Investigating the Influence of Inlet Air Temperature and Quantity on the Maximum Spray Rate in a Side Vented Pan Coater

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Abstract Summary

Both inlet air temperature and inlet air quantity are responsible for the amount of energy applied to a film coating process. This energy is needed to heat up the cores and to evaporate the liquid carrier of the spraying dispersion, which is normally water.

The inlet air volume is a crucial parameter which should be taken in consideration, when improving the drying in a film coating process. The reason for this is that an increased inlet air volume leads to a higher air velocity. This in turn reduces the time needed to evaporate and exhaust the liquid carrier applied onto the core's surface.

The trials showed clearly, that the same spray rate could be applied independently from the inlet air temperature. Hence, starting from a certain product temperature a further increase does not lead to the possibility of higher spray rate. Therefore, especially for temperature sensitive ingredients, it is of great importance that the drying efficiency of a coating process can be improved by increasing inlet air volume rather than inlet air temperature.

Introduction

[1, 2, 3]Up scaling of film coating processes can be calculated by keeping the amount of dispersion applied onto a single core constant, while it is passing the spray pattern (surface time). If too much dispersion is applied onto the cores, proper drying will not be assured leading to the risk of over-wetting. [4,5]Considering the film coating process itself, the maximum spray rate mainly depends on both inlet air temperature and quantity, as these parameters influence the drying efficiency to a high extent.

As the number of nozzles does not increase proportionally to the increase in batch size, a typical problem arising during scale up is that the relative spray rate in large scale is lower than in small scale. Additionally, in typical side vented pan coating equipment, the relative inlet air volume in small scale is distinctively higher than in large scale. [2]Therefore, for a successful scale up the process air volume in small scale has to be adapted to the conditions in large scale. This is to achieve a comparable coating process with similar moisture exposure to the core in all scales.

In Perfima production scale coating equipment, an extraordinarily huge amount of inlet air is available, which improves the drying efficiency in large scale. Therefore, higher spray rates resulting in shorter process times are possible. This paper is to investigate the influence of this equipment related characteristic on the drying efficiency of the film coating process.

Experimental Methods

Materials

[5]The ready-to-use coating material Kollicoat® IR Carmine (BASF SE, Germany) was used with an optimal solid matter content of 25 %. The formulation of the placebo cores is shown in Table 1.

Ingredients		Quantity [%]
Ludipress® LCE	(BASF SE)	79.5
Kollidon® VA64	(BASF SE)	20.0
Mg-stearate	(Bärlocher)	0.5

Table 1: Core formulation (round shaped biconvex, diameter 11 mm).

Equipment

The side vented pan coaters Perfima Lab, with 15 and 60 litre exchangeable drum as well as the Perfima 200 (I.M.A. S.p.A., Italy) were used.

Methods

Scale up was performed in three steps: 10.9, 40 and 140 kg. Each trial was carried out at three different temperatures: 50, 60 and 70 °C. After applying a first layer of coating dispersion onto the cores (about 0.5–1 % weight gain) for each setting, the maximum spray rate was determined. The decisive criterion was the surface quality, which was appraised visually, while stepwise increasing the spray rate. First signs of surface roughness indicated that the maximum spray rate had just been exceeded. This means that the pump speed just below this setting resulted in the highest applicable spray rate.

The limiting factor with regard to process air volume was the 60 litre drum in the Perfima Lab coater. The maximum amount of inlet air for the Perfima Lab coater is about 1,060 m^3/h. As the coating processes in the 60 litre drum are performed with two nozzles, the maximally available relative process air volume per nozzle is in this case 530 m^3/h. Keeping this ratio constant in all scales, the resulting air quantity in small scale is 530 m^3/h and in large scale 2,120 m^3/h.

[1,2,3]The up scaling process was calculated by keeping circumferential speed, spray rate per nozzle and the ratio of inlet air quantity and nozzle constant. In the Perfima 200, trials with increased inlet air volume were conducted as well. This allowed the coating trials additionally at an inlet air temperature of 30 °C (Table 2).

	Perfima Lab		Perfima 200	
Drum size [L]	15	60	200	200
Batch size [kg]	10.9	40	140	140
Drum speed [rpm]	9	7	5	5
Circumferential speed [mm/s]	360	361	349	349
Number of nozzles	1	2	4	4
Inlet air temperature [°C]	50, 60, 70	50, 60, 70	50, 60, 70	30, 50, 60, 70
Inlet air volume [m³/h]	530	1,060	2,120	2,800

Table 2: Settings for the side vented pan coating processes.

Results and Discussion

In all trials, comparable results with regard to surface quality were achieved. To show the dependency of the maximum spray rate on the inlet air quantity at different temperatures, a representation of the results of all trials as shown in Figure 1 was chosen.

Interestingly, the maximum spray rates for 60 and 70 °C inlet air temperature were identical, whereas the maximum spray rates found for 50 °C up to an inlet air quantity of 2,120 m^3/h were lower. As expected, increasing the inlet air quantity in the Perfima 200 led to an improved drying efficiency. This is reflected by two distinct observations: firstly, the maximum spray rate at 50, 60 and 70 °C is the same, secondly, even at a very low inlet air temperature of 30 °C a coating process is possible (Figure 1).

As with a higher inlet air temperature, more energy is applied to the coating process and then the spray rate could be increased by elevating the inlet air temperature from 50 to 60 °C. Interestingly, a further increase in temperature did not result in higher maximum spray rates. Presumably, under these conditions the energy supply is completely sufficient to facilitate evaporation of the liquid carrier. This suggests that starting from this point, the time rather than the energy supply for the evaporation is the determining factor.

This observation was supported by the fact that under these conditions, an increase in inlet air quantity led to higher spray rates. [4]The reason for this is that an increase in process air quantity leads to a higher air velocity reducing the heat transfer coefficient. This in turn leads to a more efficient heat transfer accelerating the evaporation.

The progression of the curve representing the trials conducted at an inlet air temperature of 50 °C showed that the influence of an increase in process air volume on the maximum spray rate is more pronounced. Eventually, at an inlet air quantity of 2,800 m^3/h the maximum spray rate was found to be equal for the inlet air temperature settings of 50, 60 and 70 °C.

The impact on the drying efficiency at the highest air quantity tested was so strong that a coating process even at an inlet air temperature as low as 30 °C became possible at a comparatively high spray rate of 200 g/min.

Conclusion

Both inlet air quantity and inlet air temperature do influence the maximum spray rate markedly. However, as temperature is mainly delivering energy to facilitate the evaporation of the liquid carrier, its effect is limited. As soon as the energy supply exceeds the energy demand of the evaporation process, a further increase in temperature does not affect the spray rate anymore.

Under conditions of an excessive energy supply, the time for evaporating and exhausting the liquid carrier determines the maximum spray rate. The time as limiting factor can be influenced by the inlet air volume. An improvement in drying efficiency can be achieved by an increase in process air quantity, which is attended by higher air velocity. This reduces the heat transfer coefficient causing a faster energy transfer.

The Perfima 200 allows using high process air volumes. This enables the conduction of coating processes at unusually low inlet air as well as product temperatures. Especially, if temperature sensitive cores have to be coated, this characteristic might be an interesting option to be considered in process optimisation.

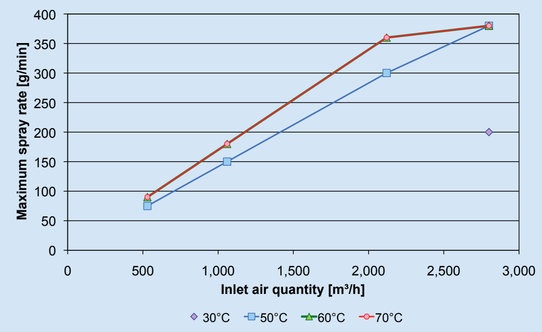

Figure 1: Maximum spray rate in different scales as function of inlet air temperature and quantity.

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