While they are expected to find new types of lightweight structures, designers in automotive construction increasingly have to decide whether to produce plastics components—be it with or without fiber reinforcement—either by injection molding, which is quite fast, or else by using the reaction processing technique, which is slightly more time-consuming, but is suited for large-scale production as well. To pave the way to rational decision making, two executives of Krauss-Maffei, i.e. Frank Peters, Vice President Sales Injection Molding and Nicolas Beyl, head of the reaction processing segment, exchanged arguments as to this issue. Both managers used to work in the respective segment of their discussion partner, and only recently switched sides, which leaves no room for statements against better judgment. Peters is first to explain his argument, starting with a very painful subject.

**Peters:** Cycle times in injection molding are between a few seconds and about a minute. Reaction processing is still ages away from these times today.

**Beyl:** However, I do see a chance to produce RTM systems in two minutes or less, within a certain period of time to come. LFI (editor’s note: Long Fiber Injection) allows for cycle times of between three and four minutes, and even for very large parts, cycle times barely ever exceed seven to ten minutes. Such parts may be several square meters large, and cannot be produced economically by injection molding, in any case.

As an example, Beyl points to the 4.5 square meter roof module of an American harvester a US manufacturer currently produces in a near-net-shape process, with a surface in vehicle color. A part this size, with cut non-directional fibers cannot be manufactured by injection molding at comparatively low costs. Applying the LFI manufacturing technique, varnish is first sprayed on the surface of

**Exchange of Blows.** In a matter-of-fact discussion, two segment leaders of Krauss-Maffei exchanged views concerning the issue which system offers more benefits to the automotive sector— is it the injection molding of fiber-reinforced thermoplastics or the production of structural components by reaction technology? This is a subject of great controversy, which shows that the right answer is hard to find.

**Injection Molding or Reaction Technology for Vehicle Components?**

The compact production cell for over- and backmolding of organosheets requires only one linear robot, and generates structural components ready for assembly.

To produce this specimen of a side-collision protection, an organosheet was backmolded with a fiber-reinforced polyamide.
the cavity. Then the mixing head with its fiber cutting unit driven by a servo motor introduces the long fibers that had before been impregnated with PU into the open mold.

**Beyl:** Along with this technique, thanks to the excellent mechanical properties and the low weight entailed, we provide designers with a wide variety of options for structural optimization of the automotive body. If processing high fiber contents by RTM, rigidities and stiffnesses can reach a level even steel parts fail to achieve.

**Peters:** In fact, with our FiberForm process designed for over- and backmolding of organosheet inserts we do not reach quite the same level of rigidity and lightness. Our large-scale production units can however produce up to approx. 300,000 parts per year, and they barely differ from established injection molding machines. Moreover, regarding 3-dimensional geometry, injection molding technology offers many more options of component design, by enabling, e.g., apertures. And another major fact is: the components leave the machine virtually ready for assembly.

**Beyl:** With such processes that operate on the open mold, we can very easily vary the fiber-matrix ratio according to the lines of force that pass through the component. Highly stressed sections such as screw-on areas can be given a fiber content of up to 70 percent. It takes only some minutes to make a roof, except for a few subsequent processing steps such as trimming or milling of apertures.

**Peters:** Reaction engineers must take care, though, that reaction does not start before the form is filled.

**Beyl:** Of course, that’s right. However, by means of temperature control in the molds, and by adding reaction retarders, we are in control of reaction. Another benefit as compared to injection molding becomes obvious mainly when producing highly stressed lightweight structural parts, and that is the option of processing long fibers.

In fact: While injection molding machines can melt short fiber pellets up to 15 millimeters size only, their range of application is much more restricted. Except for: The IMC, which will be the subject of the following discussion.

**The components leave the machine virtually ready for assembly.**
Beyl: The LFI process allows us to introduce cut non-directional long glass fibers of 12 to 100 millimeters length. This leads to high stiffnesses in large parts. And, if combined to a six-axle robot that guides the fiber laying unit, we definitely achieve reproducible load profiles in the components, too. In addition, as compared with other techniques applied to manufacture fiber reinforced structural component, the process produces barely any fiber waste, which is the case when, for instance, fabric prepregs are processed. Most of all, this is significant when high-quality carbon fibers are applied.

Peters: We can provide for long fibers in the component, entirely without fiber waste, with our IMC injection molding compounder. Being a combination of compounding extruder and injection molding machine, the machine melts thermoplastics, blends them with glass fibers from continuous rovings, and injection molds them directly into components. What is more, surface qualities are excellent, and the parts obtained are ready for assembly, requiring virtually no posterior processing at all. Especially, if considering the high requirements posed by automotive manufacturers in terms of optics and haptics, it shows that surface qualities are outstanding.

Beyl: Mr. Peters, I’m sure you are well aware of the fact that we too can achieve high-end surfaces on PU parts produced by reaction processing, if we apply an in-mold painting process or decorative films, as we did with the radiator grille for a large commercial vehicle or with the roof module mentioned before. I do admit though, that the annual production volume should be between 10,000 and 120,000 items. Correspondingly, the respective manufacturing systems for small numbers are available at only about half the price of a full-range injection molding system.

Peters: Let me add that investment costs are comparable for the two systems, for output rates of approx. 50,000 items per year. Moreover, injection molding also offers some solutions for the production of foamed components. These parts can save material and component weight, even though they are mostly seen in connection with reaction technology. Applying the MuCell technique, i.e. thermoplastic foam injection molding, we are able to save approx. 20 percent of weight and material, while parts feature high stiffness and excellent dimensional accuracy at the same time.

Applying the MuCell technique, in most cases, hydrogen in a supercritical state is impinged on the thermoplastic melt. The pressure drop from injection makes the compressed gas bubbles burst, foam the melt and form a mainly microcellular foam structure in the component.

Peters: Gas injection also facilitates melt flow. Because it reduces injection pressure, holding pressure can be completely dispensed within most cases, and cycle times be reduced by up to 15 percent. This diminished injection pressure extends the range of application for injection molding, so that even larger components can thus be manufactured.

Beyl: The surface structures obtained from foam injection molding are mostly closed, but surface qualities nevertheless fail to reach the same level as those of compact injection molded components.
INTERVIEW

Peters: The latest progress in MuCell processing was presented at the Fakuma 2012 trade show. Applying injection molds with variable temperature control will in fact put us in a position in the future, to generate foamed injection molded parts with high-quality surfaces. An alternative option remains – just as is done in reaction processing – and that is applying decorative films to achieve excellent surface qualities.

Suddenly, the two men show their experience as bridge builders in technology. Be the approaches of injection molding and reaction technology for the same or similar components very contrarian: the required property profiles of complex structures can often be achieved only if the two processes are combined.

Peters: At the site of automotive supplier Peguform, injection molding technology operates hand in hand with reaction technology, for instance for the instrument panel of the Audi A4. First an instrument panel support, a so-called “I-Tafel-Träger“, is injection molded from short-fiber reinforced polypropylene. This part determines the mechanical properties and defines the points of fastening to mounted parts.

Beyl: While, at the same time, a separate plant makes a slush film due to form the surface of the final component. The two blanks are then transferred to the central foaming plant and inserted into a foaming mold – with the support into the one half, and the slush film placed into the opposite half of the mold. Before inserting the blanks, a flame is applied to the support to improve adhesion. At the following station, a mixing head fixed to a robot arm introduces the PU mixture, and the mold is closed. As the PU cures, it foams, thus filling the hollow space between slush film and carrier with elastic foam.

Combining these two techniques thus generates a component with high-class surface, soft-touch features and high stability. At the end of the process chain, just before the panel support is supplied to the OEM, the part is submitted to final processing (i.e. deflashing, trimming) and mounting of several components.

Peters: For such production processes, technical support is however indispensable, starting from design, via the production process itself, up to production release of the parts – in order to answer possible questions, concerning e.g. undercuts or projecting edges, and harmonize these issues at an early state.

Know-how on both processes is crucial here! In view of this development, it is more and more difficult today to see injection molding and reaction processing as two separate technologies. We are talking about integration of technologies, which means successful coexistence for both partners. With so many options available, though, it may sometimes be difficult for the user to find his way.

Beyl: The more specialized a company’s range of machinery is on the one or other technique, the more difficult it is to make an objective decision in favor of an adequate system. Users should also bear in mind that connection of the processes by automation, and integration of the follow-up steps such as trimming, assembly etc., are aspects not be underestimated.

Peters: Precisely this process of finding a system is important though, wherever a technical and economical optimum is to be found. Starting from this, comprising the two processes in one...
single plant was only a stone’s throw away: techniques such as SkinForm and ColorForm are based on this idea. With these processes, a support is first produced by injection molding. A move by the mold then transfers the blank to another station, where a PU material system is applied in order to generate either a soft-touch or a brilliant surface.

Beyl: Not only can integrated processes yield components with new property profiles. They can also help reduce the cost of production – a major argument in favor of the “profitable co-existence” of reaction and injection molding technology. And this is why we are both going to make use of our common processes. In a one-shot process, molded parts can thus be given surfaces with elegant leather haptics, brilliant look and high scratch resistance.

All in all, the discussion between the two KraussMaffei segment leaders has shown that there is no clear border line between injection molding and reaction technology. Again and again, areas of application find their ways into each other’s technologies. This fact is underlined by a large number of similar components, which were produced for the automotive industry in a variety of processes and from different materials [1].

With technological developments and innovations in plastics processing approaching extremely fast today, while old know-how is becoming obsolete, significant changes are taking place and a vast range of solutions is available. In an increasing number of cases, these solutions are represented by integrated processes with machines and processes from different segments combined in one application. Knowing all the details of these machines and processes including all their variants, and being able to neutrally evaluate them, means an enormous benefit for the project partner when having to choose the optimum production system for demanding plastics components in vehicle application.

REFERENCES