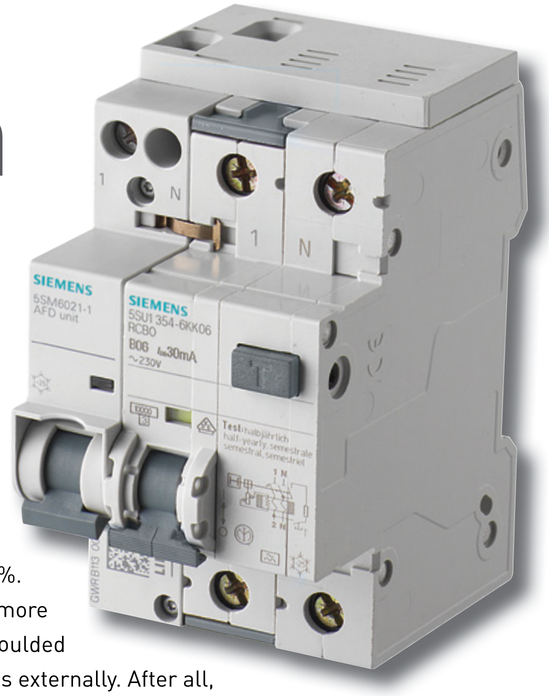
Thermosets such as BMC still offer an attractive balance balance of performance and cost in high temperature applications. Siemens shows BMC moulding can be a high-tech activitiy

BMC – a high tech moulding option



Circuit breakers provide a critical safety role, preventing electrical fires and protecting electrical cables against damage caused by overloading or short-circuits in buildings as well as industrial applications such as machine switchgear cabinets. The highest safety standards are required in design and production to ensure the devices perform with reliability.

The Siemens manufacturing site at Regensburg in Germany, which is also home to the international headquarters of the company's Low Voltage Division, focuses on residual-current-operated circuit breakers and miniature circuit breakers. The internal componentry of the devices consists of steel and copper pressings as well as a number of plastic parts made from PBT, PC or PES. These component parts are fitted into an injection moulded heat-resistant and dimensionally stable plastic housing, many of which are produced in BMC and other free-flowing thermoset powder resins such as phenolics.

"We buy in some of the components required for our products," says Siemens Regensburg plant manager Stephan Schlauß. "In the area of plastics processing, the proportion of in-house manufacture is around 50%. We source comparatively more thermoplastic injection moulded parts than thermoset parts externally. After all, there are only a few companies around that specialise in the processing of thermosets," he says.

"We predominantly use thermosetting materials for the lids and housing bodies of our miniature circuit breakers," adds Herbert Schneeberger, who is responsible for production planning for plastics parts at the company. "In some cases we do use thermoplastics as well. But these must be thermally stable, which makes the materials that much more expensive. We therefore frequently favour thermosets, even if there is a certain amount of re-finishing required."

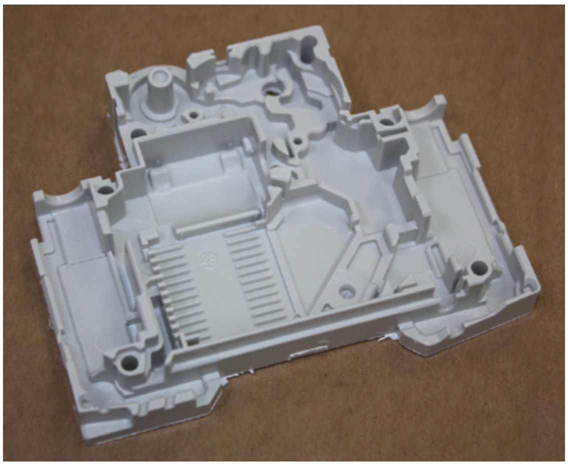
A long established processor of free-flowing thermosets, Siemens established its own BMC injection moulding operation in the late 1990s. Today, it processes some 800 tonnes of the material – a compound of unsaturated liquid polyester resin, chopped glass fibre and fillers such as aluminium hydroxide with a dough-like consistency – each year.

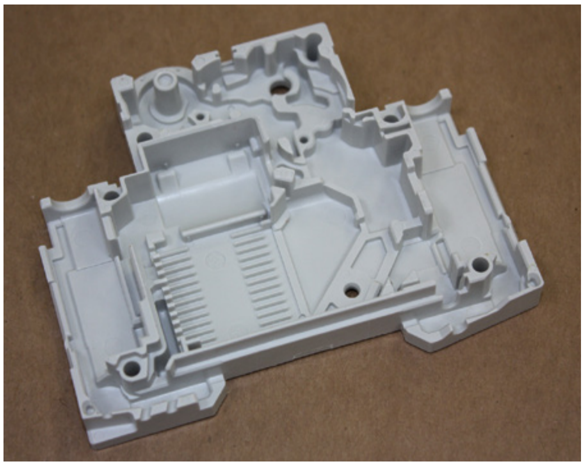
"We appreciate the great advantage of the dimensional stability that the BMCs offer," says Schneeberger. "Since the material does not absorb water, the items retain their dimensional stability permanently and don't undergo any changes in their mechanical and electrical properties either. All in all, the bulk moulding compounds impress through their good price-performance ratio."

According to Siemens, dimensional stability was one of the prime factors in its decision to get involved BMC

Above: Siemens uses BMC in its circuit breakers for its combination of low cost and high performance

Left: A Siemens' worker visually inspects breaker housings prior to deflashing





This image of a moulded housing (left) shows how good process set up can minimise flash production. Second image (right) shows the same component after deflashing

processing back in 1998. It originally used Fahr-Bucher moulding machines, but when it needed to further expand capacity in 2006, the company had to find a new supplier as Fahr-Bucher machines were no longer in production.

"What was of particular importance to us was that the feed mechanism to convey the paste-like material had to be of similar construction to the system we were familiar with," says Schneeberger. One of the suppliers considered was Sumitomo (SHI) Demag Plastics Machinery, which was then operating as Demag Plastics Group. It delivered a production system with a stuffer system – BMC does not flow into the barrel – and a screw and nozzle geometry he says was very similar to its installed systems.

"We had the same conditions as with the existing machines from the top feeding of the material all the way to the injection nozzle. That was of great benefit to us because it allowed us to transfer the previously tried and tested processes and processing parameters to the new 200 tonne machine directly and without any great adaptation effort," he says.

With a further expansion in BMC moulding capacity required in 2011, Siemens again turned to to Sumitomo (SHI) Demag. The latest two machines are based on the company's hydraulic Systec range in a 160 tonne version.

"We were changing a product, which had previously been moulded from free-flow thermosets, to BMC injection moulding. We also needed the new machines to make up for downtimes of the older machines for servicing," says Schneeberger.

The two Systec 160 machines are moulding miniature circuit breaker lids and housings on three shifts up to six days a week using six-cavity moulds. Each machine is equipped with a handling unit, which removes the items from the mould and deposits them on a conveyor belt. From there the lids and housings are transported directly into a continuous blasting line, where the flash is removed by blasting with polyamide beads.

Flash is always a challenge in production of BMC due to the low viscosity resin, but it can be minimised by careful process setting and control. "We inject into the closed mould, build up a vacuum and then vent at the end of the injection process by just briefly removing the locking force, after which we reapply the locking force and effectively pack the mould through the hold pressure," Schneeberger says. "This minimises flash thickness and the thinner the flash, the less the effort and cost involved in re-finishing."

Moulds also have to be well designed and maintained to very high standards to avoid excessive flashing. Siemens produces almost all of its thermoset moulds in-house, integrating pressure sensors in all new designs to allow it to monitor cavity pressure during production, which helps to optimise the moulding parameters. "As soon as we know which settings we should adhere to, we can do without the interior pressure sensors in further moulds without affecting part quality," he says.

Processing of BMC differs substantially from injection moulding of thermoplastics. The special material feed

The stuffer unit feeds the paste-like BMC into the plasticising screw and barrel, which is maintained at less than 30°C to prevent premature cross-linking

unit for the putty-like compound, which is supplied in bales, is one of the most obvious differences in the machine construction. Sumitomo (SHI) Demag's hydraulically-driven Poly 100 screw stuffers force the putty-type material into the feed and injection screw. At Siemens, an operator replenishes the 100-litre capacity reservoir manually with around three BMC bales per batch, which weighs around 36 kg. This does not interrupt the injection moulding process. Optical sensors monitor the quantity of material remaining in the hopper, while the injection moulding machine initiates the stuffing screw drive to maintain the stuffing pressure ahead of the screw. This is measured by a sensor and controlled via the rotational speed of the screw.

The BMC is routed via a swivelling feed arm into the cooled injection cylinder via a filling shaft. To ensure that the chemical cross-linking does not take place until the material is in the mould, the temperature of both the cylinder and the nozzle needs to be maintained at around 35 to 40°C. The injection moulds themselves are heated to around 160 to 170 °C with a combination of cartridge heaters and induction heating coils.

The BMC does not become free-flowing until it contacts the hot mould surface. It then spreads out to fill the mould, reacts and cures in the tool. The cure time is relatively short, enabling the company to achieve cycle times of under 30s. However, temperature control is critical across the mould surface.

BMC manufacturing is also different from most thermoplastics moulding operation in that it requires extraction facilities above the material charging and mould area to remove styrene vapours. Styrene acts as a component carrier and is incorporated in the cross-linking process as a copolymer. "We extract both above the stuffer and above the mould, and we regularly measure the styrene content in the hall, which is always well under the limit," says Schneeberger. Vapours are also produced during the crosslinking process itself – one of the reasons why mould evacuation and venting is so important in BMC processing.

The long history of thermosets has meant that many consider their processing to be a low technology operation. The Siemens operation at Regensburg, like many other thermoset moulding operations around the world, shows that is misconceived. "To achieve consistently high quality is our greatest challenge. The interaction between man, machine and tool is even more delicate in the area of BMC than with thermoplastic materials," says Schneeberger.

www.sumitomo-shi-demag.eu

BMC processing equipment requires fume extraction over the feeding and moulding areas to safely vent away styrene vapours and reaction gases