

Upcycling: From Old to New

The Processing Industry Closes the Recycling Loop

Machine manufacturers and plant engineers of the processing sector focused on recycling at this year's K trade fair. The numerous requirements for the recycling process are met with interesting and clever solutions.

Plastics with a wide variety of characteristics can be created in processing due to the use of fillers and additives. That makes processing the focal point of the process chain in the plastics industry. Recycled in addition to new materials are increasingly being used as base material. The future success of these recompounds depends on the one hand on the process stability, which influences the economic efficiency of processing, and on the other hand also on acceptance by processors. That is why machine and plant manufacturers are increasingly implementing individual machine concepts along with inline analysis methods in order to check and verify defined material properties per batch. Thus, the processing industry will decide the success or failure of plastic recycling.

Processing Machines

For the efficient integration of fillers and additives into a plastic matrix established concepts for processing machines exist. Although their functionality differs, all machine manufacturers take into account customer demand for high energy efficiency, great flexibility, and improved ease of use in order to enable economical production, even in small batches with frequent product changes.

Coperion GmbH, Stuttgart, Germany, a manufacturer of compounding systems, dosing systems, and bulk goods systems among other things, presented the STS Mc¹¹ compounding system (Fig. 1) at its exhibition stand; it has been optimized regarding reliable operation and improved cleaning. Its basis is a twin screw extruder with a specific torque of 11.3 Nm/cm³. Coperion has equipped the series with a new distributor battery with

coaxial magnetic valves for high operational reliability. Furthermore, the revised thermal insulation covers make access to the processing section and cleaning easier. Quick-release fasteners simplify replacement of the feed hoppers as well. To prevent vibrations during operation, the

screw extruders. The new 28mm twin screw extruder completes the ZE BluePower machine series at the lower end. This laboratory extruder features many details of the ZE BluePower series such as the diameter ratio D_a/D_i of 1.65, the 4-D or 6-D housings, and the press-fitted bush-



Fig. 1. Further development: the STS Mc¹¹ compounding system features improved operational reliability and ease of use (© Coperion)

series similar to the ZSK series is also equipped with a novel, torsion-resistant base frame. An optimized version for masterbatch production is available, for example with an extruder head for the processing of color masterbatches that ensures an even flow of the strands with minimal dead spots. Additional optimizations make cleaning and material changes easier.

KraussMaffei Berstorff GmbH, Hanover, Germany, has also expanded and optimized the existing portfolio of twin

ings for good protection against wear. It achieves significantly higher output compared to the previous 25 mm ZE laboratory extruder thanks to the motor-gear mechanism combination. Up to 43% more throughput can be achieved in torque-limited processes and as much as 70% more in volume-limited processes. The dosing and degassing units were re-developed as well. UltraFeed technology makes higher filler content in the filler dosing unit possible by means of a vacuum. A striking innovation at the exhibi-



Fig. 2. Compact twin screw extruder: the ZSE 35 iMaxx makes frequent product changes easier

(© Leistritz)

tion stand was the optional UltraGlide that permits the filled screws with the drive unit to be pulled out of the fixed processing unit quickly, thereby for instance enabling rapid cleaning and making it possible to evaluate the dispersion of fillers along the processing unit.

Leistritz GmbH, Nuremberg, Germany, has been building twin screw extruders for nearly 80 years and is now offering the ZSE 260 Maxx with a drive rating of almost 9500 kW and nearly 112,500 Nm of torque for throughput of up to 35 t/h. It uses a variable-speed drive. At a specific torque of 15 Nm/cm³, the D_2/D_1 ratio is 1.66. The processing unit can be equipped with established heating cartridges and with oil or steam heating. Leistritz also designed the ZSE 35 iMaxx with enclosed and therefore easy to clean surfaces in order to reduce cleaning effort (Fig. 2). A hood protects the entire processing and drive unit against dirt. The tempering unit is integrated into the frame and a new synchronous motor is used as well, improving energy efficiency. Overall the machine therefore makes a tidy and compact impression when it is set up. The processing unit is available in lengths between 24 and 48 L/D. Add-on modules such as side loading can be mounted on the right or left of the processing unit.

Buss AG, Pratteln, Switzerland, a supplier of co-kneading machines for compounding tasks, has revised and optimized the MX 105-22 F compounding system for processing high-filled or cross-linkable,

halogen-free, flame-protected cable compounds. The MX 105 with a throughput of up to 1500 kg/h is in the middle of the performance range for the MX series. It is available in a processing length of 15 or 22 L/D and can be equipped with two or three delivery systems. Instead of the melt extruder, a melt pump can be used for certain applications such as processing semiconductor compounds or carbon black masterbatches. The electric drives are optimized for efficiency in the operating range so that the drive motors achieve an efficiency of at least 90 %.

Extricom GmbH, Lauffen, Germany, manufacturer of the RingExtruder RE used in PET bottle-to-bottle recycling, the rubber and tire industry, and for classic thermoplastic material processing, offers replacement and wear parts for all standard, synchronous twin screw extruders regardless of the manufacturer.

The company produces single, twin and triple screw elements as well as suitable transition elements for all element versions. A broad range of kneading and mixing elements is offered as well. In addition to the established screw elements, Extricom now has high-performance elements in its portfolio (Fig. 3). Compared to the standard kneading and mixing elements, using the partly patented high-performance elements can reduce the application of energy to the product – with simultaneous better distributive and dispersive mixing. The mixing effect is maximized by generating extensional flows through geometric variations in the screw profile. Numerous combinations of different screw elements are also available, for example a conveying element with a kneading block. The goal is to realize the transfer of energy on a longer section of the shaft. In addition to screw elements, Extricom produces various housings in different material versions and with different wear protection systems. Due to a lack of space between the processing chamber and cooling channels, cooled housings are often not carried out as inline versions. Now the new development with thin-walled, replaceable wear protection bushings makes it possible to position the cooling channels close to the processing chamber. Known as a Thinliner, this improves wear protection and durability with simultaneous better temperature control.

Recycling Machines

The processing of recycling materials poses a challenge since the material is often available in a low bulk density, which makes it more difficult to draw into the processing machine. Degassing is »

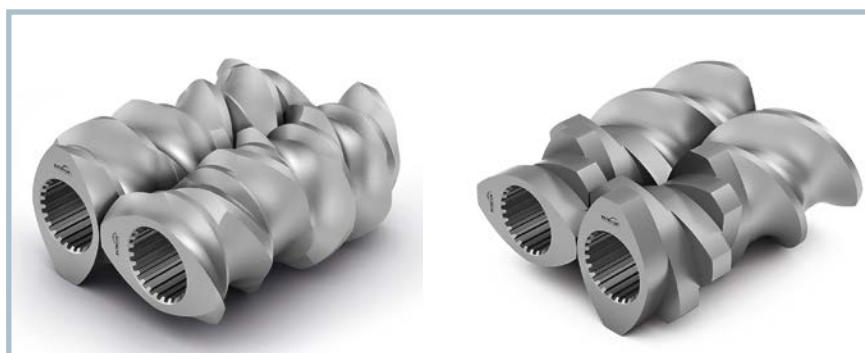


Fig. 3. Expanded range of screw elements: high-performance elements (left) and combination screw elements (right) (© Extricom)



Fig. 4. The Isec evo is designed for recycling production waste (© Pure Loop)

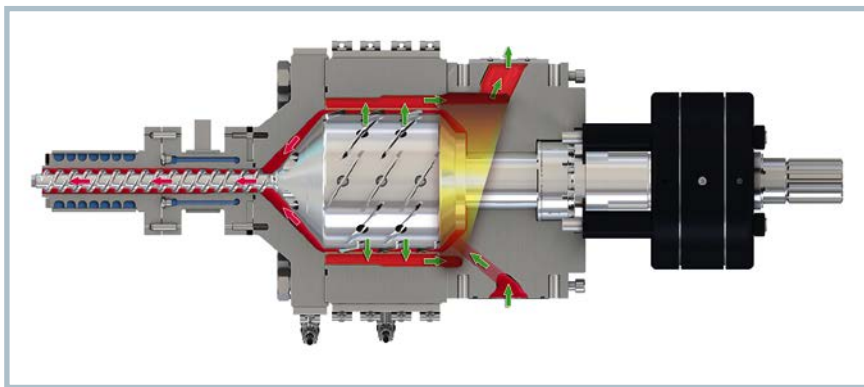


Fig. 5. Impurities are scraped off the surface of the filter basket and conveyed out of the machine by a discharge screw (© Nordson Kreyenborg)



Fig. 6. The Graviplus dosing system can combine up to eight dosing modules (© motan)

usually required during processing as well in order to remove moisture and low-molecular components. In addition to melt filtration that further reduces the level of impurities, additives and fillers are integrated in order to improve and optimize the material properties. Companies offer numerous detailed solutions as well as complete systems for this purpose. What's more, machine and plant manufacturers have solutions available for in-line testing and control of the material properties.

Disintegrating the recycling material is the first step. The Aachen-based cutting mill manufacturer **Heinrich Dreher GmbH & Co. KG** has developed the model VD 1100 shredder-cutting mill combination, for example to disintegrate purgings as well as high-volume components such as IBCs (intermediate bulk containers), canisters, and barrels. The VD 1100 presented at the trade fair integrates both pre-disintegration and grinding in one machine for a space and cost-saving design. A large front door provides direct access to the

single shaft shredder and cutting mill, thereby enabling easy cleaning after a product change. The VD 1100 can reach a throughput rate of up to 1500 kg/h.

Pure Loop GmbH, Ansfelden, Austria, founded as a subsidiary of the Erema Group, specializes in recycling homogeneous and clean production waste. The new Isec evo shredder-extruder technology is designed for re-granulating production waste in many different forms (Fig. 4). Compared to the previous model, the new development features up to one-quarter more throughput, a swiveling hood for greater flexibility, and automatic start-up and shut-down at the press of a button.

The Recycling Technology business unit of **Starlinger GmbH**, Vienna, Austria, specializes in recycling machines for thermoplastic materials among others and for applications such as PET flakes. A common problem in recycling is that the recompound has a strong odor, especially when input materials containing migrated substances from foods, cosmetics, or cleaning agents used. Starlinger has developed a method that significantly reduces the odor development of recomounds without additives. It is based on a three-stage process: First the input material is heated and homogenized in the Smart Feeder. Subsequently, the C-VAC degassing module achieves a high degassing efficiency by producing large melt surfaces before the material passes through the final process step in the Smell Extraction Unit to produce a permanently odor-free recompound.

The conical twin screw extruders with synchronous screws from **MAS Maschinen- und Anlagenbau Schulz GmbH**, Pucking, Austria, feature a large feed opening thanks to their design so that materials with low bulk density and additives at low rotation speeds can be supplied. Shear sensitive materials (such as PLA and PET) including both new and recycling materials can therefore be gently extruded at high throughput values. What's more, the short processing unit results in a brief dwell time of the melt in the extruder and a low specific application of energy. The extruder can be operated with one to three-stage degassing, depending on the requirements. A PET feeding lock can be installed to extract surface moisture. The extruder is available for throughput rates between 150 and



2500 kg/h. For the processing of recycling material, the company offers the continuous CDF melt filter to remove wood particles, paper, or non-melting foreign plastics. The melt is passed through a filtration disk with conical self-cleaning bores. Contaminants adhering to the surface are conveyed to a scraper system by the rotating movement of the filter disk and then removed by a discharge screw. The large active filtration area results in a low specific throughput, which in turn leads to a low melt pressure. The filter is available in various design sizes for throughput rates between 700 and 4000 kg/h.

Nordson Kreyenborg GmbH, Münster, Germany, developed the BKG HiCon R 250 model recycling filter in order to also filter plastic melts with moderate to high impurity levels. In the recycling filter, the contaminated melt flows through the fixed, cylindrical filter basket from the inside to the outside (Fig. 5). Conical microbores result in efficient filtration. The impurities are separated, scraped off the surface of the filter basket by a rotating

knife driving shaft, and subsequently conveyed out of the machine by a cooled discharge screw. The rotation speed of the knife driving shaft and discharge screw can be adjusted depending on the throughput, impurity level, and discharge speed. Application examples include the processing of agricultural films and post-consumer material. Here the separation of organic and inorganic materials, metals, foreign plastics, and rubber is the goal.

The core competency of **Ettlinger Kunststoffmaschinen GmbH**, Königsbrunn, Germany, is the development and fabrication of continuous melt filters for plastic melts with low to high impurity levels. The company has expanded its portfolio with the Eco-250/PET melt filter. This melt filter processes PET contaminated for instance with aluminum, paper, or PVC, and is said to offer advantages and potential savings compared to conventional backflush screen changers in PET applications such as thermoforming films for food packaging or packaging tape »



Fig. 7. The FiberXpert fiber dosing feeder is used for dosing materials such as waste films as flakes, long natural fibers, and recycling carbon fibers (© Brabender Technologie)



Fig. 8. Differential dosing feeder: exact dosing by means of electronic pressure compensation

(© Coperion)

made of 100 % PET bottle flakes. The core of the Eco melt filter is a rotating filter drum perforated by conical bores, with the melt flowing through it from the inside to the outside. A stripper continuously removes the impurities that remain on the drum surface and conveys them to a discharge shaft, so that fully automated and interruption-free operation is possible over a long time period. Constant

melt pressure and low melt losses are benefits of this design. Dark impurities (so-called black specks) are reduced without a pressure increase before the screens.

Dosing and Granulating

Motan-colortronic GmbH, Friedrichsdorf, Germany, a supplier of continuously controlled gravimetric dosing systems in particular, wants to increase productivity through improved material handling processes. The new Graviplus dosing system works according to the differential dosing principle, in which the flow of material is continuously controlled and monitored in real time according to weight. This means that bulk density fluctuations, grain size changes, and changing flow behavior cannot impair the dosing accuracy. Vibrating wire technology makes the load cell insusceptible to vibrations and temperatures. The Graviplus system combines up to eight dosing modules for granulate, micro-granulate, powder, liquid, and ground stock with throughput rates from 0.25 to 7500 kg/h (Fig. 6). A consistent dosing accuracy of $\pm 0.1\%$ is achieved. The components being added are continuously and synchronously discharged into the collecting tank by speed-controlled dosing screws. This means a homogenized mixture is supplied to the feed zone of the processing

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Fig. 9. Underwater granulating system: the PearloFlex produces spherical granulate (© Maag)

machine. Dosing modules with twin screws and agitators are used for materials that flow poorly or not at all, while weighing tanks with dosing pumps are used for liquids. Motan-colortronic therefore offers a customizable solution for the production of complex material formulations.

The core competencies of **Brabender Technologie GmbH & Co. KG** lie in the fabrication of equipment for dosing, weighing, and discharging bulk goods. Dosing long and irregular fibers such as natural, wood, as well as long (recycling) carbon fibers, but also film shreds are possible to process with the new Fiber-Xpert fiber dosing feeder (**Fig. 7**). Dosing such materials is made possible by using a special fiber screw, a container with steep walls, a large surface area, and a special agitator geometry and placement. The interaction of these parameters results in forced feeding of the screws, but needs to be individually designed for each material. Dosing of the sample materials at the exhibition stand was convincing, allowing the company to identify new processing options with this concept for materials where dosing was previously not possible.

Coperion K-Tron GmbH, Gelnhausen, Germany, improves the dosing accuracy of differential dosing feeders with Electronic Pressure Compensation (EPC) (**Fig. 8**). Pressure fluctuations in the feed hopper can impair the weighing accuracy in a closed dosing system. Compared to conventional, mechanical pressure compensation systems, the new system results in higher accuracy and improved reliability with simultaneous simpler installation. The modular system is based on pressure sensors and electronic components that can be integrated with KCM dosing control from Coperion K-Tron. Retrofitting options are available for existing differential dosing feeders.

Maag is a manufacturer of gear pumps, granulating systems, filtration systems, and powder mills. The new PearloFlex system was developed especially for the production of spherical granulate from compounds, masterbatches, blends, and recycled materials (**Fig. 9**). It is compatible with a broad range of thermoplastic materials and can reach production rates of up to 500 kg per hour. The new system distinguishes itself with high flexibility, the integration of all components on one



Fig. 10. Air or underwater granulation: the EWA 10 is flexible in application (© Econ)

frame, the high system availability, and efficiency with low waste. At the exhibition stand, the flexibility of rigging the modules for the melt pump and melt filtration with rotating and pivoting mounts was clearly demonstrated. The company also developed a method for the vacuole-free, underwater granulation of technical plastics. This Optimized Temperature Pelletizing (OTP) is based on Maag's underwater granulating technology. In the first water circuit with water heated above 100 °C, the plastic melt is cut into granulate under high pressure and subsequently cooled. The hot water is separated in the transfer unit and the granulate is passed to a cooling circuit (< 95 °C). After this second cooling process, the pressure is reduced and the process water is separated from the granulate in the centrifugal dryer. Granulate produced using OTP is suitable for direct further processing or packaging for transportation after the drying phase.

The underwater granulation systems from **Econ GmbH**, Weißkirchen, Austria, reach throughput rates of 1 to 8000 kg/h and are offered with a process water and drying system as standard equipment. The new EWA 10 water and air granulation system combines two applications in a single system (**Fig. 10**). It can be converted between air and underwater granulation in just a few steps. Initially the system is intended for processing WPC, PE, and PVC. Throughput rates up to 30 kg/h for underwater granulation and up to 10 kg/h for air granulation can be achieved.

Conclusion

Frequently changing materials demand solutions for fast cleaning and rapid changeover of the systems in order to enable economically efficient production, even in small batches. Mechanical engineering and plant construction firms are able to meet demands for great flexibility, energy-efficient processes, and outstanding ease of use with the further developments presented here. However, the K2016 trade fair also illustrates that recycling is already of great importance in the processing industry today, and that specialized processes permit the efficient production of recomponds with consistent material quality. ■

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