Direct to Highly Filled Bioplastics

Compounding PLA Formulations with a 50 % Wood Flour Content, without Premixing

Due to the differences in bulk densities and physical properties, the mixing of polylactide (PLA) together with wood flour as a filler, is not an easy task. With a newly developed process from Entex it was possible to compound an injection grade compound with a 50 % wood flour content. The process, a direct feeding of raw materials with no pre-mixing. Compounded and dried in a continuous manner using an Entex manufactured planetary roller extruder.

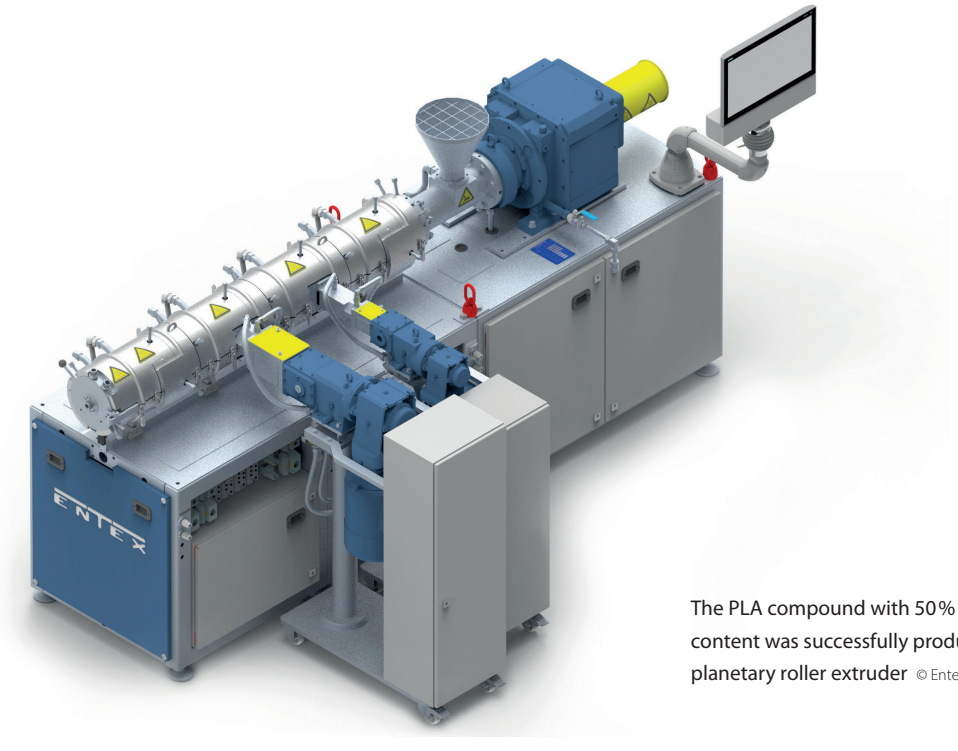
The growing demands on quality, economical manufacturing and bio-degradable properties of injection molded compounds was the base for this development. To include energy-efficiency, high quality and gentle-low-sheer processing methods with an industry focus on biodegradable, hydroscopic polymers. The continuous process was achieved with the use of a TP-WE70/1200-M3 planetary extruder (**Title figure**).

A major art of process engineering lies in the omission of processing steps. The modular system of the Entex planetary roller extruder enables continuous processing without premixing or pre-drying. Together with an exact control of mass temperature, residence times, fill-degrees and sheer energy inputs it was possible to gravimetrically feed raw materials, dry and melt the PLA, mix in additional wood flour and degas the mass before granulating. All done continuously in one step, that is "process engineering".

The planetary roller extruder originally developed for the PVC industry, due to its low sheer characteristics, has found its place in many industries around the world. These include industries where process control of temperature, homogenization, dispersion, residence times, fill-degrees and process flexibility are of highest priorities. Thanks to these extensive technological developments (**Fig. 1**), a wide range of processes in compounding, reactive processing and recycling technology have been realized. This has been achieved through a continuous striving to further development the Entex planetary roller extruder, by the greatly improved thermodynamics for process control. The planetary roller extruder therefore offers the highest performance range of all processing systems.

PLA and Wood Flour Are Difficult to Mix

The challenge of optimizing and developing an energy-efficient process for the production of an injection molding grade PLA compound was to combine the main raw materials PLA and wood flour in a continuous process, in a material-friendly way. The difficulty lays in the extreme differences in bulk densities, physical properties and viscosities. The material has to be melted, dried, mixed, dispersed, homogenized, degassed and continuously discharged with uniform »



The PLA compound with 50 % wood flour content was successfully produced on Entex's planetary roller extruder © Entex Rust & Mitschke

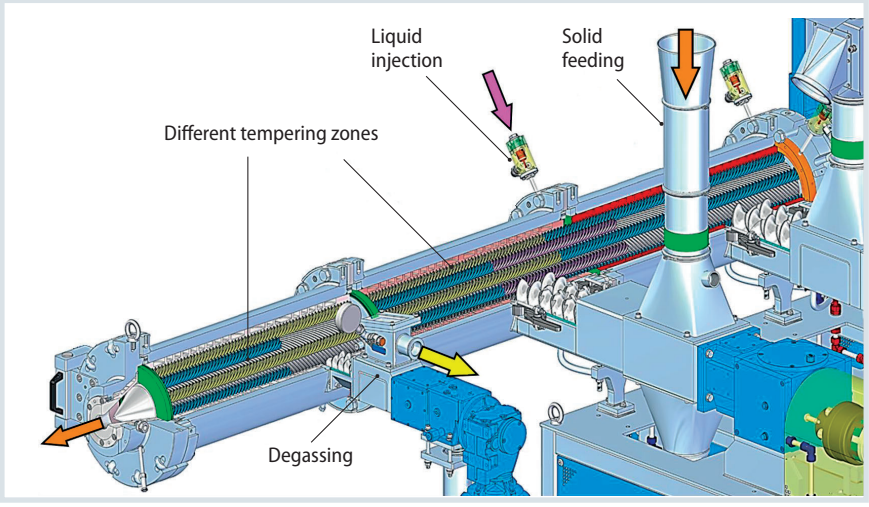


Fig. 1. Thanks to several technical enhancements, Entex planetary roller extruders can also be used for compounding, reaction and recycling processes. The thermodynamic process control was improved Source: Entex Rust & Mitschke; graphic: © Hanser

high quality and a defined viscosity under controlled temperature conditions.

PLA, also called polylactic acid, is a non-natural bioplastic. It is created from natural, renewable raw materials like sugar or corn in a multi-stage synthesis and polymerization process. PLA is a synthetic polymer and belongs to the polyesters. It has a high resistance to oils and greases but tends to become brittle under UV radiation. PLA is bio-degradable according to EN 13432, but this requires decomposition processes that are mostly only found in industrial composting plants. The wood flour in the injection molding compound serves as a biodegradable filler based on a renewable raw material.

A Continuous Mixing Process

In compounding, PLA as a solid and a premix of colorants and additives are fed gravimetrically into the feed section of the planetary roller extruder, from there the compound is conveyed into the first planetary roller section (**Fig. 2**). This is where the first mixing, drying and plasticizing of the material takes place. PLA is a hygroscopic material, which can be melted at 185 °C and dried continuously at the same time. The moisture from the drying process can escape freely as steam to the rear of the extruder, through the feed section. In production, this would be done under vacuum in order to remove volatiles to the highest degree possible.

Special Planetary Spindle Types Support the Process

In the next process step, epoxy oil is injected into the second processing section via a dispersion ring. At this point in the process, the extrudate has reached the desired temperature and plasticization, now able to mix in large quantities of wood flour. With the help of a side feeder, wood

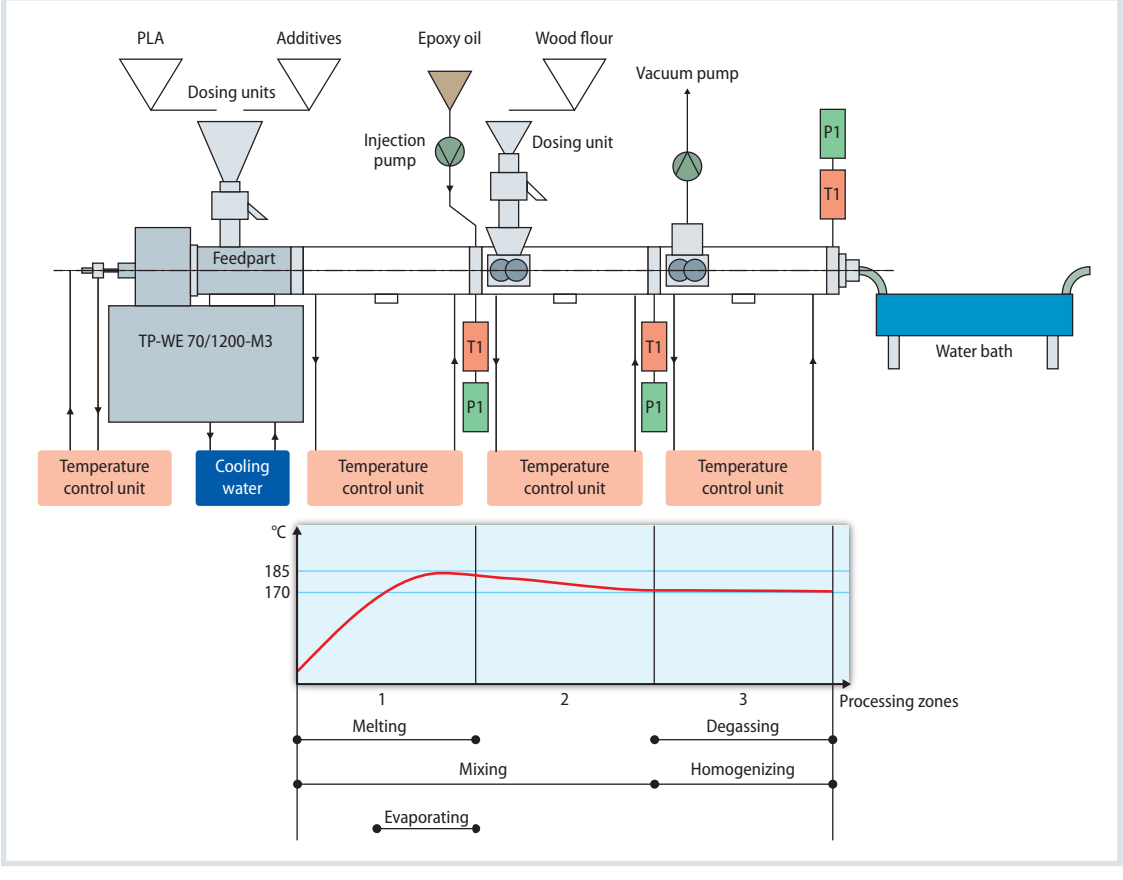


Fig. 2. Schematic system layout for processing the compound: the process is continuous and requires no premixing Source: Entex Rust & Mitschke; graphic: © Hanser

flour up to the desired proportion of 50% is conveyed gravimetrically into the second planetary section where a final mix is achieved at approximately 170 °C. With the use of special planetary spindles and different lengths a volume is crated for introducing a high amount of wood powder, with a low bulk density.

Homogenization of the Material

The extrudate also serves as a lubricant to reduce sheer energy. The liquid temperature-controlled cylinder and the intensive material milling/rolling out produce a homogeneous mass over a short distance. The process is completed in the third planetary section where degassing of the mass takes place, and the final homogenization of the material is achieved at a temperature of 170 °C. The compounded mass is discharged through a strand die at approx. 25 kg/h, cooled in a water bath and fed into a granulator for cutting.

The modular design of the planetary roller extruder from Entex with its mechanically controlled process zones and individual temperature control, enables targeted and efficient process phases. Various combinations of planetary spindles allow the creation of sufficient spatial volume so that even large quantities of solid material can be fed into the ongoing process. The intake of large quantities of fillers without premixing processes is possible only with the specifically configurated process zones of the planetary roller extruder.

Reduced Production Time and Energy Costs

Continuous processing with the planetary roller extruder can produce biodegradable bioplastics with a high wood flour content. The highest degree of homogeneity, in a consistent high-quality process. Together with the elimination of intermediate premixing steps and quality problems caused by batch fluctuations new levels of processing are achieved. In addition, continuous processing significantly reduces production and energy costs. The compound produced was successfully tested on an injection molding machine and processed into bio-degradable cutlery. ■

The Authors

Michael W. Batton is Overseas Sales Manager at Entex Rust & Mitschke GmbH; info@Entex.de

Holger Lange is Technical Editor at Entex Rust & Mitschke.

Service

Digital Version

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

German Version

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

Extrusion Blow Molding

All-Electric Extrusion Shuttle Blow Molding Machine

Uniloy Inc., a blow molding machine and mold technology company, launched the all-electric Uniloy UCS.E continuous extrusion shuttle machine for the production of bottles, containers, and technical parts**.**

In developing the new line, Uniloy used the foundations of machines from the Comec and B&W brands, which Uniloy acquired in 1985 and 1995, respectively. The UCS.E marks the 3rd iteration of their all-electric shuttle line and is the most advanced Uniloy Shuttle machine to date, as stated in a press release.

The new extrusion shuttle blow molding machine specializes in the production of bottles, containers, and technical parts as small as 50 ml and as large as 30 l and can process virtually all commercial resins enabling customers to produce everything from small cosmetic containers to large industrial packaging and co-extrusion capability of up to seven layers including bio-resins and post-consumer resins (PCR).

According to the company, the new machine uses 40 % less energy than a traditional hydraulic shuttle machine, it is significantly quieter, and it is cleaner. The removal of hydraulic fluids allows for the UCS.E to be used in a cleanroom or aseptic manufacturing environments. The new line is Industry 4.0 ready and will allow for data exchange with the customer's factory management systems and is prepared for future developments like preventative maintenance programs.

The Uniloy Software Engineering team used the new UCS.E to launch a completely redesigned HMI. The new controls reportedly are extremely user-friendly, intuitive, and modern, allowing for a speedier machine setup, numerous customizations. The machine allows easy access to all areas that require maintenance and serviceability.

The UCS.E line is suitable for the production of bottles, containers, and technical parts © Uniloy

To the product presentation:
www.kunststoffe-international.com/a/article-350604