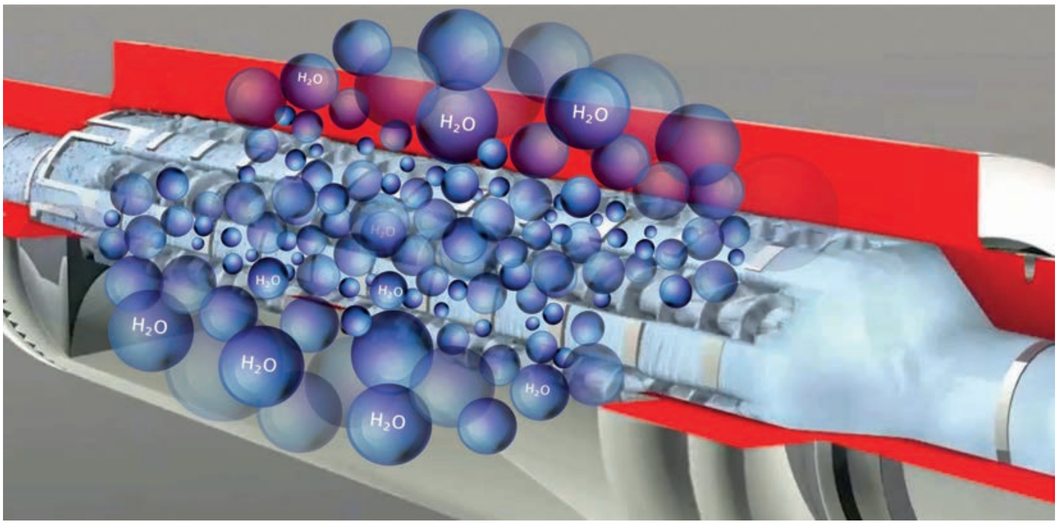
Neither Shaken nor Stirred

Cascade Extruder with Multiple Screw Devolatilization System for Compounding

The MRS multi-rotation system enables even the smallest particles to be homogeneously incorporated into polymer melts. The additives are introduced in the form of a suspension, and the carrier liquid is subsequently removed in a matter of seconds.



Evacuation in the MRS section: the MRS multi-rotation system removes from 3 to 250 l of water per hour from the polymer in less than 6 s

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In many instances, an additive's particle size is key to the changes which it can achieve in the properties of a polymer. However, as a rule, the smaller the particles, the more they tend to stick together and to form a larger particle or agglomerate.

The necessary amount of additive to be added to the polymer to achieve the desired effect is usually defined by the specific mass. However, the decisive factor in achieving the required effect in the final product is generally not the weight but the total surface area of all the particles.

Consequently, particle agglomerates are undesired as the surface area of the agglomerate in relation to its weight must be considered and this if of course far less advantageous than for individual particles.

There are several ways to incorporate additive particles into a polymer melt more efficiently. The tendency to form agglomerates is basically dependent on the specification of the additive and its particle size spectrum.

How the Formation of Agglomerates Can Be Avoided

Currently, there are three techniques used to reduce or prevent the formation of agglomerates.

- When introducing the additive into the polymer, friction in the gap between the screws (e.g. close intermeshing co-rotating twin screw extruder) is used to break up the agglomerates. In this case, success is dependent on the shear forces applied. Unfortunately, this means that the better the effect, the more shear is applied to the polymer and the bigger the risk of damaging the polymer. A compromise must be found – but the smaller the particles, the more difficult this becomes.
- The particles are coated with a release agent before processing, in order to reduce adhesion between the particles, thereby reducing the number and size of the agglomerates. The efficiency of this method is very case-specific. Additionally, the release agent frequently has an unwanted effect on the properties of the additive.
- The formation of agglomerates can be prevented by first introducing the additives into an aqueous solution (suspension) the number of agglomerates is thereby drastically reduced and the occurrence of larger agglomerates can be practically eliminated. The only problem with this solution is that the excess water must be extracted immediately after introduction of the suspension into the polymer melt. On the other hand: the smaller the particles, the more successful this solution is.

To exploit the advantages of the process outlined above, by introducing small particles into a polymer matrix via an

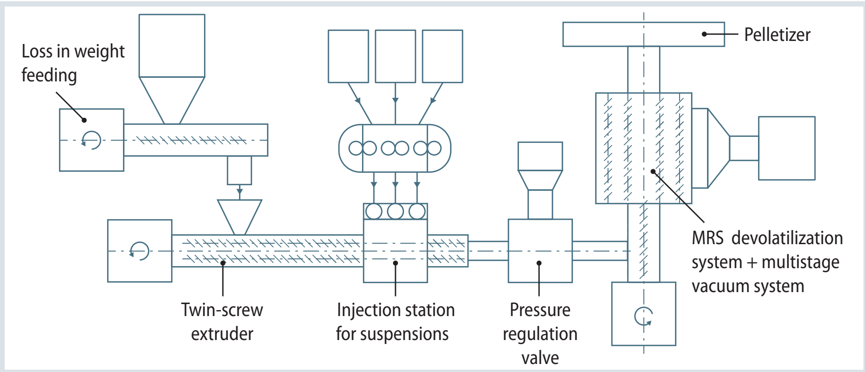

Fig. 1. Schematic diagram of a nano compounding line fitted with an MRS evacuation system

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Material: PET
Additive: $BaSO_4$

	Particle sizes of $BaSO_4$		
	40 nm	700 nm	
Suspension	approx. 1.20	approx. 0.125	Surface area of $BaSO_4$ in compound m^2/g
	<1 %	<0.5 %	Agglomerate fraction in the compound[1]
Powder	approx. 0.024	approx. 0.1	Surface area of $BaSO_4$ in compound m_2/g
	>98 %	>20 %	Agglomerate fraction in the compound[1]
	2.5 %	2.5 %	Weight fraction[2]

[1] Estimated agglomerate fraction in the compound
[2] Mass of particles in the polymer

Table 1. Comparison of particle surface areas after injection as powder and suspension Source: Gneuss; graphic: © Hanser

aqueous suspension, Gneuss Engineering has, together with a number of partners developed an optimized process, which consists of two processing steps.

To the Desired Polymer Melt in Two Steps

First, the additives (which are held in an aqueous suspension) are injected into the base polymer in a twin-screw extruder. Secondly, the water is extracted as vapor in the MRS devolatilization extruder.Based on this concept, a pilot line has been installed at Gneuss Kunststofftechnik GmbH, on which compounds with a diverse range of nanoparticles are manufactured. Among the polymers processed are PP, LDPE, HDPE, Nylon 6, Nylon 12, PET PS etc. Among the nanoparticle additives are TiO2, BaSO4, (SW) carbon nanotubes, carbon black, talc, silicates, cellulose fibers, and FE.

Table 1 lists some examples of the results achieved. During trials, barium sulfate was introduced into t a polymer melt. The additive was introduced either in suspension or conventionally, as a powder.

A key feature of this process is that the carrier liquid (which can be 15 to 20 % of the total mass) is extracted within 10 seconds after injection. The MRS devolatilization extruder was developed specifically for this. With the MRS Multi Rotation Extruder, 3 to 250 liters of water vapor (depending on the extruder size) are extracted per hour.

A Process for New Applications

With this process, developed by Gneuss Engineering it is possible to introduce the smallest particles into a polymer matrix, not only without the particles agglomerating but with an extremely homogenous distribution.

Because the particle size has an exponential effect on the total surface area of the particles, this technology offers a whole range of new applications.

The same or better effects can be achieved with a lower mass percentage of additives and the resultant polymer can offer major improvements with regard to the mechanical, optical, conductive, adhesive properties, also with regard to odor and sustainability (recycling possibilities). ■

The Author

Andrea Kossmann is a marketing manager at Gneuss Kunststofftechnik GmbH.

Service

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