DFF Sensor as a PAT Tool: Identification of Under-Processed Powders

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Densification in solvent-free powders

DFF sensor has been shown to adequately monitor wet mass densification in pharmaceutical high shear wet granulation (HSWG) (Narang, A.S. et. al. 2015, 2016, White Papers 8, 9). Blending solvent-free powders is another process where on-line real-time monitoring can provide benefits. For example, to produce a good quality carbon films, the powder needs to be granulated before calendared. An under-processed powder produces a weak film that breaks up when calendared. Densification time is adjusted based on the off-line analysis of powder characteristics which is a process that requires significant time therefore delays in the process are inevitable. Introducing an in-line process analytical technology (PAT) could significantly increase throughput and quality of the powder and thus the carbon film.

Experimental

Sample information

ENSACO® Carbon Black, by Imerys Graphite & Carbon Belgium SA, activated carbon, by Kuraray Chemical Co., Ltd., Japan and Polytetrafluoroethylene (PTFE) fluoropolymer resin, by DuPont Fluoroproducts were blended in a Peter Pugger Pugmill. Two exemplary sample powders were collected at the output of the pugmill densifier:

S1: Under-processed - produces a weak film when calendared

S2: Optimal mix

Method

The samples were analyzed in an apparatus where powder was loaded to a vertically held aluminum pipe and released to a DFF probe in a variation of hopper discharge (see White Paper 5 for details of the setup).

Results and Discussion

Several runs for each sample powder were measured and analyzed. DFF sensor raw signals for two exemplary trials from each set are shown below.

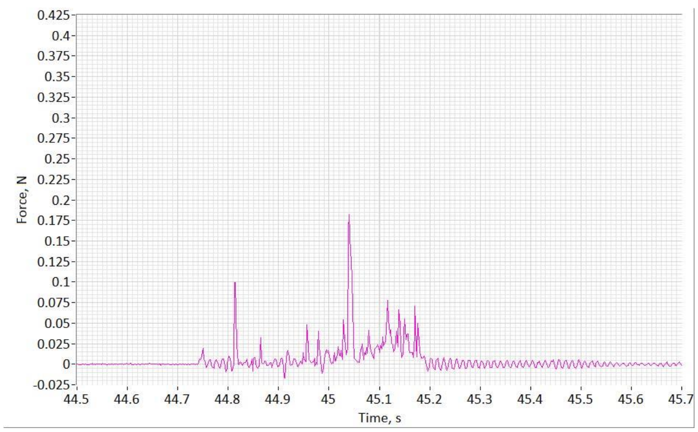
Generally, the signal from optimal mix appears to be much stronger than that from the under-processed powder. We also note that the signals are characterized by a number of randomly distributed peaks of various magnitudes. These force pulses reflect impacts of large agglomerates in the powder, therefore their magnitude and frequency characterize the degree of densification and tackiness of the powder.

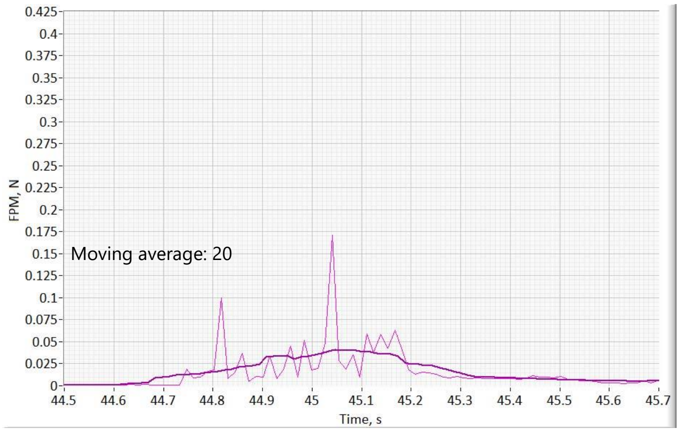
An appropriate metrics for analyzing such types of DFF sensor signals is obtained by calculating force pulse magnitudes (FPM, see White Paper 3). Using Lenterra's post-processing software, a free Fourier transformation (FFT) was applied to the raw data and a characteristic frequency of 79.55 Hz was obtained. This is the natural frequency of the DFF probe pin oscillation.

FPM for this frequency was calculated and plotted, applying a moving average of order twenty.

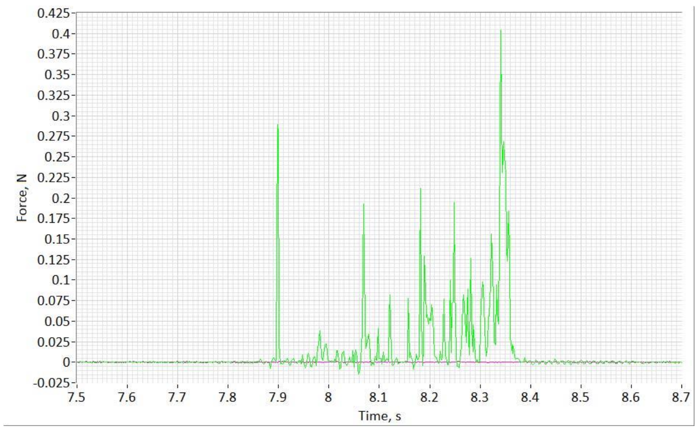
Force vs. time ***FPM vs. time***

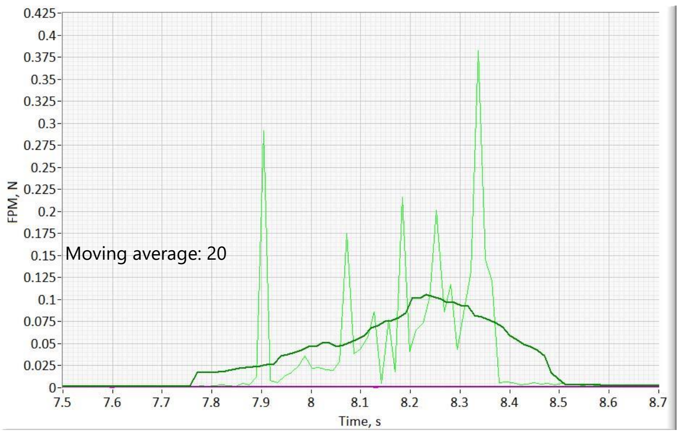
S1: Under-processed powder





S2: Optimal mix





FPM moving average appears to be an appropriate metrics that differentiates the optimal mix from the under-processed powder. For moving average order 20, the value seems to increase steadily with time, reaching a maximum in about 0.5 seconds in both tests. The value of the maximum, or at any given time from the start of force action, for the optimal mix is approximately three times greater than that for the under-processed powder.

Conclusions

Samples of optimally mixed and under-densified powders of a solvent-free carbon formulation processed using a pugmill mixer were successfully identified by allowing the powder to fall on the tip of a DFF probe. The agglomerates inside the powder manifested itself in the DFF signal as well-pronounced peaks with magnitudes noticeably lower in the under-densified sample as compared to optimal mix. The maximum value of the moving average is proposed as a metric for real-time monitoring of solvent-free powder condition in the process, by simply letting the powder to fall on the pin, for example at the output port of the continuous processing line or at the end of the conveyor belt.

DFF sensor therefore is well suited for real time characterization of the condition of the powder.

References

Narang, A.S., Sheverev, V.A., Stepaniuk, V., Badawy, S., Stevens, T., Macias, K., Wolf, A., Pandey, P., Bindra, D., Varia, S., 2015. Real-Time Assessment of Granule Densification in High Shear Wet Granulation and Application to Scale-up of a Placebo and a Brivanib Alaninate Formulation. *Journal of pharmaceutical sciences* 104, 1019-1034.

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