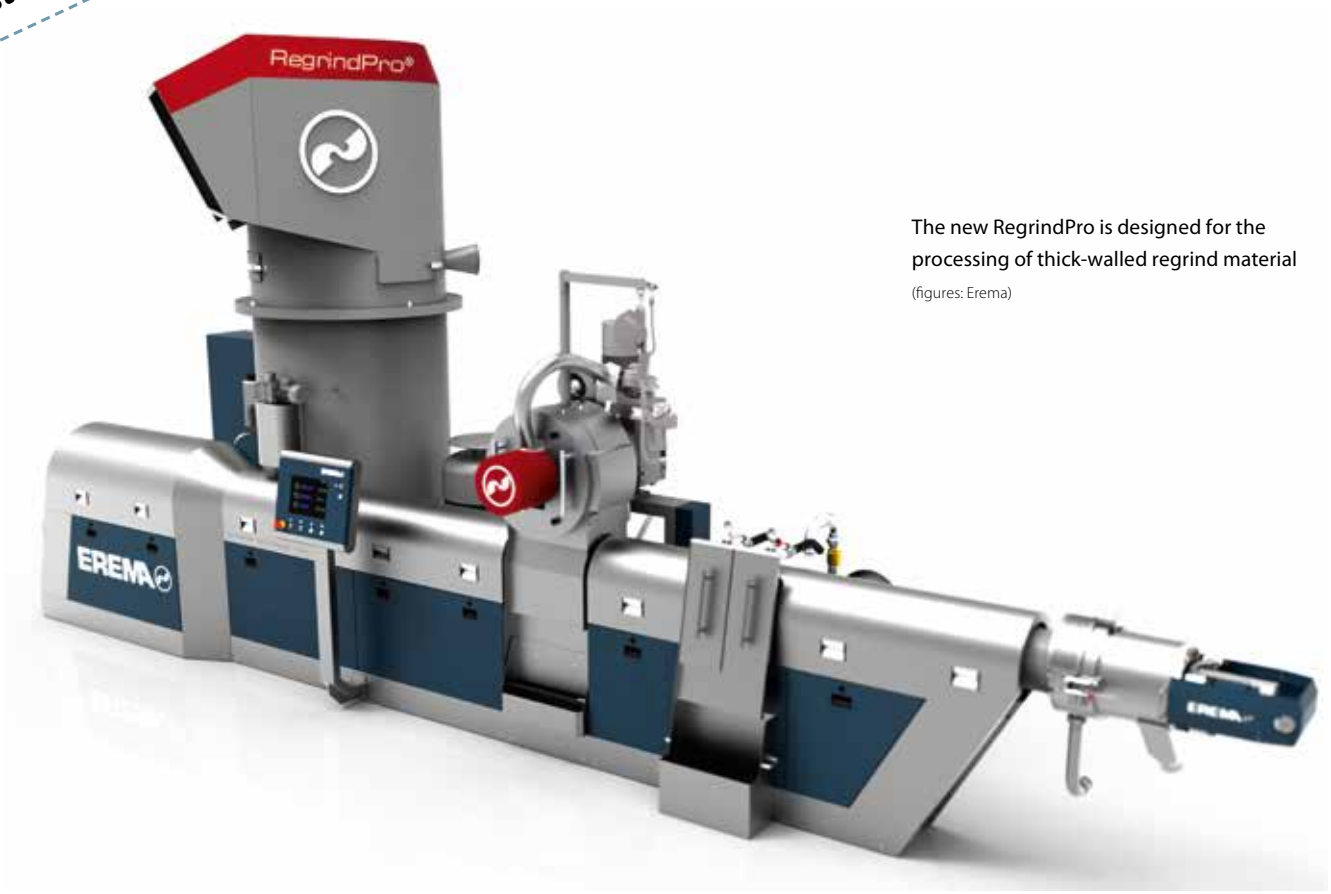

The new RegrindPro is designed for the processing of thick-walled regrind material
(figures: Erema)

Taking Full Advantage of Secondary Raw Materials

Plant System for the Recycling of Thick-Walled Plastic Regrind

To ensure that recycled pellets from regrind meet the functional requirements for the end products made from them, a specific recycling process is required. The new plant system Intarema RegrindPro is designed exactly for these requirements and uses gentle processing and efficient filtration to process thick-walled regrind to make application-optimized recycled pellets.

In order to secure the plastic loop streams also for future generations, the amount of recycled material in products has to be increased significantly. The importance of plastics as a secondary raw material is thus continuing to increase rapidly. To enable recyclates to be used 1:1 as a substitute for virgin material there are two crucial factors: on the one hand, sufficient raw recycling material has to be available and, on the other hand, it has to be possible to process this material economically to make recycled pellets with customized property profiles. Thick-walled regrind has enormous potential as input material for recycling. It is also available in sufficient quantities and, above all, is clean-sorted. Reprocessing the recycled pellets from regrind without any problems and ensuring the functional properties of the end products which are made from them, however, requires a specific recycling process – one which conventional systems on the market have so far not been able to accomplish with due thoroughness. Erema GmbH of Ansfelden, Austria, has developed the new plant system Intarema RegrindPro (**Title figure**) precisely for this purpose. The technology is geared exactly to all types of thick-walled regrind material and, thanks to the extremely gentle process and reliable filtration, can make high-grade recycled pellets from regrind.

Recycled pellets based on regrind material are an excellent alternative to

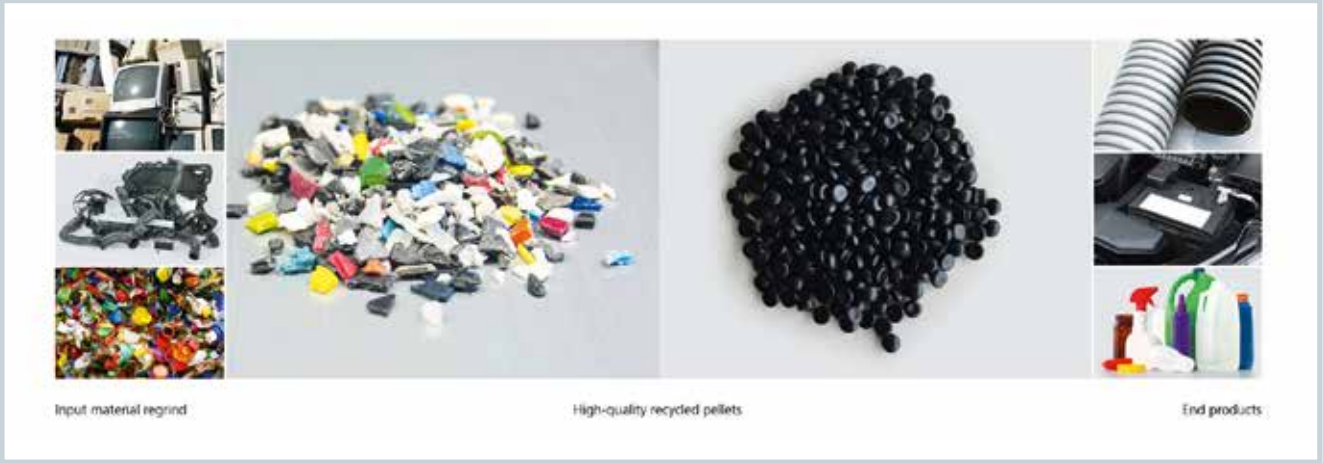

Fig. 1. The new Intarema RegrindPro technology: recycled pellets based on regrind material (thick-walled packaging, WEEE and automotive) represent an excellent alternative to virgin material for plastics processors

virgin material for plastics processors. Most of all because of the fact that regrind is easy to sort and separate and is thus available as clean-sorted input material for the recycling process. Raw material sources include thick-walled packaging such as HDPE blow-molded bottles from the hygiene and cosmetic sectors and also thermoformed and injection-molded articles made of polypropylene and polystyrene such as closure caps, cups and containers for food packaging. Plastics from waste electrical and electronic equipment (WEEE) and products from the automotive sector such as bumpers, battery packs, engine piping etc. also have great potential in terms of reutilization. The EU Directive 2012/19/EU on WEEE foresees 85 % reutilization as of 2019. This corresponds to approx. 12 million t of WEEE per year including approx. 2 million t of plastic (largely ABS, PS). Furthermore, the Directive ELV (2000/53/EC) has stipulated since January 2015 that the recycling quota for end-of-life vehicles shall be at least 85 % of the weight, and these currently consist of 12 to 15 % plastic.

An example from the USA shows the potential of polyolefin regrind quite clearly (**Table 1**): In the USA the post-consumer recycling rate for the various bottle types is currently only in the region of 30 %. The bottles are, however, easy to sort – both for the consumers and for machines – and compared to film, regrind has a higher bulk density of 200 to 600 kg/m^3 and is free-flowing. Both properties contribute to the washing and sorting processes working better and the material thus being available in a more clean-sorted form. The recycled pellets which are produced come very close to virgin material (**Fig. 1**), similar to PET bottle recycling.

The material streams are available in sufficient quantities for the use of recycled regrind as a substitute for virgin material and, compared to film, they are also available in a more clean-sorted form. Processors are, however, also interested in the rheological properties of these recyclates allowing trouble-free subsequent processing and the assurance of the functional characteristics of their end products. Besides the mechanical aspects, above all surface quality, dyeability and smell are decisive quality factors. This places particularly high requirements on the recycling process which commercially available systems have not always been able to meet so far.

Plastic bottle type	Plastic recycled	Resin sales	Recycling rate [%]
PET	1,798	5,764	31.2
HDPE natural	440.4	1,571	28
HDPE pigmented	605	1,733	34.9
PVC	0.4	76	0.5
LDPE	0.3	78	0.4
PP	62	195	31.8
Other	3.8		
Total bottels	2,906	9,417	30.9

Table 1. Post consumer plastic bottle recycling collection results in 2013 in the USA (million pound/year) (source: American Chemistry Council and Association of Postconsumer Plastic Recyclers)

The Challenge of Regrind Recycling

Due to its high bulk density (200 to 600 kg/m^3) and the fact that it is free-flowing, regrind is, as a rule, easy to dose in an extrusion system and requires no additional compacting and size reduction. The challenge, however, lies particularly in melting the thick-walled regrind particles in a gentle way, as they require more time to heat through and melt compared to thin films. With conventional treatment systems the regrind enters the single- or twin-screw extruder cold via a dosing system. A longer processing unit is thus required to melt the cold regrind particles. This increases the dwell time in the extruder and the melting process takes place under high shear stress. The polymer structure is destroyed in parts because of this, which has a negative impact on the mechanical properties of the end products. Additionally, the impurities appearing in the regrind material are reduced in size through the impacting shear forces and filtration efficiency is decreased drastically as a result. Compared to the single-screw systems, this effect is

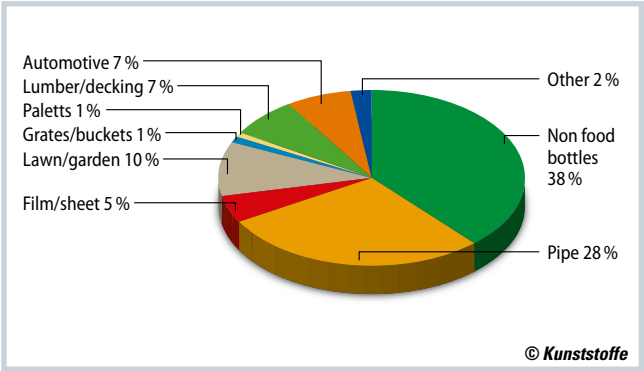

Fig. 2. Post consumer HDPE bottle end use in the USA (source: American Chemistry Council and Association of Postconsumer Plastic Recyclers)

increased with the co-rotating twin-screw extruder through up to three times poorer filtration fineness due to the low pressure build-up. The cold-fed single-screw systems lack the flexibility to handle the various regrind types such as HDPE and PP with the same quality requirements economically with one system. Additionally, moisture contents of up to 8 % mean that energy-consuming pre-drying is necessary on both systems.

The specific treatment process in the recycling of thick-walled material thus has to be designed to be able to work with different types of regrind (PP, PE, PS, ABS etc.), with a wide variety of bulk densities and degrees of moisture, plus strongly varying contaminants such as impurities like rubber, silicone and soft contaminants like wood and paper, plus foreign polymers like PET and PA. These contaminants have to be removed effectively because more and more material is being saved in wall thicknesses also in the production of e. g. bottles and pipes, and the end products are thus more sensitive to flaws through contaminants. The statistics from the USA in **Figure 2** show the end products which are made from HDPE bottle regrind. The non-food bottle segment accounts for the largest part with 38 %, followed by 28 % in the piping sector, 7 % in automotive applications and 5 % in films. In these end applications it is not only the mechanical properties, smell and dyeability but also and in particular the surface quality which is an essential criterion. This, however, can be achieved only if the recycled pellets used for this purpose have been filtered extremely efficiently in the upstream recycling process. The value added increases additionally, as the recycled pellet amount in the finished product can also be raised up to 100 % as a result.

RegrindPro Technology

What makes RegrindPro so special is that unlike other systems the regrind material is heated through already prior to extrusion which increases both flexibility in material selection and filtration efficiency as a result. This is handled by the preconditioning unit which is optimized for the regrind and in which the material is processed in an extremely gentle way by means of a rotor disc with a special tool configuration (**Fig. 3**). Thanks to the slow turning of this rotor disc the thick-walled, moist particles are efficiently dried and degassed with a high filling level and thus longer dwell time. High dwell times in the preconditioning unit are important so the regrind is not only dried but also so it has enough time to be warmed thoroughly and homogeneously. An additional benefit of the longer dwell time is that powder additives such as $CaCO_3$ can be admixed in amounts up to 20 % and, above all, be distributed well.

After the preconditioning unit the dried, degassed and thoroughly warmed material is dosed into the directly connected extruder and melted in the short universal screw with minimum shear strain. Erema's Counter Current technology offers a further benefit here which is decisive especially in terms of free-flowing materials such as regrind. This is because the screw is filled virtually pressure-free and takes only as much of the preconditioned material as required. Furthermore, the melting process with minimum shear stress increases the cleaning efficiency of the melt filter as the size of organic or mineral solid matter is not reduced. This means that even contaminants such as wood and paper can be optimally filtered because, thanks to the gentle process, the fibers do not come apart and they remain large enough to be discharged at the filter.

Through the combination of the optimized preconditioning unit with a new, particularly gentle universal screw, the RegrindPro additionally offers you a high degree of flexibility in the choice of material. This allows you, for example, to process regrind despite varying melting points and energy contents, as in the case of HDPE and PP, using the same system with full output and in a gentle way.

Once the material has been melted the melt passes through the recently enhanced Erema Laserfilter. Thanks to the redesign of the scraper geometry and discharge system, contaminants are removed even more quickly which reduces fine particles and results in even better filtration performance. This makes the laser filter particularly suitable for the post-consumer sector. In practice the optimized scraper geometry removes rubber-like, non-melting contaminants such as silicones and linked polymers quickly and continuously from the screen for even more effective filtering. The principle of the TVEplus technology also comes into effect with the filtering of the melt prior to homogenizing and degassing. This removes any impurities from the system before they can outgas and prevents the formation of undesired smells.

This RegrindPro system can also be combined with the recycling and com-

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Fig. 3. With the new RegrindPro the combination of the preconditioning unit with a particularly gentle universal screw makes for high flexibility in the choice of materials and a gentle melting process with minimum shear stress

pounding technology Corema, enabling the manufacturer to produce customized compounds based on regrind directly in a single processing step.

Comparison Test Confirms Efficiency Lead

Figure 4 compares the filtration efficiency of conventional single- and twin-screw systems with the new RegrindPro system. Natural PP regrind from the same batch was used as starting material on all systems and the respective recycled pellets were then processed to make sample films on an OCS film plant in the analysis laboratory at Erema. The defects in the films are detected automatically in the process and then categorized according to size and the area of nonconformity is shown in cumulative form. With this sensitive testing method any impurities remaining in the recycled pellets are made visible and can thus be evaluated in terms of both quality and quantity. A large number of nonconformities caused by impurities in the test film also has a negative impact on the subsequent processing of these recycled pellets and leads to mechanical and optical defects in the end products. The comparison documents the respective error analysis for the test films produced from the different recycled pellets and shows the cumulative error area share as a function of the error size. In contrast to the other technologies the curve for RegrindPro already begins to flatten at nonconforming sizes of 400 to 450 µm and stays at a constant nonconforming area share of approx. 300 ppm. With the cold-input single- and twin-screw systems tested, however, the curve rises and with it the nonconforming area of the film increases throughout the entire area measured significantly to over 1,000 ppm. The comparison shows that the recycled pellets produced with RegrindPro are filtered much better and contain significantly fewer and, above all, fewer large impurities. This difference in quality is already visible to the naked eye when you see the film sample. And it is precisely this difference in quality which has an effect on surface quality in subsequent processing of the recycled pellets to make e. g. piping.

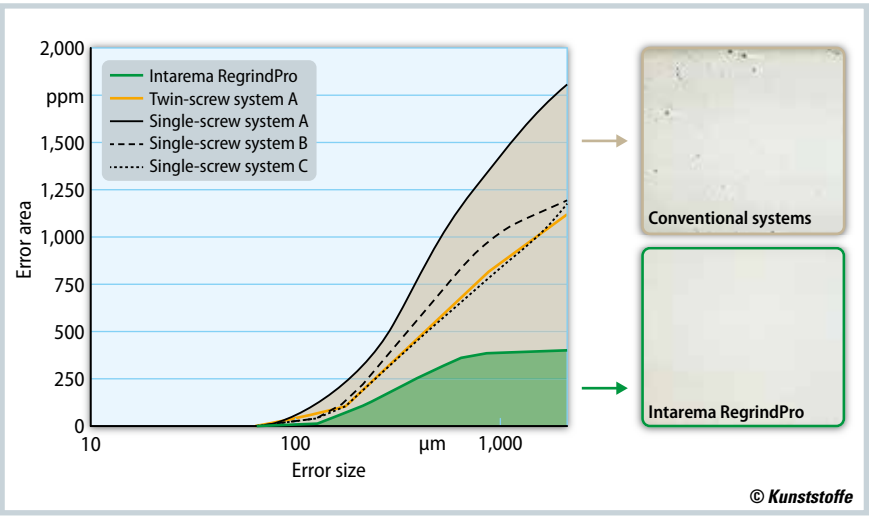

Fig. 4. Comparison of regrind recycling systems. Recycled pellet quality test: film test with nonconformity analysis on an OCS ME25/25D-V3 measuring extruder, test material: recycled pellets from PP regrind produced on different regrind recycling systems (filtration: 140 to 180 µm)

Optimum Pipe Surface despite Silicone Impurities

The efficiency of RegrindPro has been confirmed in collaboration with a pipe producer. This customer has its own recycling department where it uses post-consumer bale material consisting of HDPE shampoo bottles to make washed regrind which it then processes to produce recycled pellets for use in the pipe production process. The silicones and linked polymers of the seals of the screw tops and spray nozzles of the bottles are a key issue in the processing of this regrind. These cannot be removed completely when washing, do not melt and thus have to be filtered out during extrusion otherwise they cause holes in the pipe surface when the pellets are reprocessed.

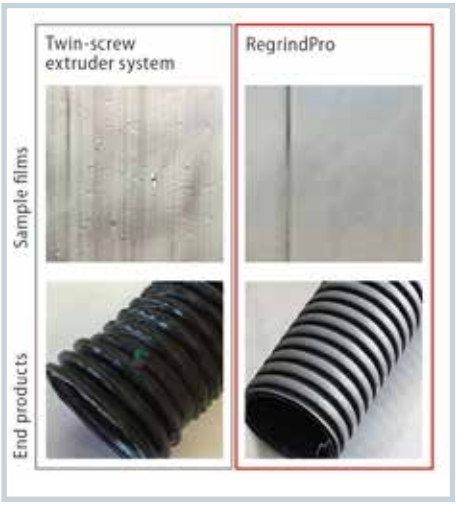

Fig. 5. Comparison of recycled pellet material quality, as produced with the customer's previously used twin-screw extrusion system (left) and with RegrindPro (right). The respective nonconforming share in the test films produced also reflects the surface quality of the pipes shown at the bottom

Silicones, for example, are difficult to filtrate as they behave like rubber, become long and thin at the filter and pass through the filter holes. This is the reason why it is necessary to keep these impurities as large as possible up to filtration. This is ensured by RegrindPro through the gentle melting of the regrind which has already been preheated. Thanks to the minimum of shear forces the silicone particles stay large enough inside the extruder and can thus be removed even more efficiently by the laser filter. Any particles which may be left in the melt are homogenized intensively downstream of the laser filter in accordance with the TVEplus principle. This is because the smaller the remaining silicone is and the finer it is distributed, the lower the impact on the reprocessing of the recycled pellets.

In order to be able to compare the material quality of the recycled pellets which are produced with the customer's existing twin-screw extrusion system and with RegrindPro, Erema carried out a control test. Both recycled pellet batches were processed on the OCS film unit into 60 µm test films in the analysis laboratory which were then analyzed with regard to their respective particle size. **Figure 5** shows that the test films made from the recycled pellets produced with RegrindPro have significantly fewer and above all considerably smaller residual impurities. Analogous to the film control test the surface qualities of the pipes produced using the respective recycled pellets were also compared. Here too it can be seen that the surface quality of the pipes made from recycled pellets produced with RegrindPro is considerably better.

The second key issue is the flexibility in the choice of material. Previously the customer had been able to process only very thick-walled regrind with up to max. 1% moisture with the twin-screw extruder used. As, therefore, the twin-screw extrusion system used in the past was only able to handle input material with a high bulk density from 200 kg/m^3 the light fractions present in the bales – such as the thin-walled plastic residues from the bottle labels – had to be separated in the washing plant. With the RegrindPro system you can now process materials with a bulk density range from 30 to 800 kg/m^3. Thanks to this flexibility in the choice of material the customer can also process these thin film scraps – i.e. the entire bale material – in-house with the new RegrindPro.

Summary

To take full advantage of the potential of recycled regrind as an alternative to virgin material a specific treatment process is required. With the new Intarema RegrindPro system Erema has succeeded in developing a plant system which is designed exactly for these thick-walled materials. In short, RegrindPro offers a number of benefits which enable you to process regrind to make application-optimized recycled pellets and make end products with a recycling rate of up to 100 %. The thick-walled regrind particles are heated through homogeneously in the preconditioning unit and prepared for extrusion. The melting procedure for the thoroughly warmed regrind particles in the extruder is gentle and takes place with minimum shearing impact. This prevents any size reduction of the contaminants prior to filtration and enhances filtration efficiency. The thorough warming of the regrind also enables the processing of polymers with different melting points and energy contents – without screw change but with high throughput at the same time. The preconditioning unit enables the processing of materials with a broad bulk density spectrum of 30 to 800 g/l and an input moisture of up to 8 %. Furthermore it is possible to admix additives in pellet form and up to 20 % in powder form. The RegrindPro package can be used on all Intarema systems (T, TE, TVEplus) and Corema. ■