Reaching the Desired Weight in just a Few Steps

KraussMaffei Customer Takata Reduces Component Weight from 560 to 275 Grams

The FiberForm process developed by KraussMaffei combines the thermoforming of organic sheets and injection molding into one process. This process results in fiber-reinforced plastic components that are particularly lightweight yet feature a high level of strength. They are used primarily in vehicle manufacturing. KraussMaffei, together with the automotive supplier Takata, further developed the process during the manufacturing of an airbag housing. As a result, the component weight was reduced by half.

Components made of fiber-reinforced composites are very much in fashion. They provide high levels of strength with extremely low weight. These translate into advantages that are increasingly in demand in the field of vehicle manufacturing. The injection molding of thermoplastic plastics is particularly well suited with regard to the requests mentioned above because it enables high levels of design freedom, short cycle times as well as the implementation of continuous fiber structures and metallic inserts.

"FiberForm" is the thermoforming and over-molding of organic sheets, platen-shaped semifinished products with continuous fibers made of glass, carbon or aramide that are embedded into a thermoplastic matrix made out of polyamide (PA) or polypropylene (PP), for example. These semifinished products are first heated, reshaped in the injection mold and then back-injected with a fiber-reinforced plastic in this process. Parts with integrated organic sheets have significantly better mechanical properties compared to components that are purely composed of short fiber-reinforced injection molding material.

Even more lightweight with fiber-reinforced thermoplastics: the airbag housing manufactured by Takata using the FiberForm process (© KraussMaffei)

First Development Step: Transitioning to the Organic Sheet

In a joint project team based in Germany with Takata AG in Aschaffenburg and KraussMaffei Technologies GmbH in Munich, the team optimized an airbag housing that houses the gas generator in addition to the folded airbag in less than a year. In the event of accidents, the housing must be able to withstand the explosion and the pressure when the airbag inflates. For this reason, walls with a thickness of up to 3 mm are required in parts manufactured with compact injection molding. After just three development steps, it has now been reduced to 0.5 to 1 mm – and the weight is reduced by just under 51 %.

A compact reference part made of PA6 with 40 % short glass fiber reinforcement and a part weight of 560 g produced in series formed the starting point. In the first step, engineers used an organic sheet with a polyamide matrix and fiberglass reinforcement in 2014. Even at this early stage, the weight decreased to 330 g.

A linear robot with a standard configuration (type: LRX-150) handled the organic sheet throughout the entire process in the system concept that was presented at the NPE trade show in March, 2015. This included every step from the transfer from the magazine to insertion into a centering station and then into the infrared oven all the way to the positioning in the mold. During production of the airbag housings, they were removed from the mold automatically in a free fall, because combining the organic sheet insertion process and the component demolding would have required relatively complex and heavy grippers. Moreover, the cycle time would have been extended because one linear robot would have to complete both tasks.

Second Step: Converting to Long Fiber-Reinforced Polypropylene

The next development step came immediately after the NPE. The project team changed from polyamide to polypropylene for both the organic sheet and the injection molding material, selected a long glass fiber reinforcement instead of the previously used short fiberglass reinforcement and decreased the fiber content to 30 % as a result. The scale shows a weight of 275 g now – an additional savings of 55 g.

The project team additionally changed the complete layout of the manufacturing cell. From looking at the current airbag housing production process presented at the Fakuma in October 2015, it becomes clear that two LRX-350 linear robots are being used. At first glance, it would appear that these linear robots are doing something that might be misunderstood as being inefficient: they are passing the organic sheet to each other. During this process, in fact, multiple process steps can now run in parallel. This configuration makes it possible for component demolding to occur in a short cycle time. Additionally, it enables a weighing process to be integrated (for checking the shot weight consistency) and the organized deposit of the parts on a conveyor belt. The scale and the conveyor belt are integrated into the CX 300 injection molding machine's standard protective housing in a space-saving manner.

Robot 1 grips the centered organic sheet directly using a device and transfers it to robot 2 which feeds it into the infrared heating station. Afterward, robot 1 moves into a standby position for component demolding. Robot 1 removes the finished housing upon completion of the injection molding cycle, places it on the scale to check its weight, then places it on the conveyor belt and lifts the next semifinished product. During this time, robot 2 transfers the flexible organic sheet into the injection mold after the heating process where it is gripped by two pneumatically operated contact pins. At this point, the mold is located in an intermediate position to be able to attain short transfer times.

Handling the organic sheet heated to approximately 180 °C in the infrareds is a challenge. To ensure that the fibers are not damaged during the subsequent reshaping process, the core temperature must be higher than the softening temperature of the matrix material. This requires a shortest possible transfer time from the infrared heating station to positioning in the mold. Due to the fact that they are unheated, clamping grippers lead to partial heat dissipation and can therefore only be inserted in positions that do not need to be reshaped in the mold.

Parallel process steps: the demolding of the component and the insertion of the organic sheet are decoupled from one another using two linear robots on a common Z-axis (© KraussMaffei)

Compared to the NPE version, installation area required for the system decreased by 25 % thanks to the mechanical coupling of both linear robots to a common Z-axis and a longitudinal discharge for the finished parts. Six machines instead of five on the same area leads to a significant increase in the productivity of a hall. The entire production process has been completely integrated spatially and in terms of control technology. Everything takes place in the standard protective housing of the CX 300 as well as within the MC6 machine control system that now helps operate the scale for checking the shot weight as well as the infrared ovens.

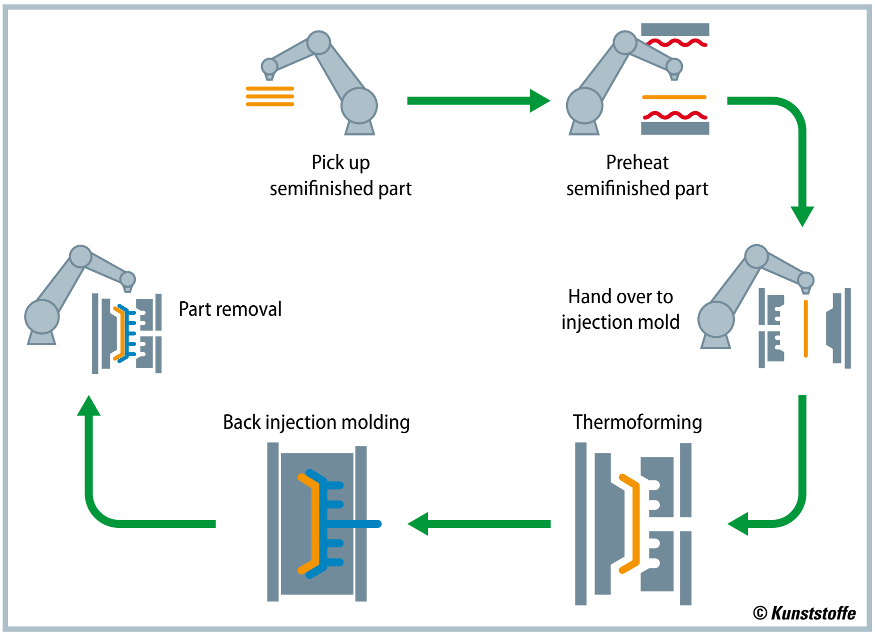
Sensitive Heating Process

The heating process is an essential step in this process sequence. The heat-up time via infrared is significantly shorter compared to circulation systems. However, the control of high-performance infrared heating units often remains critical because overheating the semifinished product surface and the resulting thermal degradation of the matrix leads to reject parts. Depending on the material thickness, the heating process lasts between 15 to 60 s. It is divided into the time the

Compact production cell: the logistics for feeding the organic sheet, the scale and the conveyor belt are integrated into the protective housing of the CX 300 injection molding machine (© KraussMaffei)

surface needs to reach the set temperature and what is called the heating time which represents the time required until the core of the material reaches this temperature.

Using the MC6 control system, the mold setters can monitor and check each individual heating process without having to leave the machine control panel. In addition, the most important parameters when heating and the injecting molding parameters are fully documented. As a result, the production process can be traced transparently, a characteristic that is particularly important in safety-related components. A distinction between good parts and reject parts can be made during production using tolerance bands that are defined for parameters such as the heat-up time. This ensures the re- »



The FiberForm process is divided into six elementary process steps (source: KraussMaffei)

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liable heating of organic sheet blanks, even with an infrared oven.

Third Step: Mixing Materials to Save Costs

All savings options for the airbag housing were exhausted in the design by redesigning the component and optimizing the system concept. However, this was not yet the case with the material. The last target requirement here is another reduction of costs. Almost regardless of the fiber content, PP long fiber granulates are approximately 30 % more expensive than non-reinforced PP granulates which means that mixing them yourself saves money. If you require a long fiber content of 30 % as is the case in the airbag housing, it is useful to use equal parts of highly concentrated PP granulate with 60 % long glass fibers and a PP polymer dilution.

This alone can cut material costs by 10 to 15 %. Customers additionally benefit from an increase in flexibility. Plastics processors can adapt the fiber content to individual requirements and develop their own recipes. Precise feeding and metering are prerequisites for preventing fluctuations in weight and consistency, which in turn prevent defective parts.

KraussMaffei applies its knowledge and experience from plastic extrusion and developed an integrated solution in conjunction with Motan-Colortronic that features special metering modules used for the first time in the discontinuous injection molding process. They meter the PP-LGF60 granulate and the polymer dilution in equal parts and with minimum bottom-feed into the plasticizing unit where they will be mixed and processed. In doing so, the separation effects that would occur if both materials would be blended dry is circumvented.

Metering high concentrates requires a special development concept due to the complex flow properties. A uniform mass flow for this granulate type can be guaranteed by using the Motan-Walkwand C-Flex M feeder. Fluctuations when setting the fiber content can be significantly reduced compared to conventional mixing concepts. According to current measurements, they are in an order of magnitude that corresponds to the batch fluctuations of the material manufacturer.

It is not surprising that Udo Gaumann, Manager Core Engineering Materials at Takata, evaluated the entire project that redesigned the component and used long-fiber granulates positively: "In conjunction with the great potential for lightweight construction that the FiberForm technology offers, the investment pays off very quickly and can therefore be considered a cost-effective lightweight construction solution."

Guaranteed Weight Consistency

The FiberForm process, with its easy-to-control but complex sequence in terms of content involving heating up the organic sheet and over-molding with fiber-reinforced plastic, also benefits vastly from another KraussMaffei development: Adaptive Process Control (APC). This machine function evens out fluctuations in the injection molding process that can occur during a batch change or in deviations in the heating process of the organic sheet by adapting and continuously modifying the changeover point from injection pressure to holding pressure phase at each individual shot by utilizing an online measurement of the melt viscosity. This results in parts that are extremely consistent in terms of weight. As the demand for weight-reduced, fiber-reinforced components are continuously growing, particularly in the automotive area, many more opportunities for the use of this solution package will surely arise. ■