Solid free-form fabrication in fired ceramic as a design aid for concept modelling in the ceramic industry

Design case study:

Denby Cup

Denby Pottery is one of the UK's most well-known and long-established ceramic manufacturers. The company was founded in the early 19th century and is a household name in the tableware industry. Denby competes in the global marketplace for traditional and contemporary tableware, and is well known for its high-quality stoneware, china and glaze finishes. The Denby design team are based at the company's factory and headquarters in Denby, Derbyshire. Denby Designers were amongst the first ceramic designers in the UK to make extensive use of 3D computer aided design and rapid prototyping for the production of concept models within the ceramic new product development process. Denby has in-house 3D printing facilities – the company uses the Z-Corp powder 3D printing system to fabricate prototype models in the standard Z-Corp plaster-based composite material. The standard Z-Corp materials allow the designers at Denby to effectively communicate the shape of their designs but not the more subtle material qualities of ceramic i.e. the weight, tactility etc.

The 3D printing research team at the UWE Centre for Fine Print Research embarked upon a collaborative project with designers at Denby Pottery to investigate the use UWE's newly developed ceramic 3D printing process for the production of concept models for ceramic new product development. Denby design manager Gary Hawley recognised that the UWE ceramic 3D printing process offered the potential to create a concept model which would be closer in look and feel to a manufactured ceramic item than the existing Z-Corp plaster-based modelling material. Denby designers provided the UWE team with a 3D CAD model of a cup which is representative of Denby's typical output. This is shown in figure 1.

Figure 1 Denby cup

In order to maintain the shape of the cup during the firing process, it is necessary to create supporting structures or setters which are made from the same 3D printed ceramic material as the piece itself. 3D CAD model of the cup was used to generate the shape of the setters. The inside surface of the bowl of the cup and the top of the handle were identified as key surfaces which would be supported during firing. Using Rhinoceros (Robert McNeel Associates) these surfaces were offset by 0.5 mm, to allow clearance between the cup and setters. Standard Rhino NURBS modelling tools were then used to construct the setters based on these key surfaces (Figure 2). The 3D printed cup and setters are shown prior to firing in figure 3 and 4.

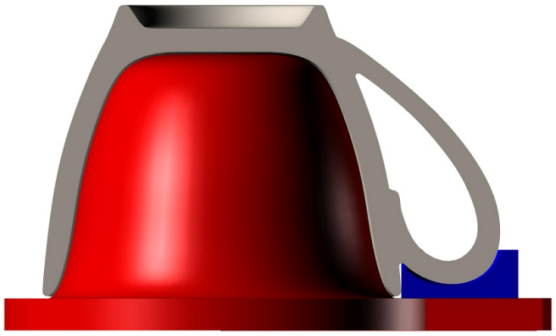

Figure 2 Cross section CAD model showing the cup and setters

Figure 3 3D printed ceramic cup and setter prior to firing

Figure 4 3D printed cup on setter prior to firing.

Following firing the cup was removed from the kiln and inspected. Whilst the body of the cup had maintained its shape with minimal distortion, the lower part of the handle which was unsupported during firing had deformed as shown in figure 5.

Figure 5 3D printed cup on setter following firing

In order to better maintain the shape of the cup handle, an additional setter was designed to fit inside the handle to support it during firing. The additional setter is shown in figure 5. When the cup with new setter was fired, the additional support was found to greatly reduce distortion in the handle, leading to much more satisfactory results.

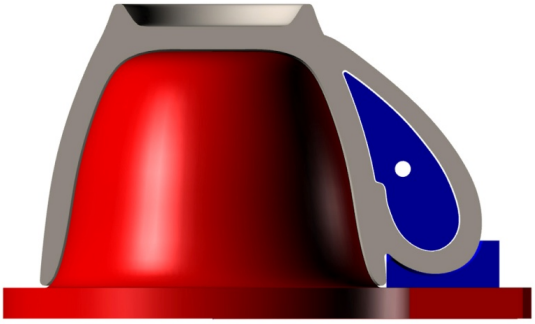

Figure 5 Cup with additional setter to support handle during firing

Figure 6 Cup and setter with handle support following firing

Figure 7 Biscuit fired cup

Figure 8 Finished cup with porcelain slip coating

In conclusion, we can state that this case study demonstrates that ceramic 3D printing may be employed to fabricate an item of shape and section thickness that is the same or similar to that of a typical mass-produced piece. The problem of maintaining the shape of the delicate handle section was overcome through the use of an additional setter to support the handle during firing. We anticipate that a similar approach could be adopted in future for other delicate items with vulnerable features, enabling them to be fabricated by ceramic 3D printing and then successfully fired.