High-Quality Visible Parts in a Single Step

System Partnership Flanks Integrated Clearmelt Process on Its Way to Series Production

Together with partner companies Engel has developed a highly integrated process for delivering pre-finished visible parts in a single working step. For Fakuma 2017, the development partners expanded the range of Clearmelt applications and presented the first manufacturing cell for exterior automotive parts that is almost ready to go into series production.

Aside from the high-quality appearance of the parts and the high efficiency of the integrated process, Clearmelt technology scores points in exterior areas for the scratch resistance of the surfaces. The D-pillars produced by Engel at Fakuma feature in a current SUV model (© Engel)

Producing high-quality yet rugged surfaces often still poses a challenge for plastics converters. The production processes frequently require several separate working steps along with the associated logistics. For Rosti Automotive, process integration is essential as a way of countering rising cost pressures and strengthening its own competitiveness.

Located in Leamington Spa, southeast of Birmingham, in the heart of the UK's automotive industry, this supplier develops and manufactures a wide range of interior and exterior parts and engine components for the world's major auto makers. As a development partner for Engel Austria, an injection molding machine maker and system supplier, Rosti Automotive is putting the latter's Clearmelt process through its paces, testing the possibilities and evaluating its suitability for series production.

The manufacturing cell at Engel's booth during Fakuma 2017 provided visitors with an insight into one of its current projects. A Duo 2460/500 injection molding machine with integrated linear robot (type: viper) produced D-pillars for a current SUV model fully automatically (**Fig. 1**). The robot removed the pre-finished high-gloss visible parts (**Title figure**, **Fig. 2**). Up until now, Rosti has been producing these parts conventionally in several working steps. It produces the blanks by injection molding and then paints them.

The integrated Clearmelt process, too, molds the thermoplastic base carrier first. However, the surface is then immediately finished with a layer of polyurethane in a second cavity of the same mold. The polyurethane provides both a high degree of gloss and excellent scratch re- »

Fig. 1. The D-pillars were produced during Fakuma 2017 on a Duo injection molding machine
(© Engel)

Fig. 2. The Clearmelt process is fully automated. A linear robot removes the pre-finished parts and places them on the conveyor belt
(© Engel)

sistance. The size of the production run and the conditions in the molding shop determine whether processing of the thermoplastic and the PU takes place sequentially (with the aid of a sliding table) or in parallel (rotary platen). The process presented at the trade fair did not require any external release agents, a fact which greatly simplifies the system engineering and ensures high process stability.

Pooled Competence

The highly integrated, fully automated process is the result of close collaboration by four partner companies. For, only by ensuring that all components of the manufacturing cell dovetail with each other from the outset is it possible to fully exploit efficiency and quality potentials. The four companies are innovation leaders in their respective sectors and have acquired a high level of technological know-how in the combined processing of thermoplastics and PU as a result of their collaboration over the last few years:

- Engel Austria GmbH, Schwertberg, Austria, provides expertise in multi-component injection molding processes and their automation,
- Schöfer GmbH, Schwertberg, Austria, provides toolmaking expertise for multi-component and polyurethane processes,
- Hennecke GmbH, St. Augustin, Germany, specializes in PU metering technology, and
- Votteler Lackfabrik GmbH & Co. KG, Korntal-Münchingen, Germany, is a producer of raw materials.

It was this range of expertise that persuaded Rosti to become involved in the collaboration. The development partners are a well-rehearsed team. In Engel, users have a central contact partner for the equipment, including molds in some cases, from configuration right through to after-sales service. In addition, Engel integrates the individual components of the manufacturing cell into the control system. The entire process can be controlled via the control panel of the injection molding machine – this increases not only the ease of operation but also process reliability. For controller generations CC200 and CC300 (**Fig. 3**), Engel can also retrofit the technology to existing injection molding machines.

Assistance Systems Boost Process Consistency

To further increase process consistency under real-life conditions, the Duo machine can be equipped with three assistance systems from Engel's "inject 4.0" range. During injection, "iQ weight control" adjusts the speed profile, switch-over point and holding pressure shot by shot as necessary, thus compensating for variability in raw material and ambient conditions. At the same time, "iQ clamp control" determines the optimum clamping force on the basis of mold breathing and then automatically adjusts it.

While these two software solutions are in use for the thermoplastics processing, the third mostly benefits PU processing. "iQ flow control" links the injection molding machine to the temperature control unit, so that the speed of the pump in the temperature control unit automatically adjusts to current requirements on the basis of the readings provided by the "e-flomo" water distribution system. The result is higher energy efficiency.

Aside from high process consistency and reproducible part quality, cycle time is a critical factor to the success of series production, and progress has been made here, too. Whereas curing of the polyurethane used to lengthen the entire process by up to 30 s, the time difference between it and production of the carrier part has been reduced to the current level of 10 s.

Color Changes in Less than 15 Minutes

A further milestone has been set by Hennecke with its new Colourline and Multi-Connect systems for the polyurethane process. Previously the Clearmelt process

was only able to process colorless polyurethane to this high level of efficiency. But Hennecke has now split isocyanate and color processing into two systems in order to be able to process different colors in rapid alternation. Color changes take only 15 minutes.

In the Colourline concept, the isocyanate unit is installed as a stationary unit on the injection molding machine. The Multi-Connect color modules are designed as mobile carriages. The Multi-Connect parking station, which provides up to seven color modules simultaneously, is used for homogenizing and pre-tempering the different color systems. The user undocks the module with the desired color from the parking station, moves it to the isocyanate unit and re-docks it there (**Fig. 4**). The isocyanate unit then takes control of the color module.

Each color module is equipped with its own mixing head, so that there is no chance of colors mingling during a color change. Due to this intelligent "plug and play" principle, color changes do not entail any purging or cleaning measures. Engel demonstrated at Fakuma how easy it is to change the color. It produced the D-pillars alternately in black and metallic-silver.

In this regard, the new PU systems developed by Votteler have proven to be extremely rugged, a fact which makes them predestined for decorative trim on the vehicle body. They have passed both the Kalahari and Florida tests for heat resistance and lightfastness, the carwash and stone chipping tests, and even remain verifiably undamaged by tree resin and bird droppings.

Fig. 3. The CC300 controller of the injection molding machine controls the entire process, including PU processing (© Engel)

This means that the polyurethane-coated visible parts are also superior to painted parts in terms of surface finish. Moreover, Clearmelt is the only process on the market to deliver different surface structures which are both pre-finished and scratch-resistant (**Fig. 5**). It faithfully reproduces embossed structures, such as leather grain, whereas painting often obliterates such fine structures.

Filling Backlit Displays with PU

However, the greatest advantage of the integrated process is its high cost-effectiveness. Any comparative costing of the total cost of ownership (TCO) versus injection molding plus separate painting process needs to take various factors into account. The decisive factors are part size and design. For example, the mold technology required for a complete automotive hood made by the Clearmelt process is still very complex and expensive. In addition, long flow paths require a thicker polyurethane layer than short ones. Consequently, material efficiency decreases with increase in component size. It is now already economically viable to apply polyurethane layers in thicknesses of 300 to 1000 µm.

The low viscosity of reactive polyurethane components poses special challenges for molds which feature complex geometries and undercuts. Movable elements in the mold such as core pullers and sliders need to be sealed individually. Schöfer is continually working on new solutions for this purpose – most recently it developed ejector systems for PU- »

coated components and a way of sealing openings in the carrier structure with polyurethane.

As a result, e.g. backlit displays, can be integrated into the part design. For various reasons, many of these developments require that the mold surface be coated. Schöfer is currently a partner company in the Cornet Caracoat project, collaborating with the universities of Leoben in Austria and Paderborn in Germany, among others, to specifically lower demolding forces.

Control Elements without Buttons or Switches

Combination with in-mold labeling (IML) also affords huge scope for functional integration. Control elements are produced by back-molding capacitive foils and flooding with polyurethane. This yields fully enclosed, rugged control surfaces that can be designed to be planar, or to feature raised and recessed areas. Since the functional elements incorporated with the IML foil are very close to the surface, their efficiency is particularly high.

The automotive cockpit of the future will no longer require switches and controls, and this will open up completely new horizons for designers. In addition, production of injection molded control elements through combination with PU finishing and IML is generally more cost-efficient than separate production and assembly of the switching elements. Clearmelt technology is therefore by no means the preserve of the premium auto segment, but will also help to bring greater comfort and a more attractive design to high-volume vehicles.

Fig. 4. The Multi-Connect color modules are designed as mobile carriages that dock on to the isocyanate unit and are controlled by it (© Hennecke)

Further application areas outside the automotive industry include control panels for washing machines and other white goods as well as medical devices. Conventional control springs are particularly risky in sterile areas, such as operating theaters, because bacteria become trapped where the switch and control knob are connected to the front panel and are difficult to remove. Composite technologies based on capacitive electronics improve safety here, especially since polyurethane surfaces are also highly resistant to chemical cleaning agents and disinfectants. ■

Fig. 5. The Clearmelt process is able to deliver different surface structures in a single working step – pre-finished and scratch-resistant (© Votteler)

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