WHITE PAPER –

Design Impact of Wurster Coating Spray Nozzles

Comparison of Schlick HS/04 and Glatt LD-nozzle

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COMPARISON OF TWO WURSTER SPRAY NOZZLE DESIGNS

1) Introduction

The Schlick HS04 nozzle has been the standard for production size Wurster processes. The quality of a coating or laying process in a Wurster insert is highly dependent on the droplets generated by the spray nozzle. Therefore, possible bearding of the liquid insert which could have a negative influence on the spray pattern and the droplet sizes should be removed as soon as possible.

The patented Glatt LD04 Wurster spray nozzle for production size inserts was developed to offer superior handling:

- In the case of bearding, it allows a removal of the liquid insert for cleaning without process interruption.
- Varying of the air cap position of a Schlick HS04 can significantly change the spray. For convenience, it is recommended to align the air cap flush to the liquid insert (0 mm spacing). The air cap of the Glatt LD04 nozzle was designed in a fixed position to reduce the number of variables, i.e. the spray is only dependent on the spray rate an atomization air pressure.

As process functionality and reproducibility of the droplet sizes and the droplet size distribution are the most important design attributes of spray nozzles, the spray pattern of the Glatt LD04 nozzle must be comparable to the conventional Schlick HS04 nozzle.

For this study the operational parameters and spray patterns of the two nozzle designs (see Figure 1) were examined and evaluated. The following study will show that the sprays of a Glatt LD04 and a Schlick HS04 nozzle with the air cap are the same.

Figure 1: Schlick HS04 nozzles mounted into Wurster processor (left). Liquid insert of a Glatt LD04 nozzle removed (right).
2) Methods

Testing was conducted at Glatt’s New Technology Innovation Center. Various spray characteristics of the nozzles had to be determined. On the one hand the atomizing air consumption and velocity were examined using a vane wheel anemometer.

On the other hand the atomized spray droplets and the distribution had to be compared to each other. This was done by analyzing the droplet sizes at defined cross sections of the spray cone by means of laser diffraction analysis. To compare the droplet size distribution the Sauter mean diameter (SMD) was used which is defined as the diameter of a sphere having the same volume-to-surface area ratio as a spray droplet of interest under the assumption that all droplets of the spray have the same diameter. The SMD is commonly used to characterize droplet sizes of a spray.

To better outline the comparability of the nozzles the spray droplets were analyzed at several spray rates and spray pressures in order to cover the wide operation areas of the nozzles.

3) Atomizing air consumption and air velocities

Different spray patterns can be expected, if there are air consumption differences of the two nozzles. The air consumption measured in m³/h is a direct result of the atomizing air pressure (bar). Each nozzle was tested with two different liquid inserts (1.8 and 2.2 mm). The consumption of each nozzle as pictured in Figure 2 was measured starting at a pressure of 0.1 bar and then increased by 0.1 bar steps. The resulting graphs show minor differences between the two nozzle types at (very) low atomizing air pressures. The graphs start to drift apart at approx. 0.4 bar and remain linear, however with different slopes. Therefore, with increasing atomization pressures, the differences of the consumption between the nozzles will also increase. For the following list, several results were picked to highlight the deviation in absolute numbers:

<table>
<thead>
<tr>
<th>Nozzle: Liquid insert:</th>
<th>HS04</th>
<th>LD04</th>
<th>measured air consumption (m³/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.8mm</td>
<td>2.2mm</td>
<td>1.8mm</td>
</tr>
<tr>
<td>Set air pressure (bar)</td>
<td>measured air consumption (m³/h)</td>
<td>26,528</td>
<td>26,615</td>
</tr>
</tbody>
</table>

Table 1: Exemplary list of measured air consumptions
Figure 2: Air consumption against atomization pressure (NOTE: The graphs of the LD04 with different liquid inserts are identical which is why the green graph (LD04 1.8mm) cannot be seen.)

The air velocities were determined by mounting a vane wheel anemometer at a distance of 20 cm to the nozzle. The atomization pressures were set from 1 to 5 bar, starting at the lowest pressure and increasing by 0.5 bar steps. The results in Figure 3 correlate with the results of the air consumption measuring’s; the air velocity of the HS04 nozzle is generally higher than the LD04 nozzle. However, given the fact that during a Wurster coating process most spray droplets are encountered by a solid particle within 20 cm, the average difference of the air velocity within this area is less than 2 m/s and thus trivial.

Air velocities

Figure 3: Air velocities against atomization pressure
4) **Droplet size analysis**

The diagrams generated by the laser diffraction analysis illustrate the influence of the spray rate and atomizing pressure on the droplet size and the distribution. With increasing atomizing pressure the spray droplets decrease. **NOTE:** 50 g/min is considered a low spray rate for this particular nozzle size. Therefore, for the sake of completeness, it will be displayed in the diagrams but disregarded in the further consideration. At atomizing pressures below 3 bar the influence of the spray rate is more significant than at higher atomizing pressures, where the droplet sizes at the different spray rates tend to converge. Generally the spray rate should be set in regard to the atomizing pressure (and vice versa). High spray rates should correlate to an appropriately high atomizing pressure. Too low atomizing pressures will lead to an inhomogeneous spray and a wider droplet size distribution, which can be seen in the diagrams in Figure 4; both nozzles generated the largest droplet sizes at the lowest atomization pressure and highest spray rates. Generally atomization pressures below 1 bar are considered an insufficient working range for these specific spray nozzles.

![Sauter mean diameter D[3][2], Glatt LD04](image1)

![Sauter mean diameter D[3][2], Schlick HS04](image2)

**Figure 4:** Visualization of droplet size depending on spray rate and atomization air pressure. Left Glatt LD04 nozzle, right Schlick HS04 nozzle
Another significant finding is that both nozzles generate comparably small droplet sizes in a range from 5 to 10 µm starting at an atomization pressure of approx. 2 bar without regard to the spray rate. This becomes more apparent in the diagrams of Figure 5; the progression of the SMD “flattens” at all tested spray rates. This atomization pressure displays an optimum working range and highlights that higher atomization pressures are not needed, as significantly smaller droplets cannot be generated. This may be valuable, as in some cases high shear forces caused by highly pressurized atomization air may cause breakage of fragile core material. NOTE: The scope of these trials was limited to one particular spray liquid. The influence of liquids with an other viscosity could produce different results.

![Figure 5: Comparison of SMD. Left Glatt LD04 nozzle, right Schlick HS04 nozzle](image-url)
5) Results of spray cone measurement

Figure 6 shows the profile of the spray resp. the SMD at different points in the cross section of the spray at a spray rate of 400 g/min and an atomization pressure of 2.5 bar. The nozzle was positioned 38 mm below the laser and then moved stepwise approx. 12.5 mm upwards until the nozzle was 38 mm over the laser. The droplet size measurement was performed at each position.

The results show SMD between 10 and 15 µm for the cross sections of both nozzles. The difference of the SMD between the two nozzles at -38 mm is less than 2 µm and at every other position less than 1.5 µm. This difference is trivial, therefore the sprays can be considered to be identical.

![Distribution, Glatt LD04](image1)

![Distribution, Schlick HS04](image2)

Figure 6: Comparison of the droplet distribution. Left Glatt LD04 nozzle, right Schlick HS04 nozzle

6) Conclusion

For production sizes Wurster processors for particle coating the Schlick HS04 nozzle is standard. In regard to the coating process an inhomogeneous spray may lead to agglomerating of the pellets. To overcome handling issues in case of bearding on the nozzle, Glatt developed the LD04 nozzle which allows a removal of the liquid insert without process interruption and a fixed position of the air cap to reduce variables.

Thorough testing was conducted to determine the similarity of the Glatt LD 04 nozzle to the Schlick HS04 nozzle. The HS04 nozzle has a negligibly higher air consumption and velocity compared to the Glatt nozzle. However, more important than the air consumption and velocity are the generated droplets. The SMD was measured at various atomization pressures and spray rates and the profiles of the spray patterns were evaluated. Both the droplet size and the profile measurement showed comparable results at the same spraying parameters. At representative atomization pressures > 2 bar the droplet sizes were practically the same; the differences of droplet sizes are within the range of < 5 µm.

In addition to this many processes have successfully been transferred from a Schlick HS04 to a Glatt LD04 nozzle without adaptation of the process parameters.