SMC AT ITS BEST: DESIGN FOR MANUFACTURE

From the coffee machines and cookers in our homes, to the electrical cabinets on our streets and the body panels on our cars, SMC and BMC have been present in our lives for decades. In these, and countless other applications, SMC and BMC offer competitive and sustainable alternatives to metals and thermoplastics, and yet these composite materials are still underutilised by many designers and manufacturers. Here we address a number of frequently asked questions concerning design and manufacture of SMC/BMC components and offer some practical tips to ensure successful deployment of these versatile materials.

WHERE SHOULD SMC/BMC BE USED?

SMC/BMC materials can be thought of as bridging the gap between steel and thermoplastics. They deliver parts that weigh less than metals but provide higher strength and stiffness than many thermoplastics. They are a particularly good choice for components with complex shapes. With SMC/BMC it is possible to design a highly complex, multi-functional part to replace 20-25 steel components. This capacity to consolidate parts at reduced weight has been successfully exploited in numerous designs, including automotive decklids, doors and front-end modules.

Composites also possess a range of further desirable properties. Excellent dielectric behaviour means SMC/BMC is often a safer option than metals for applications requiring electrical insulation, such as electricity meter cabinets. And extreme temperatures are not a problem.

SMC AND BMC COMPOSITES

Sheet moulding compound (SMC) and bulk moulding compound (BMC) are fibre reinforced polymers, also known as composite materials. They consist of a thermoset resin (typically an unsaturated polyester), a fibre reinforcement, an inorganic filler, and various additives to improve processability and performance. Formulations can be tailored to deliver specific properties in the final product, such as fire resistance.

The reinforcement imparts strength and stiffness to the compound. Glass fibre is the most popular reinforcement, but carbon fibre can be used to provide greater weight savings. In SMC the length of the fibre is in the range of 25-50 mm, and in BMC it is 6-12 mm.

SMC and BMC are converted into components using cost-effective compression moulding and injection moulding processes. Production volumes of more than 1 million parts/year are achievable using these highly automated, industrial processes.

Because of its longer fibre length, SMC has greater flexural and tensile strength than BMC. It is ideal for the manufacture of large, relatively flat, fairly intricate parts which combine structural performance with a smooth finish. The ability to produce Class A painted surfaces has led to an increasing number of automotive applications for SMC. BMC is better suited injection moulding and the manufacture of smaller, more intricate parts. BMC applications include consumer appliances and car headlight reflectors.

SMC/BMC components can be recycled at the end of service life.

SMC and BMC retain their mechanical properties and dimensional accuracy over a very wide temperature range, making them ideal for applications where the behaviour of metals and thermoplastics may be diminished, such as components installed in polar regions, or valve covers for car/truck engines. SMC/BMC is also a poor conductor of heat and well suited to high temperature applications where a metal part would become too hot to touch. This is one of the reasons why the exterior housings of kitchen appliances such as sandwich toasters and waffle makers are often made of BMC.

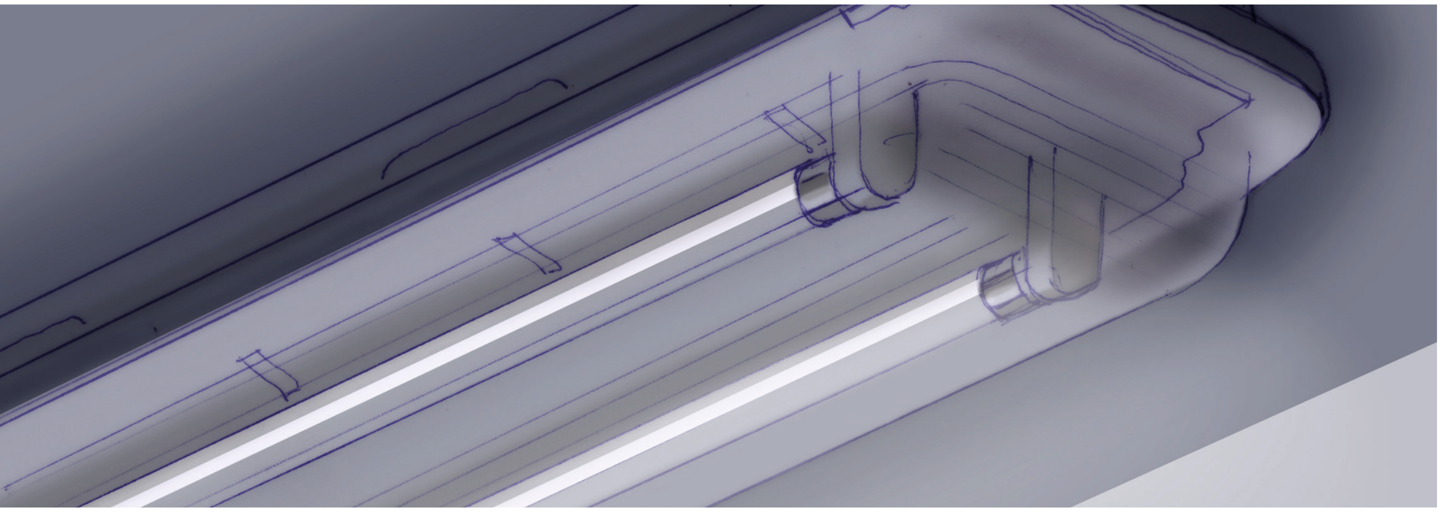
Composite materials are also extremely durable and resistant to abrasion, corrosion and weathering, resulting in very low maintenance requirements and a longer service life.

WHAT PRODUCTION VOLUMES ARE POSSIBLE?

Compression moulding and injection moulding are industrial processes well suited to high levels automation. Fast cycle times and high production rates are easily achieved, whilst also delivering process consistency, and great predictability of dimensions and part performance. Typical cycle times are of the order of 1-2 minutes for parts with 2-3 mm wall thickness.

20 years ago it was already possible to manufacture SMC waterproof housings for outdoor lighting at a rate of 15,000 parts a day (more than 2.5 million parts per year) in a factory operating with 21 robots and only three people. The components were 1.3 mm thick and 1.3-1.6 m long and the reject rate was 0.6%. This enabled the parts to be highly cost competitive with comparable thermoplastic and metal alternatives.

Since then SMC technology has continuously progressed and it is now mature and ready to use for your end-use application.



Very thick SMC parts require longer moulding cycles. For example, a cycle time of 1.5 hours was required for the SMC housing of a swimming pool pump. This component was 130 mm thick in places and weighed 160 kg. SMC was selected to withstand the corrosive effects of seawater, as well as for its design flexibility and dimensional accuracy.

For typical SMC applications on trucks, like spoilers and fenders, 10,000 parts/year is common. For higher volume SMC parts like electrical cabinets, and BMC parts in appliances, volumes can easily build up to 100,000s of parts/year.

HOW IS A SUCCESSFUL SMC/BMC DESIGN DEVELOPED?

The design of an SMC/BMC part is not solely a job for the design team. The design must fulfill the functional requirements of the application, but it is also essential that the part can be manufactured as efficiently and economically as possible. Developing the design, the material, the moulds and the production process in parallel is the key to success.

The good news is that huge advances have made in SMC/BMC materials over the past 30 years. A broad range of standard SMC/BMC formulations tailored for specific applications are now available and their properties are well documented. Formulations are more consistent and much easier to mould, enabling more reliable production and the manufacture of high-quality parts of more complex shape.

Correct mould design and construction is also crucial to minimise rejects and production downtime. If the mould maker is not consulted during the design process there are likely to be issues in realising some features of the mould. This could lead to problems in releasing the part from the mould, or a need for more frequent mould maintenance.

All stages of the production line – from material preparation, to moulding, through to finishing – should be optimised to ensure fast cycle times and minimal waste. In an optimised process both reject parts and production waste can be reduced significantly, conserving resources and lowering costs.

If this collaborative approach is taken, a development time of 1.5-2 years from the first design to the start of production is typical. For a very simple design, with one simple mould, this could be cut to as little as little as six months or less.

WHAT ARE THE STEPS IN THE DESIGN PROCESS?

The design and validation steps for SMC/BMC are similar to those for a thermoplastic part. The designer creates a computer aided design (CAD) model of the part and simulates its mechanical performance under real-world conditions using finite element analysis (FEA) software.

The missing link for the development of SMC parts is information on how the fibre is orientated, which will strongly influence the part's mechanical behaviour. For optimum performance the majority of fibres should be orientated along the main load paths. Several brands of software are now available to simulate the compression moulding process, indicating how the mould will fill and the orientation of the fibres. This enables the mechanical properties in each element of the FEA mesh to be calculated far more accurately than from use of supplier/laboratory data and leads to more precise results from the structural analysis. The moulding simulation also provides useful data on mould fill time and highlights the presence of any undesirable effects such as weld lines. The choice of material, the design of the part or mould can then be modified as necessary.

WHICH MAIN DESIGN ELEMENTS INFLUENCE THE PART'S COST?

The weight of the part (amount of material used) is of course a major factor, but the thickness of the part is also important. Thinner sections cure faster, enabling faster cycle times.

The complexity of the design will also influence the cost of the mould. Features such as undercuts add complexity. Simpler moulds with less undercuts (and consequently fewer moving parts) will lead to lower maintenance costs, reduced mould downtime, and higher production output. An undercut of even 2 mm can have large consequences for the design of the mould.

MOULDING TERMINOLOGY

DRAFT ANGLE
The degree of taper allowed on the sides of a mould so that the part can be removed.

EJECTOR PINS
A series of telescopic pins hidden in the male side of a mould that lift in unison to remove a cured part from the mould.

UNDERCUT
A negative or reverse draft in a mould that does not allow part removal without a special moveable section in the mould construction.

WELD LINES (KNIT LINES)
Surface defects or areas of reduced structural integrity which potentially occur when flow fronts meet in the mould cavity.

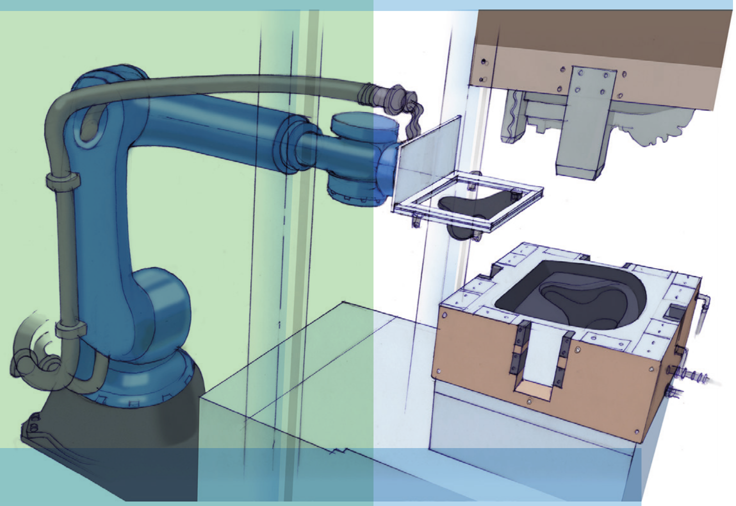
WHERE DO THINGS TYPICALLY GO WRONG IN THE DEVELOPMENT PROCESS?

As discussed previously, designing the part without considering the whole manufacturing process is a frequent mistake. Small changes in part design will influence manufacturing layout and impact manufacturing efficiency.

The second common error is incorrect design of the moulds. Some companies are tempted to cut costs in the area of mould construction, but this is a false economy since the resulting moulds are not optimised and do not work efficiently. Although the company initially saves some money on moulds, ultimately they lose far more through inefficient production.

For example, centering of the mould – typically achieved by adding wear plates around the mould to precisely guide the two halves of the mould as it closes – is a standard mould design. If centering is eliminated to reduce mould cost, the mould shear edge (the 0.1 mm gap between the mould halves which allows air to escape but prevents SMC flowing out of the mould) can be damaged after moulding as few as 100 parts, resulting in reject parts, production downtime, and maintenance costs. In the end, the overall project cost is higher.

The efficient release of the part from the mould is another important consideration. Investment in a more sophisticated ejection system which guarantees smooth, reliable ejection of parts will quickly be repaid through lower reject rates and reduced downtime.



HOW MUCH DOES AN SMC MOULD COST?

The typical cost of a steel mould for moulding SMC is less than €100,000, which is approximately 10-30% lower than the price of a comparable mould for thermoplastics.

The cost of an aluminium mould is lower than steel, but aluminium is less suitable for higher volume production. As a guideline, a steel mould can mould 10,000-15,000 parts, while an aluminium mould needs to be replaced after 500-1000 parts.

For prototypes, although a less expensive aluminium mould may seem attractive, a steel mould moulds more reliably (with fewer rejects) and it can be re-used for the first series of production.

The cost of a steel prototype mould depends on the design of the part. For a part of approximately 1m x 1m, without ribs, the price could be around €10,000-15,000. If there are ribs the part ejection process is more complicated, which increases the cost.

IS IT BETTER TO MANUFACTURE PARTS IN-HOUSE OR OUTSOURCE PRODUCTION?

Manufacturers choosing to use SMC/BMC for the first time should consider whether they want to mould the parts themselves or outsource this work. Obviously, outsourcing does not require investment in moulding presses and allows the moulder's processing and design experience to be exploited. Many companies, however, have decided that developing in-house SMC/BMC moulding capabilities is of strategic importance and have therefore invested in building their own expertise and manufacturing footprint.

There are a variety of SMC/BMC moulders active in the market and each will have their own specialities and strengths. A key consideration when selecting a sub-contractor is their ability to design the moulds correctly. A design and development partner familiar with the SMC/BMC supply chain can help the manufacturer choose the right moulder for their project.

ACKNOWLEDGEMENTS

The European Alliance for SMC/BMC would like to thank Jean-Luc Labonne for his invaluable assistance in creating this guidance. Jean-Luc Labonne possesses more than 25 years of industrial experience in manufacturing SMC/BMC components for a broad range of applications and markets. In 2016 he established the consultancy CIME, in Quetigny, France, and now advises companies on how to develop SMC/BMC parts and optimise their production processes. He can be contacted by e-mail: **jl.labonne.cime@outlook.fr**

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January 2021