG] and/or the hydraulic pressure [bar; Alexanderwerk AG].

The ribbon samples had been analysed on their texture inside the ribbon by the CTX Texture Analyzer [AMETEK Brookfield, USA; Figure 3.,4.]. The calculations determined the ribbon stiffness [k, >>k-MEAN; N/mm] as the main ribbon parameter/attribute at this work. It has been identified the ribbon stiffness profile in its lateral direction for each compaction process. The k-MEAN parameter furnished the information about the technology transfer between two scales.

Results

The ribbon stiffness parameter [k, >> k-MEAN; N/mm]

The whole/complete ribbon width [25mm] is necessary condition to get accuracy measurement of the ribbon texture and following calculation operation for this process parameter [k, N/mm; Figure 5.]

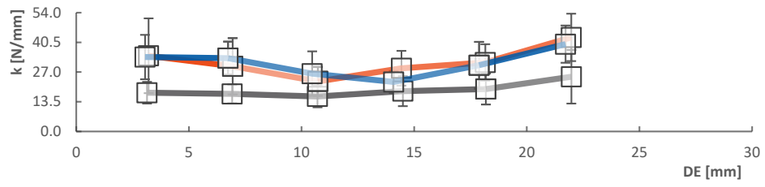

Figure 5. Gerteis AG compactor. Three operation modes with the SCF variability. The SCF had this range values: 9,6 kN/cm (grey colour), 11,2 kN/cm (red colour), and 12,5 kN/cm (blue colour).

For Alexanderwerk AG [Figure 6.], the width of the compacting roll surface is 75 mm. This is problem for the accuracy evaluation the ribbon texture itself. The ribbon fragments were of width up to 50 mm from the ribbon edge. There is the lateral ribbon non-uniformity in this case.

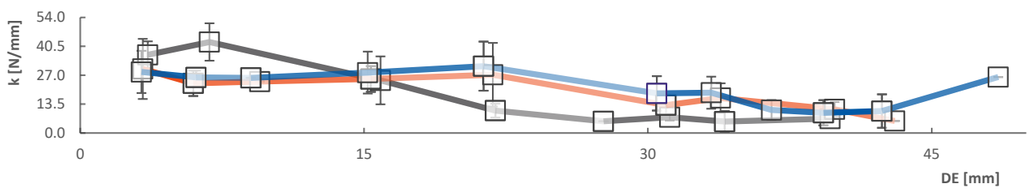

Figure 6. The ribbon stiffness profile as result of the hydraulic pressure, that has been set up in individual operation mode at Alexanderwerk AG compactor. The hydraulic pressure had this range values: 120 bar (grey colour), 140 bar (red colour), and 160 bar (blue colour).

Insomuch as the parameter k [N/mm] was not uniform across the ribbon, the mean value was used, k-MEAN [N/mm; Figure 7.,8.]. The ribbon stiffness [k, [N/mm]] should correspond to the ribbon relative density [ribbon apparent density [g/cdm]].

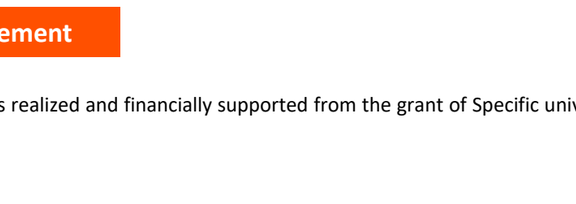

Figure 7.,8. The SCF or hydraulic pressure is necessary for attaining certain k-MEAN [N/mm]. When these relationships have been put together, we can get a correlation between the setting of both compactors necessary to produce a ribbon with the same k [N/mm].

Conclusion

The k-MEAN [N/mm] parameter was selected as the main parameter to characterize compacted powders of this technology process. It provided a good correlation with process parameters in the effective range of compaction, but the correlation did not extent to very high compaction force region due to over-compaction of the material. In overall, if used within machine operability limits, it can be utilized to produce ribbons with the same properties at two different scales [Alexanderwerk AG, Gerteis AG].

References

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