Adjustable Dispersion Rings Reduce Setup Times

Planetary Roller Extruders. When compounding polymers and additives on two or multi-stage planetary roller extruders in the laboratory changeovers between different materials are a common task. A newly developed adjustable dispersion ring system significantly reduces setup times.

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Planetary roller extruders are used amongst other things to manufacture compounds. Their advantages include exact and homogeneous melt temperature control, a very large surface area compared to other processing equipment and most of all low shear. Compounding of various polymers on a two or multi-stage planetary roller extruder requires modification of the dispersion rings to suit each product.

In multi-stage planetary roller extruders these dispersion rings are fitted between the individual barrel sections. The dispersion ring gap has a decisive influence on the residence time in the upstream planetary roller module. Long residence times lead to good dispersion. In addition the degree of dispersion is also influenced by screw speed, mass flow, melt temperature as well as the number and type of satellite screws.

Until now the dispersion rings in multi-stage planetary roller extruders could not be changed or adjusted during operation. Changing the dispersion ring requires time consuming dismantling and reassembly which leads to long downtimes. This has a significant effect on processing times and the manufacturing costs of a compound. The development of an adjustable dispersion ring system has meant that downtime can be greatly reduced.

Variation of the ring gap is generally realized using a one piece thrust ring or a two part dispersion ring. The one piece thrust ring is slid into position over the central spindle. The internal diameter of the choke ring is predominantly determined by the external gearing diameter of the central spindle. With this solution the ring gap is dependent on the gearing profile. The two part dispersion ring allows the ring gap to be varied. In this case the central spindle is reduced to a defined core diameter and the dispersion ring comprises a pair of separate semi-circular shoes that are centered by a support ring where the support ring also determines the positioning of the planetary screws. The internal geometry of the shoes alters the ring gap to the surface of the shaft **(Fig. 1)** [2].

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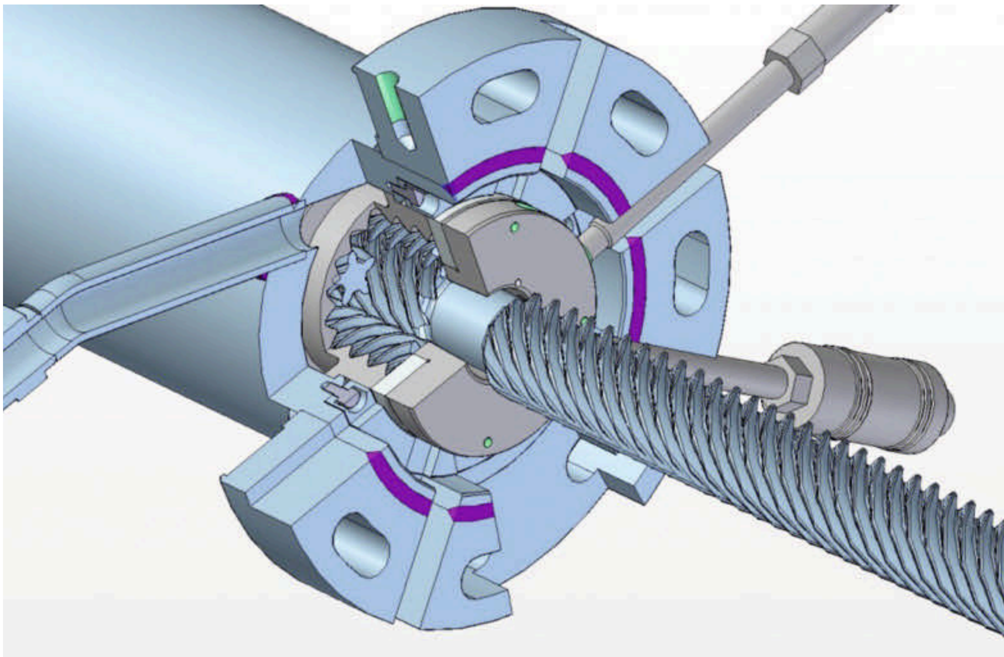

Fig. 1. Location of the dispersion ring in a planetary roller extruder [3]

Variations with a Perforated Disc System

The trials with adjustable dispersion rings were conducted on a TP-WE 70/800-M2 from Entex Rust & Mitschke GmbH, Bochum, Germany, in the pilot facility at the Institute of Polymer Technology (ikd) which is part of the University of Applied Sciences, Darmstadt, Germany. This planetary roller extruder is normally used as a laboratory extruder and has two planetary roller modules, each with six planetary screws. A perforated disc system was used as the adjustable dispersion ring, comprising two perforated disc pairs that could be rotated relative to one another. Through the rotation different patterns of holes with correspondingly different cross-sectional areas can be realized.

The advantage of this system of adjustment is that open channels do not have any indentations or protrusions so that the melt can flow smoothly through them. The central opening is chosen so that the gap provides for a minimum flow rate, which means safer operation and a

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Fig. 2. Schematic representation of the perforated disc system [2]

defined minimum cross-sectional area. The arrangement of the patterns of holes is limited by the maximum internal diameter that results from the positioning of the planetary screws (**Fig. 2**). A hydraulic diameter as comparative value can be calculated from the sum of the hole patterns and the central opening [1].

Determination of the Degree of Mixing

In order to validate the perforated disc system the dependence of the specific drive energy on a comparative diameter (hydraulic diameter) was determined in trials (**Fig. 3**). The specific drive energy is a way of expressing the energy input delivered per kilo of material. The higher the specific energy input the higher the degree of mixing. The highest specific drive energy occurred in each case in the closed position. Increasing the ring gap in non-adjustable dispersion rings increases the hydraulic diameter and the specific drive energy falls exponentially with this. The reduction in specific drive energy is significantly flatter with the perforated disc system. At comparable hydraulic diameters the specific drive energy is higher with the adjustable dispersion ring.

In order to evaluate the degree of dispersion of the compound produced color measurements were carried out on the pellets. The base resin was polypropylene to which 3 % of a yellow masterbatch and 0.5 % of a blue pigment was gravimetrically added. Phthalocyanine was used as the blue pigment since it is often very difficult to disperse in co-rotating twin screw extruders. In this series of evaluations poorer dispersion, that is a large number of large agglomerates, was indicated via lighter, yellower and greener colormetric LAB values. Highly homogeneous distribution on the other hand has the opposite effect on the colormetrics, since the pigment can more effectively deliver its desired color influence [2].

The dependence of the color on the hydraulic diameter is depicted in **Fig. 4**. The closed positions of the perforated disc system and the non-adjustable dispersion ring have comparable starting values. The reproducibility of the color values under identical process parameters and dispersion ring diameter is +/– 0.5. With increasing hydraulic diameter of the non-adjustable dispersion ring a large increase in the b* color component is seen.

The color component b* for the perforated disc system shows a clear progression in the opposite direction. The first three adjustments can be regarded as having constant b* values. However, at the maximum opening, i.e. largest hydraulic diameter, a reduction in the b* value is seen. This means that the yellow component is lower and the blue component dominates, which can be interpreted as an optimal dispersion of the blue pigment. In the system previously investigated an increase in the hydraulic diameter for the non-adjustable dispersion ring system always led to a reduction in the influence of the blue pigment, i.e. poorer dispersion.

The unreported values for L* (lightness) and a* (red/green) correlated with the progression of the L* and a* values in **Fig. 4**. The perforated disc system delivers a very homogeneous dispersion of the color pigment and the resulting color change is significant with increasing hydraulic diameter [2].

Economic Considerations

The use of adjustable dispersion rings is limited to lab extruders or comparable usage profiles. Through the use of an adjustment system the number of reconfigurations can be significantly reduced. However, due to the larger number of components an increase in the time required for these reconfigurations can be expected. On balance the technical advantages of the perforated disc system outweigh the disadvantages and have a positive effect on productivity.

Conclusions

An adjustable dispersion ring system reduces setup times and optimizes the de- →

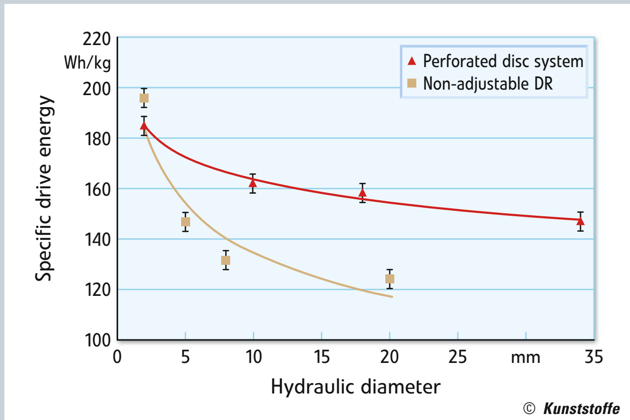

Fig. 3. The dependence of specific drive energy on the hydraulic diameter [2]

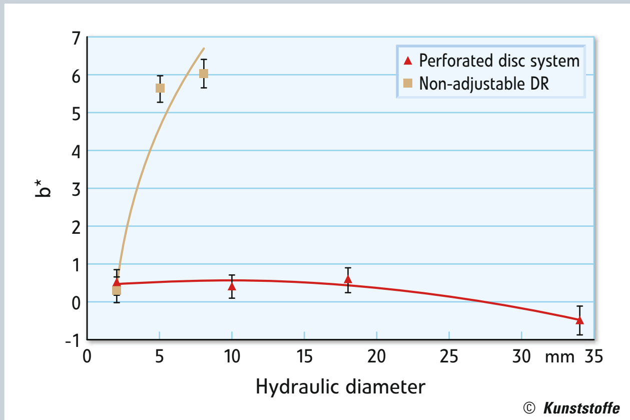

Fig. 4. The dependence of the color component b* on the hydraulic diameter [2]

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gree of mixing when working with compaction agglomeratable powder pigments. The perforated disc system is an attractive solution for laboratory extruders and is particularly suitable for the manufacture of polyolefin based masterbatch. Use with thermally unstable materials has to be regarded critically. The degree of dispersion can be established without difficulty by color measurements of the pellets. ■

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