Use of Process Analytical Technology (PAT) for monitoring and optimizing powder mixing processes

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The Process Analytical Technology (PAT) approach, which is well established in the pharmaceutical and chemical industry, was successfully applied on food manufacturing. PAT is about the IDENTIFICATION of critical process parameters in the manufacturing process as well as in-line sensors enabling real time process MONITORING and CONTROL for the continual improvement of quality and costs.

A food manufacturing process was analyzed in view of critical unit operations and process parameters. A strategy to assess and develop in-line sensors to monitor and control the critical unit operations was put in place. Sensors were used to make the invisible visible, which further improved our process understanding and enabled the optimization of the manufacturing process. The advantages and limitations of PAT will be discussed for powder mixing, which is one of the most important unit operations when producing powdery products. During mixing, the foundation of a compliant and consistent product is laid. But the homogeneity does not only effect product quality but quite often also the asset intensity of downstream unit operations. For a given installation and recipe, the homogeneity of the mixed mass is mainly influenced by the mixing time, the speed of the mixing devices as well as the filling degree of the mixer. Traditionally, the analysis of the powder mixer performance is quite time intensive, which makes the studies of parameter variations difficult. Several samples are taken after different mixing times, analyzed with off-line analytics and the variance is calculated to assess the mixing progress with time [1].

In his PhD thesis “Continuous dynamic mixing of cohesive powders” [2], Kehlenbeck has already shown the power of near-infrared (NIR) spectroscopy to access continuous and batch powder mixing processes [3]. An industrial application of the developed self-cleaning near-infrared probe (air flushing) was not possible as a contact between probe and product was required:

- In contrast to the model ingredients maize starch and calcium carbonate used in the framework of the PhD thesis, most food powders are moisture as well as temperature sensitive and tend to form layers in the mixer. After a short time of operation, a layering on the measuring window of a near-infrared spectrometer would occur, which cannot be removed by air flushing and would cause an incorrect measuring result.
- Furthermore, industrial mixers do not have openings allowing an immersion of near-infrared probes in the fluidized mass without drilling holes.

In the meantime, powerful near-infrared spectrometers for a contactless measurement in distances of up to 60 cm were commercially available. The assessment of this technology for process monitoring and optimization was successfully restarted in pilot and industrial scale.
The following topics will be covered:

- Process Analytical Technology in general
- Impact of the mixer filling degree on the mixing homogeneity
- Impact of the sample size on the measuring result
- Use of near-infrared spectroscopy for monitoring continuous and batchwise working powder mixers in pilot and industrial scale (time and trajectory plots)
- Comparison of off-line reference and in-line near-infrared measurements
- Until the World Congress on Particle Technology (WCPT8), it is expected that the impact of the particle size on the mixing result was also investigated and can be discussed.

[1] Kehlenbeck, V.; Sommer, K.: Different methods to determine the mixing performance of a batchwise working screw mixer; Powder handling & processing Vol. 15 (2003) No. 5, pp. 318-327
[2] V. Kehlenbeck: Continuous dynamic mixing of cohesive powders; PhD Thesis Technical University Munich 2016
[3] V.Kehlenbeck: Use of Near Infrared Spectroscopy for in- and off-line performance determination of continuous and batch powder mixers: opportunities & challenges; Procedia Food Science 1 (2011) pp. 2015 – 2022