A case study on:

Unexpected Charge: Challenges Arising from Electrostatic Effects

During powder processing a lot of particles get in contact with each other and processing equipment, during these contacts several issues may arise. Problems like particle attrition or abrasion, deformation, dust formation, but also electrostatic build up due to triboelectrification. Triboelectrification is the phenomenon where particles get charged after each contact with another material. Every particle gets charged and discharged during the processing operations. Depending on the charge rate this could lead to several challenges. Particle agglomeration is one of the challenges, which could lead to worse flowing properties or even blockage. Contamination of processing equipment could take place if particles get a charge high enough to stick to the wall. Or at worst, sparks could be generated if the charge differential becomes too large, and could lead to the ignition of dust explosions.

Case

This case concerns the problem that one of our customers faced in the manufacturing of a high-end automotive product. The performance relies on a surface finish with polymeric particles that are coated on the surface. During this coating process an uneven dosing of polymeric particles was observed which led to a distinct performance loss. The observation happened after a change in particle size, reducing the size by two, while the flow properties of the powder remained the same. After switching the powders, contamination and agglomeration was observed.

Triboelectrification

Smaller particles have a higher surface area, since triboelectrification is a surface phenomenon the hypothesis is that small particles acquire more charge and therefore are more likely to stick to processing equipment. During the processes the powders undergoes several steps, at every step particles get in contact with each other and with the equipment. This implies that every step in the process is a potential source of the triboelectrification and therefore all interactions with any material used in the process should be investigated. During the powder processing various steps in could lead to triboelectrification, the powder is dosed using a fluidized bed, after which the powder flows trough stainless-steel tubing and eventually lead to a Teflon dosing unit.

Powder flowing though stainless steel pipes during the powder processing.

Positive	Glass	Easily becomes (+) charged
	Calcite	
	Mica	
	Wool	
	Quartz	
	Nylon	
	Aluminum	
	Paper	
REFERENCE	Cotton	
	Wood	
	Amber	
	Stainless Steel	
	Hard Rubber	
	Copper/Nickel/Brass	
	Tin	
	Polyester	
	Polyurethane	
	Polyethylene	
	Polypropylene	
	PVC	
NEGATIVE	Teflon	Easily becomes (−) charged

Triboelectric chart of materials often encountered during industrial processing.

Triboelectrification will always happen and based on their ranking in the triboelectric chart, the particles will either get a negative or a positive charge. The triboelectric chart is an empirical determined chart. Not all materials are ranked in the chart, but most materials used in the industry are already ranked once in experimental research, like the triboelectric chart above. Based on the charge that particles acquire, an estimation can be made how the material will interact with another material close by in the triboelectric chart.

What was investigated?

To mimic the interactions occurring during the processing, the following interactions where taken into account: **particle-particle** interactions and **particle-wall** interactions.
For the **particle-wall** interactions different types of wall-materials were investigated since multiple materials are used in the equipment Based on the processes, pneumatic transport and fluidised bed dosing, the following experiments were conducted: Particle size analysis, Fluid bed charging and charging during transport.

Fluidized bed set-up.

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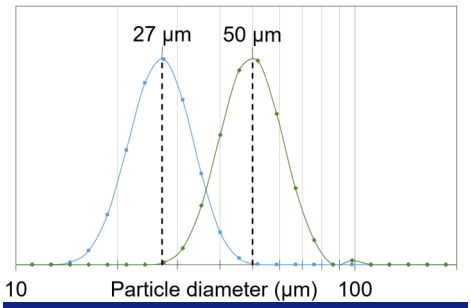
The interactions with the product and stainless steel and polypropylene were tested. The tests are performed by rolling the particles through tubes from either stainless steel or polypropylene. Letting the particles have intimate contact with the wall materials to quantify the **particle-wall** interactions. Laser diffraction is used to confirm the particle size difference and the minimum fluidisation velocity is obtained to measure the **particle-particle** interactions in a fluidized bed.

Particle size

Laser diffraction is used to confirm the particle size difference, in order to validate whether the hypothesis is in line or in contrast with the charging.

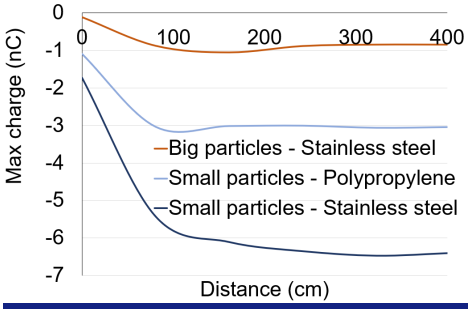


Particle size difference between the two investigated powder samples.

Based on the observed particle size distributions it can be concluded that the particle sizes are indeed different from each other and variate from each other by a factor of two, with a mode of 27 µm for the small particles and a mode of 50 µm for the large particles.

Particle-wall interactions

Particle-wall interactions were investigated by letting the powder flow through pipes made of stainless steel *or* polypropylene. The charge acquired by the sample after each meter was measured.

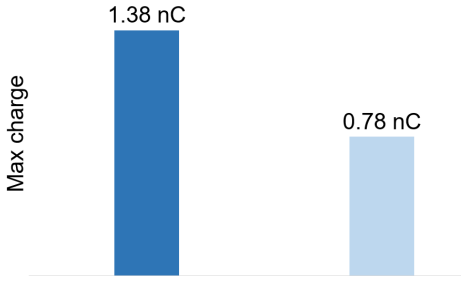


Difference in triboelectric charge between the small and large particles.

After 3m a plateau was measured indicating that the maximum charge is acquired. By quantifying the slope and the plateau, the charge rate and maximum charge is determined. Comparing the different wall materials, it could be concluded that stainless steel has the greatest effect on the acquired charge. The two different samples were compared to obtain information which sample tends to charge the most. Both samples react likewise with the two different wall materials. Based on these results, it could be concluded that the sample has the most interaction with stainless steel and that the smaller particles acquire 5 times more charge than the larger particles.

Particle-particle interactions

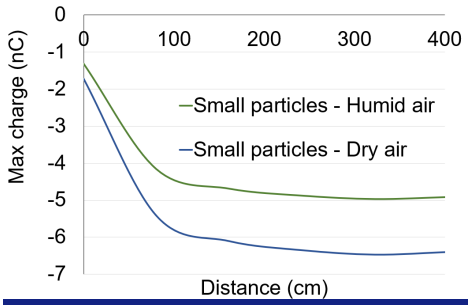
Particle-particle interactions were investigated by fluidising the powder in a stainless steel chamber to mimic the processing for multiple periods of time, after quantifying the charge acquired, the charge rate and maximum charge were determined. The latter is conducted when a material is solely in contact with itself. Comparing the charge rate and charge density, it could be concluded that the sample with the smaller particles obtained more charge, by a factor of two.



Difference in charge acquired between small particles and large particles in a fluidized

Influence of moisture

During processing often relatively dry compressed air is used. The moisture content in compressed air could have a possible influence on the triboelectric charging or discharging and therefore could create problems or is a solution. As the moisture content in the air goes up, the air gets more conductive and therefore improves discharge of the particles.



Difference in triboelectric charge between the small particles, under different conditions.

A higher relative humidity results in a more conductive surface layer on the particles, since triboelectrification is a surface phenomenon therefore the higher relative humidity results in a lower triboelectric charge.

On the other hand, too much moisture can reduce flow properties, so an optimum must be found.

Conclusion

It was hypothesized that smaller particles acquire a higher charge during different processes and therefore resulted in improper dosing. Based on the different experiments it could be concluded that the smaller particles are indeed more sensitive and more obtain charge and faster. This could lead to malfunction of the process equipment if the charge differences will be high enough. The two different methods to charge the particles show indeed a difference in charging and show that **particle-wall** interactions have a greater affect than **particle-particle** interactions. Especially a huge charge difference is observed when the particles contacted with stainless steel. Since a substantial amount of pipes in the pneumatic conveying are made of stainless steel, indeed the switch to smaller particles may have caused a huge impact.

In order to keep using the small particles in the coating process an adjustment of the process operation has to be made. During the fluid bed operations and pneumatic transport an air flow with a higher relative humidity should be used in order to suppress the triboelectrification of the small particles.

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