Window for the Loading Door

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Eye-catcher in the white goods market: Novotronic washing machine with its large polycarbonate viewing window over the washing machine door (photo: Miele)

Design Highlight. Two plastic components, a ring on the inside and viewing glass on the outside, cover the loading door of a Miele washing machine in such a way that no assembly elements are visible – and customers almost find themselves developing a sense of appreciation for the esthetics of household appliances. The factory assembly unit, which combines all the individual parts into a single module, provides an object lesson in mastering the complexities of large-scale industrial production.

Window for the Loading Door

CLEMENS DORIAT

It is difficult to obtain an overall view of this plant – you have to walk through it to take it all in – past two injection molding machines, the towering buffer storage racks and the almost endless chain of assembly and welding stations, not forgetting the optical component testing unit, then under the high stand with the plastic silos right through to the pallet stacks with the fully assembled washing machine doors. In between, synchronized conveyor belts that feed the plant with glass and metal parts from outside, and safety guards, behind which articulated robots handle the various intermediate stages of the end product, force visitors to take a circuitous route. The sheer diversity of plastics technology is displayed here in a huge microcosm, as it were.

"This is a fully automated mechanical assembly process straight out of the textbook," says Andreas Fried, the technical director (photo: Doriat)

The Devil Lies in the Detail

"Really this is nothing special. What we see here is classic automation technology. Mechanical assembly, adhesive bonding, primer coating and welding – these are hardly new processes." Is this just Swabian modesty coming out in Gerhard Fried's words? Before you have time to reflect on this, the commercial director of Urbach-based Fried Kunststofftechnik GmbH adds: "The challenge lies in mastering the diversity of the various processes and efficiently combining the individual steps in this dimension." As is so often the case: The devil lies in the detail.

The route from plastic pellets to fully assembled washing machine door is a long one. And, just as, according to the well-known saying, a long journey starts with the first step, so this process begins with the first of four cycles in all: two stations for injection molding and assembling the inner door ring and plastic viewing window, one station that marries these two plastic parts with the glass door, and an ultrasonic welding station that joins everything firmly together. The entire plant is fully automated, apart from manual loading of the assembly parts and filling up the pellets.

The two injection molded plastic parts, the outer viewing window and the inner ring cover the glass door

The cycle time for the process, in which all the steps run synchronously is about one minute. At some points, the different components are held in intermediate storage for a short time in order to decouple individual plant sections from each other.

In the first section of the plant, an injection molding machine with 6,500 kN clamping force (manufacturer: Krauss Maffei) produces the solid inner ring of the door module from a PC+ABS blend. This component is picked up by an articulated robot (Kuka), which swivels it round to a station where it is treated with atmospheric plasma. This is necessary to ensure that the adhesive which is later applied all round the ring sticks better. The freshly molded ring is held in buffer storage, while a robot picks up another part for assembly. After an ink jet printer has printed the date, time and serial number on the white ring, the assembly system inserts the so-called ejector, a resilient rubber stopper, which opens the door when the knob is pressed. Then the hinge bushes are press fitted and the hinges and retaining catch are fastened onto the component with the automatically supplied screws and pins. "This is a fully automated mechanical assembly process straight out of the textbook," says Andreas Fried, the Technical Director. Andreas and Gerhard Fried are cousin and nephew respectively of the senior partner, Hans Fried, who founded the company in 1978.

Gerhard (left) and Andreas Fried in front of a mold for the cab roof of an agricultural machine. The mold was forged from a 100-tonne block (photo: Doriat)

The dimensions of the plant can best be appreciated from a bird's eye view

(photos without credit: Fried Kunststofftechnik)

Four Cameras Inspect the Injection Compression Molded Viewing Window

The second section of the plant starts at the two-component reversing plate machine (Krauss Maffei) with a clamping force of 9,000 kN. In one mold half, the viewing window for the washing machine door, which measures 480 mm in diameter, is injection compression molded from crystal-clear polycarbonate, while in the other mold half a circumferential edge is overmolded onto it from a gray-colored component (PC+ABS). "The part almost looks like a large transparent Frisbee," explains Gerhard Fried. The art lies mainly in combining injection compression molding

i Company Facts and Figures

Headquarters	Fried Kunststofftechnik GmbH Wasenstraße 90, D-73660 Urbach, Germany
Website	www.fried.de
Partners	Hans, Andreas and Gerhard Fried
Subsidiaries and affiliates	–
Production sites	Urbach, Germany
Total area occupied by company	30,000 m^2
Built area	12,000 m^2
Total investment	over 10 million EUR since 2004
Headcount	170
Annual sales	34.5 million EUR (2006)
Ebit/Ebitda	no data
Export rate	18 %
Products	technical plastic parts
Spectrum of component weights	100 g (housing for color spectrometer) to 35 kg (tractor cab roof)
Client industries	domestic appliances, medical technology, electrical sector, machinery manufacture, sanitary engineering, automotive construction

Main customers	include Agfa, Bauknecht, Bosch, Carl Zeiss Meditec, Claas, Fresenius, Gildemeister, John Deere, Jungheinrich, Liebherr Hausgeräte, Linde Material Handling, Maquet, Miele, Oerlikon, Rittal, Sartorius, Siemens, Villeroy & Boch, Wittenborg
Raw material consumption	approx. 7,000 t/a plastics (ABS, ASA, PA, PBT, PC, PMMA, PP-GF, PS)
Technologies used	injection molding, particularly thermoplastic foam injection molding, injection compression molding, hybrid and multicomponent technology, ultrasonic welding, two-component adhesive bonding
Machinery Plastics processing	14 injection molding machines from 2,000 to 32,000 kN (manufacturers: Battenfeld, Engel, Krauss Maffei)
Equipment Further processing	painting robots, painting stands, assembly devices, machining tools
Other equipment	mold construction, quality control
CA, BDE systems	Unigraphics, Pro-Engineer
Certification	DIN EN ISO 14001:2005, ISO/TS 16949:2002

– a process in which the mold is left partially open during the injection phase, creating a so-called compression gap – and multicomponent technology. This component, too, is treated with plasma on removal from the mold and before degating (film gate). In the testing station, four high-resolution industrial cameras inspect the transparent part for quality defects, such as the black spots or occlusions so feared in optical moldings. This is why Fried keeps careful watch for sources of contamination in material handling and ensures a clean production environment and gentle processing with short melt residence times in the hot runner. The material (Lexan LS2, GE Plastics) is supplied in "Hella quality", i. e. a quality specified for the production of automotive headlamps.

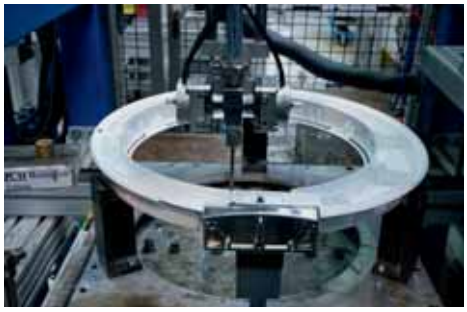
While the camera system sorts out the few defective parts, the good ones end up temporarily in an intermediate storage unit. From there, a conveyor belt transports them to a station (Zappe packaging machine) where they are covered with skin film, rather in the same way as PC screens. The film protects the scratch-sensitive surface of the polycarbonate window throughout the entire logistics chain and is only removed when the washing machine has been installed on the customer's premises. "To cover a component of this size with skin film is not an everyday process. We only found one manufacturer in Germany who was prepared to take on this challenge," explains Andreas Fried. During the production process, the film is wound off a 600 mm-wide roll, heated with an IR heater, vacuum sucked onto the component and then cut.

From Injection Molding to Washing Machine Door Assembly

Similar difficulties were experienced in finding a suitable camera system. "Although there are countless suppliers, most cameras are only designed to inspect small parts. To inspect a component of this size in a cycle of only 60 seconds with such a high resolution is something else," says Andreas Fried, and emphasizes that: "We are talking here of faults with an edge length of 1/500 mm." This is an obvious reason why the testing station (Intego) has four cameras in operation – two to scan the transparent part, one the gray layer and one the edge. These cameras feed data to the defect recognition software.

The three individual parts are welded at eleven points to form a complete assembly

In the third, central section of the plant, the glass door is joined to the two plastic components. In this operation, a robot takes a massive glass door from the manually loaded store and places it in an industrial washing machine. Since it is contaminated with dust and cardboard debris during transport from the glass manufacturer to the plastics processor and it is no longer accessible on the inside after joining to the plastic viewing window, the glass door must be washed before installation. Gerhard Fried laughs: "As an injection molder, you suddenly have to become a washing specialist." The next process step is rather like bonding automotive windshields. The glass, duly washed and dried, is treated with a primer, while at the same time a robot applies a bead of adhesive onto the inside of a completely assembled door ring. A two-component, PU-based adhesive is used. Now the robot just has to press the glass door onto the white plastic ring.



After removal from the injection mold, the inner ring is in turn treated with plasma, fitted with assembly elements, joined to the glass door and welded into a complete door assembly in a fully automated process

"Finally, the cover is fitted," concludes Andreas Fried, summarizing the operation in the last station. As soon as the robot has placed the viewing window on the door assembly, all the components are welded together for life on an ultrasonic welding machine (Herrmann Ultraschall) – at eleven different welding points. "Again, it is not easy to weld such a large component reliably when the ultrasonic horns lie directly on the visible surface. Naturally they must not be allowed to damage the surface," says Fried. "It is fortunate that in Germany we are particularly well supplied with specialists in plastics technology."

So the door parts have passed through all the production stages in a one-minute cycle. The whole automation process works on the pull principle – in this way, jams in the production line can be quickly freed. Another, fourth, robot finally lifts the welded door assemblies into special transport frames, which are standing ready in a pallet station. From there the frames, filled with three layers of door assemblies, are transferred to a buffer store that can bridge a five-day production bottleneck – a minimum safeguard, considering that there is only one of each injection mold. How the washing machine doors finally reach their destination is explained by Gerhard Fried in one sentence: "From the store, we deliver just-in-time to the

Miele production line at Gütersloh, Germany, where the doors are installed in the washing machines."

Design Masterstroke

The Fried plant has been producing washing machine doors in three-shift operation since February 2006. It is designed for a capacity of 300,000 doors per annum. To ensure that at the end of the process, the parts come off the production line in the high quality specified by Miele, virtually every stage of the process is inspected several times: injection compression molding parameters, primer application, completeness of assembly, the mix ratio and hardness of the two-component adhesive, welding path and welding energy, and, of course, the optical quality of the parts. "We have no alternative, because once the assembly is complete, we can no longer test it, except by destructive testing, and that would help nobody," sums up Andreas Fried with a touch of irony.

The component only achieves its full effect when it is installed in the washing machine. It is hard to believe that the capacity of Miele washing machines is not greater than that of other brands – quite apart from the fact that this front is a genuine eye-catcher. To describe this as a design masterstroke is certainly no exaggeration. "We had to draw on all our experience when it came to optimizing the product in an iterative development process so that we could incorporate the individual processes such as adhesive bonding, welding and primer treatment.," continues Gerhard Fried. And because the assembly is invisibly welded and the colored part of the polycarbonate viewing window conceals some inner functional parts, not a single assembly element can be seen. Give credit where credit is due: the Technical Parts Association (Fachverband Technische Teile) of the German Federation of the Plastics Processing Industry (GKV) has honored this work with its Technical Parts (TT) Award 2007.

The Urbach-based company's first involvement with white goods, a washing machine tub, happened more or less by chance. "It virtually fell into our lap," remembers Gerhard Fried. "But that was a turning point in our company's history and marked our entry into high-volume industrial production." At the beginning of 2000, production of washing machine tubs switched from metal sheet to plastics. When the original supplier encountered financial difficulties in 2003, Fried took on the order – and has kept it until this day. "We were successful because we did not slavishly imitate the production process as it then was but optimized it and contributed our know-how to the mold. The serial production process is now run by one operative whereas the conventional process required four people," continues Gerhard Fried.

The glass doors are loaded onto the production line manually. The glass door washing unit and buffer store can be seen in the background

Turning Point at Urbach

The company was entering uncharted waters at that time in terms of the order volume, which ran to several hundred thousand units. Until then, the majority of Fried's business had consisted of small to medium-sized production runs – 100 housings for surgical microscopes or 300 sunbeds here, 1,000 industrial coffee machines there. Many of these large, thick-walled parts are produced by thermoplastic foam injection molding to open up more sophisticated design possibilities and achieve higher dimensional stability. But the foam structure inside such moldings usually shows up as so-called marbling on the surface. So if these moldings are to be used for visible parts, they must be painted – a process that is costly and time-consuming and, in some cases, manual because of the small lots involved. High-volume parts, on the other hand, are usually injection molded in a standard process. "We supply 350 active customers from small to medium-sized businesses with between 100 and 7,000 units per annum but since we entered

A robot places the fully assembled washing machine doors carefully into transport frames

The polycarbonate viewing windows are thoroughly inspected for optical quality after the injection compression molding process (photo: Doriat)

Certificated according to
ISO/TS 16949:2002
and
DIN EN ISO 14001:2005

high-volume production, the proportion of solid injection moldings has risen to 50 percent," comments Gerhard Fried. Now, domestic appliances, with just three customers, represent one-third of our sales, while the remainder is distributed between many other industries (see Table). Although sales to the domestic appliance sector have doubled in the last five years, Fried does not think that this growth has reached its limits yet: "From the viewpoint of site potential, it is conceivable that we could even triple sales."

With the expansion into high-volume production, the requirement profile has also changed. While foam injection molding often involves handling large parts – for example, the shot weight of a dialysis unit is 25 kg, that of a tractor cab roof 30 kg – in solid injection molding, it is more a question of developing complex production lines with robots and integrating other processing technologies, such as processing glass-fiber-reinforced plastics and overmolding a gray cast iron hub (hybrid technology) in the manufacture of washing machine tubs or injection compression molding and multicomponent molding to produce washing machine viewing windows. After a brief pause for thought, Andreas Fried says: "Perhaps it is one of our strengths that we are able to transfer our know-how in injection molding and mold construction to new applications and combine technologies from many industries to produce technically sophisticated parts."

One Goal Remains

Only one thing has not so far been accomplished and that is to produce the washing machine door itself from plastic. At the moment glass still retains the advantage of superior scratch resistance. But this goal is perhaps closer to being attained than the abolition of all the buckles, rivets and buttons on laundry items that would scratch a polycarbonate door. And then the route through this plant will be a little bit longer still. ■

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