The RingExtruder process unit comprises 12 co-rotating, tightly intermeshing screws, arranged in a ring. These screws are enclosed by the inner core and the outer barrel. The melt stream is divided into 12 individual mass flows, ensuring high mixing efficiency.

A favorable volume/surface ratio leads to technical advantages such as precise temperature management or intensive surface renewal and therefore degassing efficiency.

For 3D Animated Movie for workings of RE3 Century Ring Extruders go to: http://monte.net/capabilities/animation_motion_graphics/3D_technical_animation_CPM

RingExtruder for PET-Recycling

The advantages of the multi-shaft concept for process technology fully apparent in the case of PET recycling. The large feed cross-section ensures excellent feeding of flakes with a low piled weight or non-uniform shape. A narrow dwell time spectrum combined with a high self-cleaning rate ensures low product stress and optimum colour values of the residual granulate.

Extremely high degassing efficiency enables maximum throughput rates even in the case of heavily contaminated PET flakes or flakes that have not been pre-dried.

Since 1999, the RingExtruder RE® has been successfully used for bottle-to-bottle recycling of PET. Throughput ranges between 2800 and 34,000 tonnes per year.

Currently, more than 200,000 tonnes per year of high-grade PET regranulate are produced worldwide with RingExtruders.

Advantages

With the RingExtruder PET recycling system, maximum product qualities are achieved at minimum manufacturing costs. This is in accordance with the basic idea of recycling and helps to counteract the poor competitive situation compared with virgin PET.
Advantages at a glance

- Globally recognized product quality with top IV and very good colour values.
- Excellent decontamination of post-consumer material for safe use in food packaging.
- Very low energy consumption for low operating costs and low CO2 emissions.
- Throughput of up to 4500 kg/h or up to 36,000 kt/year.

Compact design of the overall system for maximum output efficiency and minimum space required.

The flexible construction enables quick adjustment to new task and requirement profiles. High plant availability and long maintenance intervals mean extremely short amortization times.

**PET-Recycling**

The manufacturing of plastics often also means disposing of plastics. This applies in particular to plastics used for packaging.

The prerequisite for plastic recycling is the creation of a complete cycle, comprising the raw material manufacturers, bottle manufacturers, drinks bottling plants and recycling companies.

Polyethylene terephthalate (PET) is a lightweight, virtually unbreakable plastic, which can be used for a wide range of applications. Plastic bottles made of PET have many advantages over other raw materials and are easy to recycle.

**Why PET-Recycling?**

PET recycling offers economic and ecological benefits. PET can be recycled up to 100 % and can be put back into circulation as a high-grade raw material.

PET recycling also helps to reduce waste, lower CO² emissions, reduce energy and water consumption during manufacturing, ensure a consistently high product quality and create a value added chain from the waste right through to the sorted raw material.

The importance of plastic recycling is underlined by EU Directive 2004/12/EC, which requires every EU member country to introduce a collection system for post-consumer plastic waste.

This directive represents an important step within the EU in the environmentally sound handling of the material – plastic packaging – and helps to promote further progress.

In the drinks industry in particular, the basic idea of recycling through the introduction of bottle return systems has exploded in recent years and is now a driving industry sector.

**PET recycling considerations**

What is important when it comes to PET recycling is product quality and the recycling costs per tonne of PET.

In terms of product quality, particular attention must be paid to ensure that the recyclate produced is safe for use in the food industry. This means removing any contamination from the post-consumer material and manufacturing a product as a new article.

The so-called "decontamination" of the recyclate is carried out mechanically by means of filtration and
physically through degassing. Whereas pure filtration is an easy problem to solve, when it comes to the decontamination of volatile and non-volatile components, the degassing capability of the extrusion system and/or the downstream or upstream SSP must be taken into consideration.

The necessary decontamination capability is demonstrated via FDA Approval or via testing specific to drinks producers.

Manufacturing costs take several factors into account, for example line availability, maintenance costs, cleaning work and operating costs. Within the past few years, strong competition has arisen between R-PET (recycled PET from drinks bottles) and virgin PET (new material). High demand has resulted in high market prices for the most important raw material of post-consumer bottles. Due to the rising costs of PET flakes compared with virgin PET prices, manufacturing costs are key to the economic efficiency of PET recycling. Our objective is to create a highly efficient and economical system, combining individual technologies to form a holistic concept.

**Plastics Compounding Applications**

Normally, compounding plastics requires a balance between the energy needed to melt and mix the formulation without creating too much shear. It requires temperature history to excessively degrade materials and adversely affect product properties. Compounding TPO (thermoplastic olefin) elastomer blends is particularly challenging when the best balance of a modulus property and a strength property is needed.

The RingExtruder's superior mixing and material temperature control proved significant. Properties achieved with TPO samples from a RingExtruder certainly exceeded those properties commonly associated with a batch melt mixer or a continuous twin-screw extruder.

Two typical non-filled, TPO formulations were compounded with a batch melt mixer and a RingExtruder. The first contained 13 wt% elastomer and the second 25 wt%. The flex modulus, elongation at break, tear strength, and yield stress of each of the 4 samples was measured and compared. In every case, results when using the RingExtruder were superior to those when using the batch melt mixer. Using the RingExtruder, all of the properties except elongation at break were better at 13 wt% elastomer than at 25 wt% elastomer. Using the batch melt mixer, only the flex modulus was better at 25 wt% than at 13 wt% elastomer.

**Plastics Recycling**

Polymer degradation and decreased product properties are an issue when plastics are recycled using conventional extruders. To demonstrate reduced degradation within a RingExtruder, the effects of multiple passes through a 30 mm RingExtruder and a 58 mm diameter twin-screw extruder were compared. Although the RingExtruder had a greater volume per diameter length and is capable of greater throughputs, it was postulated that degradation within the RingExtruder would be less due to smaller channel sizes and material temperature increase.

A virgin polypropylene with a melt index of 12.8 was fed to both extruders, pelletized, and allowed to cool. Starting with cooled pellets in each case, this process was repeated 4 times with each extruder. The melt index after each pass through the RingExtruder and the twin screw extruder is plotted below. The final melt index of the material through the twin screw extruder is more than twice that of the material through the patented RingExtruder!
Ballistics

Armor Composition

The next historic innovation in armor is underway. Current state-of-the-art body armor is formed from a ceramic layer adhered to a polymer composite. The outer ceramic layer fragments an incoming round, distributing its energy over a wide area. The composite layer is extremely tough and captures the fragmented projectile through controlled deformation and effective energy absorption.

Producing armor plates to reliably stop a projectile requires an optimal balance of weight, toughness, and extremely consistent material properties. This can only be achieved with extremely well controlled materials processing. Current manufacturing methods limit quality, consistency and cost effectiveness of mass production.

RingExtruder Materials Processing

Century, Incorporated is fostering the next innovation in materials processing for composite armor by developing advanced materials processing technologies that enable improvements to both the ceramic and polymer layers. The core advancement lies in the advanced mixing technologies from the innovative 12-screw RingExtruder.

The RingExtruder is a revolutionary development in compounding technologies, consisting of a fixed ring of 12 co-rotating extruder shafts. Because pelletized raw materials are fed into the feed hopper at a precise ratio, the RingExtruder provides the mixing qualities of a batch system without the inconsistencies inherent to a discontinuous operation. The RingExtruder is a continuous mixer capable of producing composite material at 150 lbs per hour—perfectly mixed, perfectly metered, and absolutely consistent.

Armor Improvement with the RingExtruder

To strengthen the composite layer of armor, the RingExtruder’s advanced mixing brings together fibers, ceramic particles, and binder(s). Through stretching (elongational mixing), rather than shear, the RingExtruder brings these materials together to form a composite that is tougher, lighter, and less costly than current technologies.

This scanning electronic microscope image demonstrates the high quality product of the RingExtruder. Three key materials are visible: fibers, particles, and binder. By more effectively coating the fibers than current methods of production, the RingExtruder enables reduced percentage of costly binder material, making body armor production more economical.
**Metal Matrix Composites**

What is an MMC?

Like a golf club shaft, where the carbon fiber that stiffens the plastic resin - in a metal matrix composite - ceramic fiber / particles are positioned in the metal to enhance a specific property. Century’s efforts are focused on High Volume Manufacturing Process Technologies. The RingExtruder’s continuous process allows the following advantages:

- Efficient mixing technology for homogeneous fiber/particle distribution
- “Powder to Parts” continuous process
- Extrude Net Shape or Formable Mix
- Repeatable, Reliable Process
- Automated Process with Minimal Labor
- Superior Performance in Quality & Quantity

Benefits of MMCs over Monolithic Alloys:

- Increased Stiffness
- Less Thermal Expansion
- Improved Wear Resistance
- Improved High Temperature Performance
- Vibrations Damping

The Benefits Enable These Applications:

- Significant Weight Reduction with Aluminum MMC brake drums
- Lightweight Engine Block with similar CTE bearing blocks & cylinder liners
- Lightweight Reciprocating Masses – Aluminum / Mg MMC connecting rods; Drive shaft components
- Enhanced Vehicle Body Stiffness (cast nodes in body structure)
- Reduced Maintenance (no wear)

MMC Product Opportunities

- Lightweight Products for the Transportation Market
- Selective Reinforcement with Metal Matrix Composites
- Replace Conventional Materials in Braking Systems with Lightweight MMC Brake Rotors & Drums
- High Performance Structural Insulation
- High Temperature Lightweight Insulation for Portable Fuel Cell Applications
- Growing Market with Immediate Product Need

MMC Brake Rotor

- 50% weight reduction
- Longer life (unlimited life on rear brakes)
- Less heat build-up
Aluminum MMC Brake Drum
- 50% weight reduction from ductile iron
- Longer life
- Better vehicle NVH
- Significant weight reduction opportunity for multiple axle vehicles

Lightweight Steering Linkage
- 50% weight reduction from ductile iron
- Selective Reinforcement
- Squeeze Cast Aluminum

Ceramics Compounding

Adequate dispersion and orientation randomness of engineering fiber as well as consistent properties have been issues for the typical batch solution processing of ceramic formulations. It was thought that the gentle and efficient mixing of the RingExtruder would allow these formulations to be compounded continuously as solids and not as a weak solution requiring large amounts of water to be removed.

Solids formulations containing high concentrations of very hard ceramic particles and fiber as well as small amounts of organic and inorganic binders were fed directly to the RingExtruder. Some of the material was allowed to transfer directly to the inner ring to balance the inner and outer flows for more efficient gentle mixing. The larger surface area of the RingExtruder allowed good control of material temperature to avoid overheating and gelling the formulation. The result was a smooth and pliable extrudate ready for direct fabrication into ceramic products before drying and firing. The fiber bundles were dispersed to individual, randomly oriented fibers.