Further Developments in the Digital Fabrication of Ceramic Artworks

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Abstract

David Huson and colleagues at the Centre for Fine Print Research in the School of Creative Arts at the University of the West of England are conducting a three-year AHRB funded research project into the use of Digital Fabrication techniques in the area of Art/Craft ceramics.

Now in the final year the project is continuing to advance methodologies in the use of digital fabrication techniques to form models and moulds for the production of ceramic artworks and refining the process of forming a ceramic object directly by the use of 3D printing technologies.

The direct 3D printing of ceramic powders has been shown to be a viable procedure for translating 3D computer generated models in to physical ceramic forms which can then be fired and further processed.

This paper will detail the progress of the research to date and will use examples of current artwork projects to illustrate how these techniques have been developed and refined to allow artists and crafts persons to investigate and implement ideas and concepts that were previously unattainable.

Introduction

The Centre for Fine Print Research at the University of the West of England in Bristol has recently been awarded a substantial grant from the United Kingdom Arts and Humanities Research Council to fund a three year project “The fabrication of 3Dimensional art and craft artefacts through virtual digital construction and output to investigate the use of 3D rapid prototyping and digital fabrication techniques in the areas of Art/Craft and Designer /Maker Ceramics.

The CFPR has had much experience in working with industry to incorporate unique and useful fine art based paradigms into industrial research partnerships and commercially successful developments. This integration of industrial needs and academic research has formed the basis of a number of the Centre’s previous AHRC grants and Knowledge Transfer awards.

The CFPR has ongoing experience in the application of digital fabrication techniques in an artistic context and has completed a project using digital technology to convert photographic images into a ceramic relief surface by using 3D design software and a desktop CNC milling machine. The application of a specially tinted glaze to this surface allows a permanent fully continuous tone image to be produced on a ceramic tile.

The Progress of the Project to Date

Year 1

The first year of the project was devoted to researching the literature in the field, and purchasing and becoming proficient with the equipment and software. Artworks were designed in CAD and printed out in Z Corp material and exhibited at an exhibition at the Royal West of England Academy in Bristol.

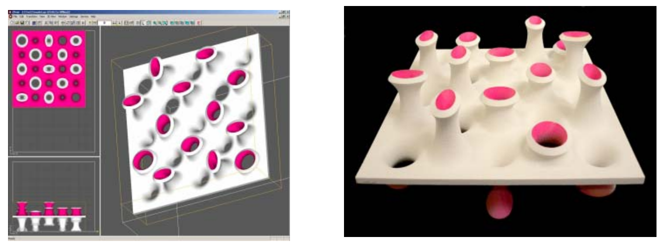

Figure 1. CAD model of artwork & 3D print

Experiments were undertaken to print a ceramic-based powder in a Z Corp 310 3D printer. A commercial spray dried tile granulate was used for the initial trial but proved to be unsuccessful and disintegrated when removed from the build bed. By grinding the granulate and adjusting the saturation of the binder it proved possible to print an object that could be removed from the bed, but the green strength was extremely low and it was impossible to de-powder. It was necessary to sinter the printed object at a low temperature, remove the excess powder and then re-fire to the body maturation temperature.

Figure 2. 3D ceramic printed from granulate

Year 2

In year two a 3D ceramic printing body was developed based on a traditional earthenware recipe, the individual body components could then be varied to give the most desirable properties for both printing and firing.

Adjustments to the pH of the ceramic body mix as well as the particle size and the saturation of the binder gave significant improvements to the green strength and it was possible to 3D print, de-powder and fire a ceramic object

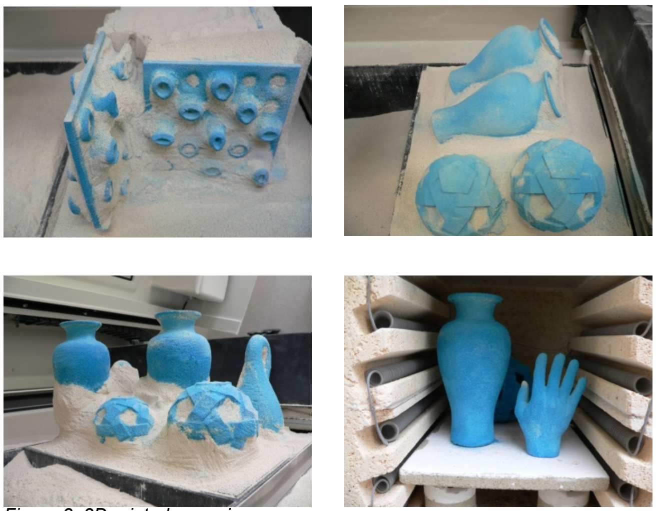

Figure 3. 3D printed ceramic

Figure 4. Fired/Glazed 3D printed ceramic

Although large steps had been made during year two of the project there were still significant problems to be addressed in year three. The main problem to producing a fine ceramic object was the layer shifting that occurred during the printing, this was worse on low aspect ratio objects and could be reduced by careful attention to the orientation of the object in the print bed.

It could only be eliminated by reducing the saturation of the binder, which diminished the green strength and brought back the problems of the object breaking up in the build bed. Other problems that needed to be addressed were the coarse surface finish and the high-fired contraction and porosity.

Year 3

Particle size analysis was carried out to compare the size distribution of the proprietary Z Corp powders to the ceramic powders used in years one and two.

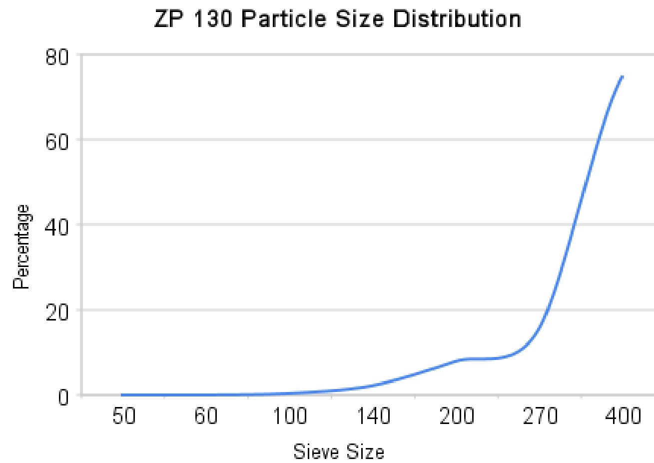

Figure 5. Particle size distribution

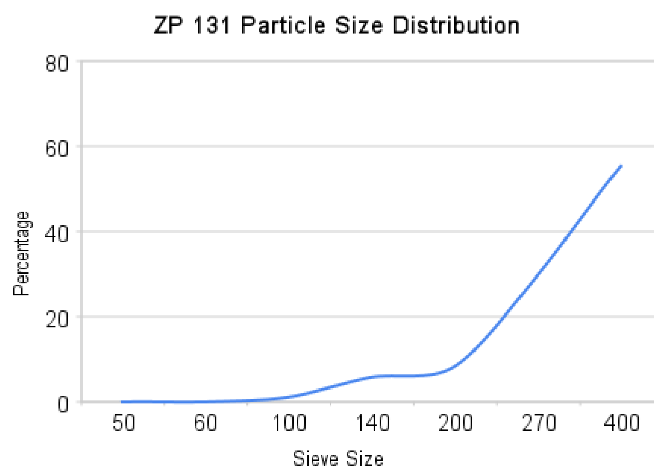

Figure 6. Particle size ***distribution***

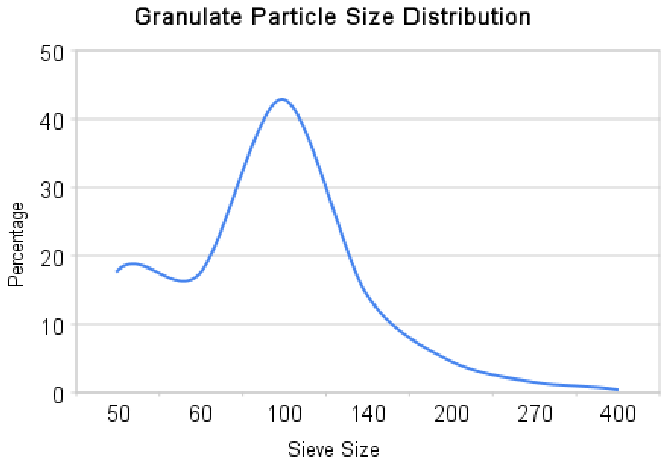

Figure 7. UWE granulate particle size distribution

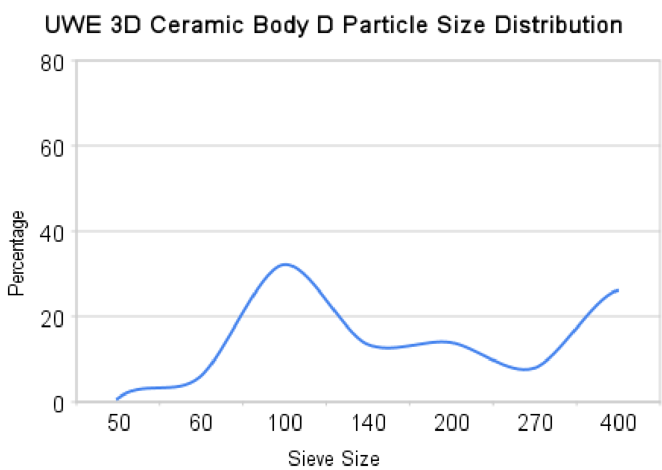

Figure 8. UWE body D particle size distribution

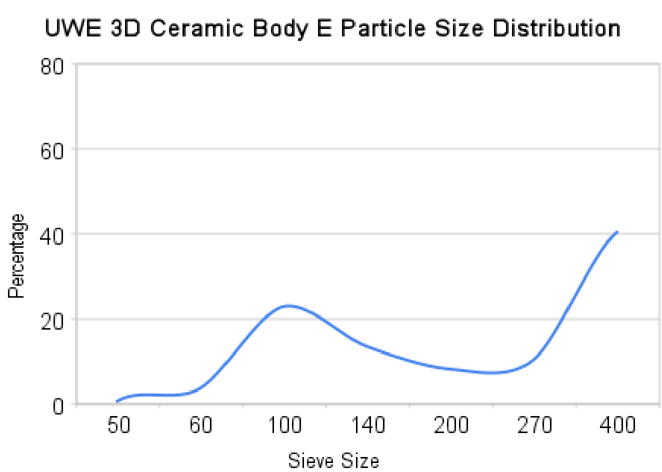

Figure 9. UWE body E particle size distribution

To improve the green strength a new body was formulated, again based on a traditional earthenware but with the addition of a cellulose binder and acidifier as tests had shown that a pH of less than 4 was beneficial to the unfired strength, the body was ground to increase the percentage of particles finer than mesh No. 270 to improve the surface finish.

A series of test pieces were produced on a Z Corp 310 printer and the green strength was shown to be greatly increased compared to earlier 3D ceramic printing bodies and for the first time it was possible to print thin sections and remove them successfully from the build bed.

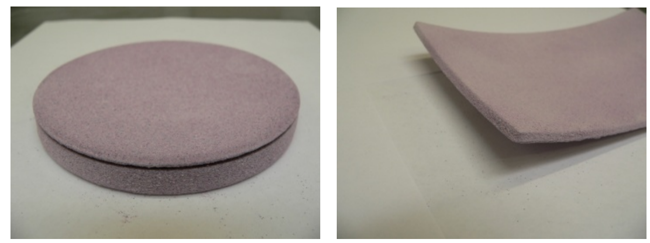

Figure 10. Ceramic 3D printed plate and tray

A series of test pieces were printed and fired at different temperatures to determine the fired contraction and the vitrification characteristics

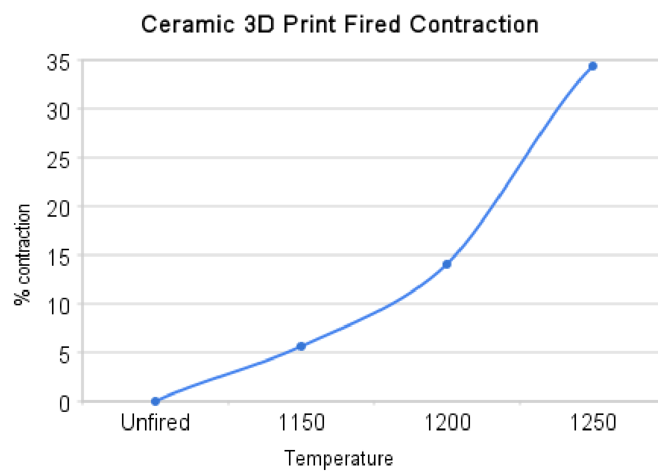

Figure 11. Ceramic 3D print contraction

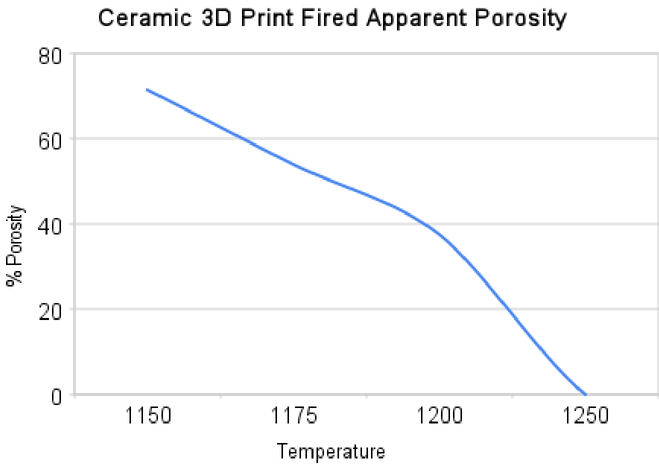

Figure 12. Ceramic 3D print fired apparent porosity

Figure 13. Ceramic 3D print size comparison unfired to 1250 deg C.

Conclusions

By adjusting the body formulation and controlling the binder saturation levels and the printed layer thickness it has proven possible to 3D print a ceramic body mix with good green strength and surface finish.

Compared to conventional ceramic forming techniques the apparent porosity and fired contraction is still high, but work is continuing with the use of ceramic material infiltrates both before and after firing to solve this problem.

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Author Biography

David Huson is a Research Fellow at the University of the West of England. Previously he has worked in the ceramic industry, holding positions of Research and Development Manager, Technical Manager and Works Manager. He also ran his own business for five years producing commercial ceramics. He is currently researching photo ceramics and the use of digital fabrication techniques for Art/Crafts and Designer/Maker ceramics.