Mixing to Recipe

Flexibility and Efficiency: Buzzwords among Compounders

Machine and system manufacturers for compounding plastics are improving tried and tested equipment technology by optimizing details. A number of measures can make production more flexible and efficient.

The pretreatment of plastics, or compounding, is an essential factor in plastics processing. The property profile of the final product can be finely tuned by adding in filler materials. Increasingly specialized products require increasingly complex material formulations. Moreover, processors have to be supplied with materials in very small quantities at economical production costs. This requires a high level of flexibility and efficiency in compounding. Increased plant utilization is once again another hot topic.

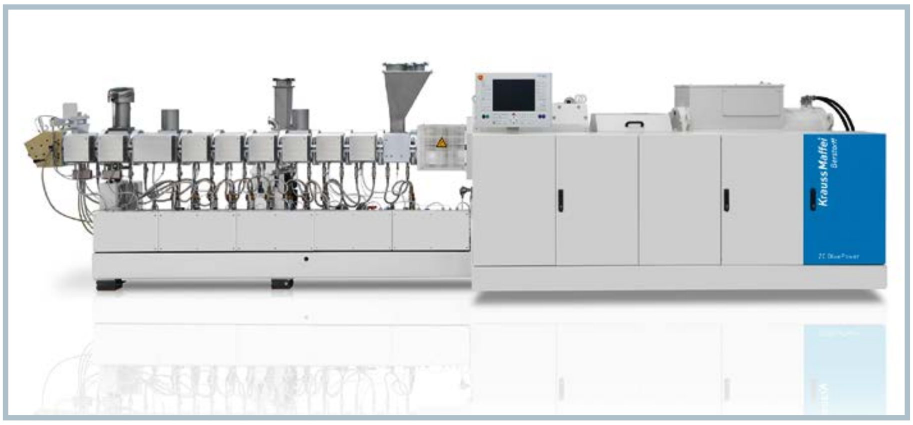

Fig. 1. ZE BluePower twin-screw series extruders feature high torque density while increasing volume over the predecessor series (figure: KraussMaffei Berstorff)

Co-Rotating Twin-Screw Extruder Is still the Standard Machine

Modular screw and barrel construction in co-rotating twin-screw extruders enables them to be configured specifically for almost all kinds of processing. Moreover, co-rotating twin-screw extruders are known for highly effective mixing at high throughputs – the reason why they have been the standard compounding machine for many years.

KraussMaffei Berstorff GmbH of Hanover, Germany, introduced the newly developed ZE BluePower series twin-screw extruder already at the K2013 (**Fig. 1**). This series is now available in 42, 52, 65 and 80 mm sizes and will eventually replace the ZE-UTX series. Compared with the same size machines of the previous generation, the new development increases both torque density by more than 30 %, thereby raising throughput in torque-limited processes, and increases volume by more than 23 %, also raising throughput in volume-limited processes. Diameter ratio is now newly optimized to 1.65 at 16.0 Nm/cm^3 torque density. In addition to improvements in the drive, in the highly loadable screw shaft materials and in gear geometry on the screw shaft, KraussMaffei has concentrated on the reproducible mounting and preloading of the screw. For this, a hydraulic pretensioning unit was developed that creates a defined tensile load, but no torsion load on the screw shaft. The defined pretensioning force also prevents melt from penetrating between screw section and screw mandrel. Time-consuming dismounting and cleaning can thus be avoided. Besides several optimizations in detail, the side feeder intake opening was widened, for instance, to simplify input of large amounts of filler material. When abrasive fillers are processed, optional oval anti-wear sleeves can be used in the cylinder (**Fig. 2**). Thus, in severe wear situations, only the sleeve is replaced, not the entire cylinder. Moreover, the elliptical shape of the sleeve narrows the gap to the heating/cooling cartridges, thereby enabling more precise temperature control in the plastic melt.

The ZSK Mc[18] series from Coperion GmbH of Stuttgart, Germany, increases specific torque from 13.6 to 18 Nm/cm^3 over their previous series machines. This enables compounding at a higher screw

Fig. 2. An oval sleeve narrows the gap to cooling/heating cartridges (figure: KraussMaffei Berstorff)

filling level and increases throughput, while markedly reducing energy input. At the moment, the series is available in sizes from a ZSK 45 Mc[18] up to a ZSK 119 Mc[18]. The series has been expanded to include a ZSK 26 Mc[18] for laboratory applications. In order to utilize available power, Coperion has, i.a., developed the Feed Enhancement Technology (FET). This technology involves using a gas-permeable wall in the intake zone to apply a vacuum so that the material volume of powdery filler can be increased. This enables increased throughput of powdery fillers with low bulk density. For processes requiring less torque, Coperion relies on the ZSK MEGAvolume Plus with a 1.8 diameter ratio. Here the existing series ZSK 43 MvPlus to ZSK 125 MvPlus have been supplemented by a ZSK 27 MvPlus. The standard machines have also been revised. The STS Mc[11] (**Fig. 3**) now boasts a specific torque of 11.3 Nm/cm^3, and maximum speed has been increased from 800 to 900 rpm's. The processing section has a modular construction, and processing length can be varied from 24 to 68 D. With Coperion K-Tron to supply dosing equipment and with Coperion Pelletizing Technology, Coperion offers additional key components from a single source, thereby picking up on the trend toward complete systems.

With the ZSE 27 iMaxx introduced at the last K-Fair, Leistritz Extrusiontechnik GmbH of Nuremberg, Germany, is concentrating on the development of formulations and processes or their scale-up to production systems (**Fig. 4**). Compared to its predecessor ZSK 27 Maxx, the ZSE 27 iMaxx lacks a separate control cabinet. The entire electric equipment including a water-cooled frequency converter is built into the frame base, with the result that extruder storage space shrinks and its mobility expands. Another modification is a smaller, water-cooled Siemens motor, but with no loss of power. An additional feature is the closed twin-loop temperature control whose forward and return flow as well as coaxial valves are located in the media canal. The closed water circulation reduces water consumption and remains independent of water quality. In addition to the improved protection class IP54 (heater cartridge IP65), the new ZSE 27 iMaxx impresses with smooth surfaces and a powder-coated frame base, both of which are easy to clean. Leistritz has improved the ease of operation and simplified maintenance while keeping its predecessor's advantages of high torque and large volume. With these characteristics, Leistritz's ZSE 27 iMaxx is aimed at institutes, research facilities, engineering schools and small batch producers, as well. »

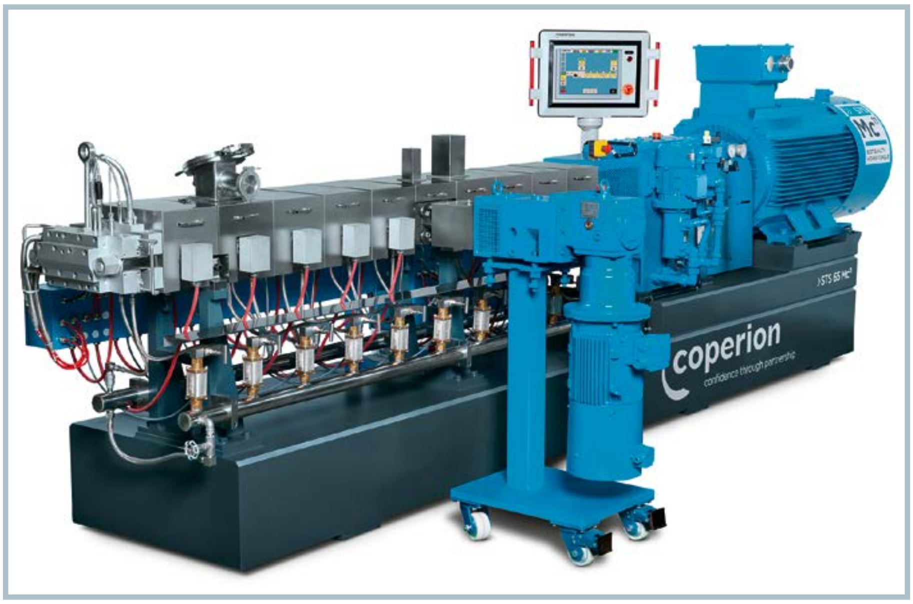

Fig. 3. The STS Mc[11] series features an increase in torque up to 11.3 Nm/cm^3 (figure: Coperion)

Fig. 4. The new ZSE 27 iMaxx has been optimized for research and development work

(figure: Leistritz)

Extrusion machine manufacturer MAS Maschinen- und Anlagenbau Schulz GmbH of Pucking, Austria, is promoting a new way to utilize its twin-screw extruders with co-rotating conical screws, namely, the combination of in-line film recycling and compounding in 6 sizes from 20 to 1,600 kg/h. The MAS extrusion system combines the good plasticizing and homogenizing action of a parallel-screw extruder with the specific advantages of a conical twin-screw system. Among these are good feeding through the large intake and a correspondingly large intake volume. Materials with low bulk density, such as film flakes, can be drawn in easily, while additives can be added simultaneously, eliminating the need for side feeders. At low levels of energy consumption, materials are gently plasticized and homogenized. Polymer structure degradation is low, the physical characteristics of the starting material, such as elongation at break and tensile strength, are maintained, the manufacturer claims. The MAS extruder can serve as a starting base for the concept of integrated recycling-compounding lines arranged in cascade (**Fig. 5**). The MAS extruder is then combined with a rotating screen-disc filter and a downstream single-screw degassing extruder that conveys to a pelletizing system. According to the manufacturer, energy consumption measures out at 0.24 kWh/kg when processing 60 % PP film-flakes and 40 % powdery additives.

Erema Engineering Recycling Maschinen und Anlagen GmbH of Ansfelden, Austria, concentrates on the development and production of plastics recycling systems and components. Its Corema product has been on the market for about three years. This product line combines the advantages of recycling and compounding in a single process step, thereby enable the production of specified raw materials based on recyclates and optimized for application. Variations in the quality of starting materials can be compensated through the use of this product line, as well as by using filler and/or reinforcing materials. The property profile of the recyclate can be precisely

The Author

Maximilian Adamy, M.Sc., does research in the field of compounding and reactive extrusion.

Service

Digital Version

- A PDF file of the article can be found at ***www.kunststoffe-international.com/1150158***

German Version

- Read the German version of the article in our magazine ***Kunststoffe*** or at ***www.kunststoffe.de***

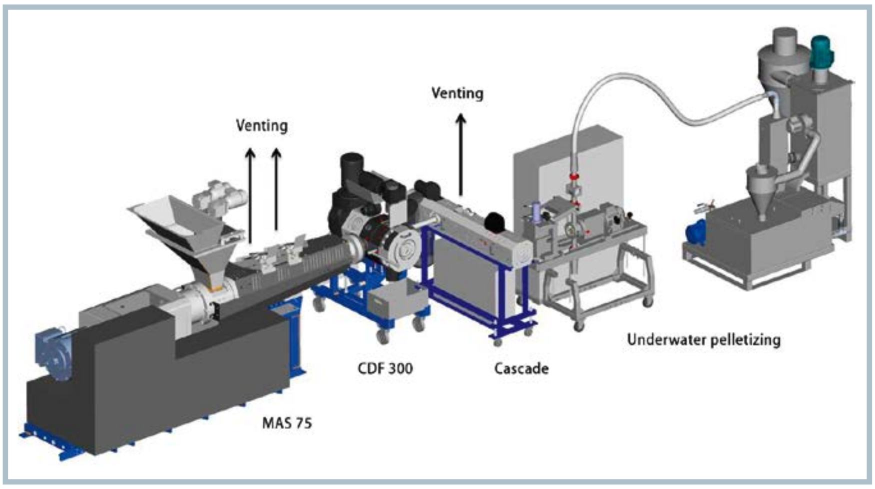

Fig. 5. Example of a cascade extruder system capable of direct compounding of recycling material

(figure: MAS)

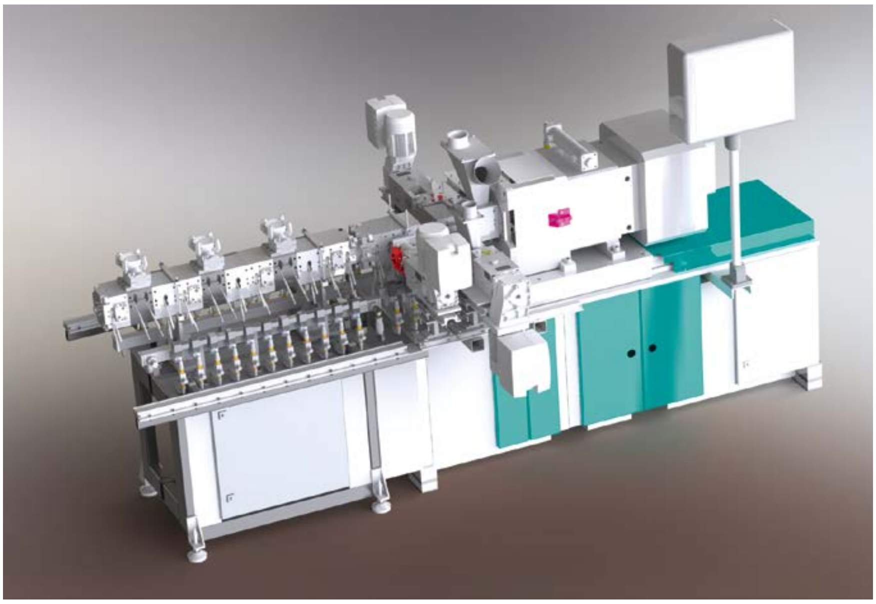

Fig. 6. The RingExtruder RE1 XPV with 100 L/D processing length has been optimized for reactive extrusion (figure: Extricom)

adapted to its final use. The Corema product line features flexibility with regard to useable starting materials and can be supplied in versions for small amounts of 300 kg/h, as well as for large volumes of up to 4 t/h.

Reactive Extrusion as Chemical Challenge

What once began as compounding is turning into a partially chemical process that makes it possible to utilize the potential in chemical modifications of polymers. Reactive extrusion expands the field of application for plastics, but requires specialized compounding units.

The geometric design of the RE RingExtruder from Extricom GmbH of Lauffen, Germany, has 12 co-rotating screws arranged in a ring, and is suitable not only for compounding thermoplastics, but also for chemically modifying polymers in the compounding unit. Due to the geometric design, the surface of the double-flighted screws is stripped off twice with each turn of the screw. This results in very short dwell times. According to the manufacturer, dwell time can also be increased by 20 min and more with a correspondingly long processing section and appropriate process control. The large ratio of heat exchange surface area to volume enables production temperature to be kept within narrow limits and degasses reaction by-products efficiently. The possibilities of the processing technology are enhanced by the Z technology which is conducive to location change procedures, chemical reaction and degassing. Expanding the RingExtruder RE1 XPV (**Fig. 6**) by a processing section length of 100 L/D has led to successes in the polycondensation reaction of high-temperature polyamides, for example, as well as in the production of functionalizations of biopolymers.

The dispersive introduction of fillers into a plastic melt presents an essential challenge for compounding. Especially nanofillers, e.g., carbon nanotubes, can lead to property improvements only if the fillers are not agglomerated, but homogeneously distributed in the plastic melt. Gneuss Kunststofftechnik GmbH of Bad Oeyhausen, Germany, chose to face this challenge. With the aid of their reactive extrusion concept, they have succeeded in mixing suspensions and emulsions with various plastics, such as PC, PET, PP, in such a way, that several additive components combine homogeneously with the molecular structures of the plastic melt without agglomerating. Gneuss' reactive extrusion concept is based on the linkage of two extrusion techniques in cascade, thus enabling a high particle content (> 10 nm) to be worked directly into existing plastics. By this method, resulting properties can be significantly improved, such as thermal conductivity, flow characteristics, or abrasiveness. In a first step, additives dissolved in a suspension are worked into the polymer by a twin-screw. In a second step, the suspension is removed from the polymer »

Fig. 7. This Econ Water and Air Pelletizer combines air and underwater pelletizing in a single unit (figure: Econ)

with the aid of a high-performance MRS degassing extruder, thus leaving only the additive in the polymer. Homogeneous distribution of additives succeeds thanks to the patented multi-rotation system of the MRS.

Finally Pelletizing Technology

Subsequent to compounding, the manufactured plastic has to be supplied in the form of defined and further processable pellets. Pelletizing can be done by either the hot- or cold-cut method. Underwater pelletizing, which belongs to the hot-cut techniques, is characterized, i.a., by a high degree of automation, a small footprint in production, a closed system, as well as the production of lenticular pellets. These advantages accrue not only in industrial production, but on a laboratory scale as well. For this reason, Econ GmbH of Weisskirchen, Austria, has designed and built the EUP 10 compact underwater pelletizer. The EUP 10 was originally conceived as an exhibit item. Due to demand for an underwater pelletizer for laboratory applications, where often only small throughputs are required, the EUP 10 graduated from machine model to lab equipment. Depending on configuration and material, the EUP 10 achieves between 1 and 30 kg/h. With some materials, output can be increased to as high as 50 kg/h. The lab unit thus enables the processing of small amounts of material. Despite its compact construction and 80 kg component weight, the EUP 10 offers all the advantages of patented thermal insulation. For example, thermal insulation prevents the melt from "freezing" in the die holes, just as in the larger Econ underwater pelletizers. Another new product from Econ is the EWA (Econ Water and Air Pelletizer) (**Fig. 7**). The combination of the ELG air pelletizer and the EUP underwater pelletizer offer a high degree of flexibility particularly in lab applications, since the same machine can be used for both underwater and air pelletizing. Although almost all thermoplastics can be processed by means of underwater pelletizing, some materials have to be extensively dried, e.g., Wood plastic compounds or materials with a high natural fiber content. Air pelletizing provides an alternative for these materials, since air is used to cool and convey the pellets, thereby eliminating a final drying of the material.

The Eflex pelletizing system by Gala Kunststoff- und Kautschukmaschinen GmbH of Xanten, Germany, was also developed to improve production flexibility and efficiency for compounders and masterbatch producers (**Fig. 8**). It enables economic production of small amounts of products with frequent changes of material, since the pelletizing system can be cleaned and set up in a few minutes. Moreover, diverse optional water filters are available, meaning that the water does not have to be changed even for extreme material or color changes. This again saves time otherwise required for cleaning and for heating fresh water, as well as the energy expenses involved.

Fig. 8. The Eflex pelletizing system enables efficient and flexible production of small amounts of material (figure: Gala)

Conclusion

Due to the increasing complexity and number of materials formulations, machine and system manufacturers have to provide solutions for flexible and efficient systems, so that compounders can continue to produce profitably in the future. Compounding therefore lies at the center of plastics processing, since the range of application of the material plastic is expanded and defined in this process step. ■