Injection moulded glass ceramics – the advantages add up

Those somewhat nostalgic looking beer bottles with the flip-top caps made from porcelain are familiar to us all.

Rösler recognised that even tried-and-tested products can still be improved and so developed caps made from fast-firing glass-ceramic compounds. The compounds, which mainly comprise recyclable glass and ceramic waste, are fired in an energy-saving way at low temperatures. They can be processed using a new injection moulding technique and are advantageous for the recycling process. After being used many times, these new caps can be melted down together with the returnable bottles.
recipes and ascertained their various densification temperatures. As expected, the temperatures fell as the proportion of glass was increased, which meant that energy consumption dropped continuously too. Further energy savings were achieved by moving the firing process from tunnel kilns to fast-firing kilns, which have considerably shorter throughput times.

Other properties that affect the end product were also examined closely, such as the breaking strength and appearance of the fired compounds. The researchers used a scanning electron microscope to investigate the reasons for fractures observed in the test specimens. Since the glaze also contributes to the stability of the bottle cap, the glass formulas and application techniques were likewise optimised for the production process.

Rössler’s research proved to be highly successful. The new mixtures, which to a large extent contain recyclable glass and porcelain-compound waste alongside the usual ceramic raw materials, have enabled the firing temperature to be reduced from 1420 degrees Celsius to 1230 degrees Celsius. The combination of the new compounds and the fast-firing technique has reduced energy consumption by 20 percent compared to the old process. Another great advantage of the glass-ceramic compounds is their full recyclability. Due to the high proportion of glass that they contain, they can be melted down together with recovered glass and then recycled without impairing the glass quality.

Parallel to this, the Research Institute for Inorganic Materials carried out research into improving the low-waste injection moulding process for further ceramic compounds. Preliminary tests showed that natural, unfired clays possessed nearly satisfactory ductile properties for processing on injection moulding machines. Clay-based raw materials could be injection-moulded to make simple green bodies, though their stability was too low. An environmentally-friendly binder still needed to be found that would ensure the moulded pieces would solidify in the casting mould.

It quickly became evident that the normal temperature gradient for plastic or powder injection moulding (in which the hot compound solidifies in the cold mould) was unsuitable for the binder system that the researchers were looking for. Many chemical reactions take place faster and more favourably as the temperature is raised. For this reason the researchers decided not to cool the casting moulds but to heat them to approximately 70 degrees Celsius. This inversion of the temperature gradient gave the new process its name – inverse-temperature injection moulding.

The researchers tested a variety of binders in various proportions and blends for the inverse-temperature injection moulding technique. Their persistence was worthwhile. They found an environmentally-friendly standard product that provided the green body with sufficient stability. And that is not all it can do. Not only could they use it to process clays like kaolin in the laboratory but also other ceramic raw materials like aluminium oxide, silicon carbide and even metal powder. The fast-firing compounds that Rößler developed did not present any problems either. This work has resulted in as yet unexploited areas of application being opened up to this favourable injection moulding process.

The laboratory findings have been put into practice. The inverse-temperature injection moulding technique was optimised for fast-firing glass-ceramic compounds and Rößler carried out successful production trials with these cost-effective materials. Meanwhile, bottle cap production has been fully converted to using the new materials.