Materials and Process Innovation for 3D Printing of Ceramics

David Huson
Research Fellow
Centre for Fine Print Research
University of the West of England
Areas of investigation

• The use of 3D printing technologies and CNC machining to translate a computer 3D model into a mould capable of producing a bespoke ceramic artefact

• The use of laser scanning, reverse engineering and digital fabrication techniques to facilitate the production of short runs of bespoke ceramic artefact

• To research the possibilities, and then develop the methodology of forming a bespoke ceramic artefact directly by the use of 3D printing and other RP technologies
3D lab equipment
3D laser scanning
Z-Corp Powder-Binder 3D Printing System

Roller

Print Head

Feed Piston

Build Piston

Feed Drive

Build Drive
Z Corp 310 Printer
3D printed artworks
3D printing of ceramic artworks

- The 3D computer model is drawn in a CAD program or generated from data collected by a 3D scanner (or a combination of the two)

- The proprietary material in a Z Corp 3D printer is replaced with a ceramic body powder

- 3D printing of ceramics allows an artist to move directly from the 3D model to a finished article without using traditional modelling and mould making processes
3D printed ceramic test pieces
CAD model of ‘impossible’ ceramic object
Printing object in ceramic powder
Post-processing printed ceramic
3D printed ceramics
Spray dried ceramic body

- Advantage
  - Easily available
  - Prepared body
  - Correct thermal expansion

- Disadvantage
  - Coarse grain size
  - Poor green strength
  - Needs pre-sintering to post process
3D ceramic printing with ball clay
3D ceramic printing with ball clay

• Problems
  – Layers curling during printing
  – Layers moving during printing
  – Cracking and distortion
3D ceramic printing with ball clay

• Advantage
  – Easily available
  – Fine particle size
  – Better green strength so no pre-sintering required

• Disadvantage
  – High plasticity
  – Low thermal expansion
  – Difficult to fit glaze
Earthenware type ceramic body

• Dry blended from powder constituents
  – ball clay
  – china clay
  – silica filler
  – flux
• Binder additives to improve green strength
• Adjust orientation in build bed to reduce layer shift
Printed examples
Fired examples
Earthenware type ceramic body

- Far better but still some problems
  - Layer shift
  - Variable surface quality
  - High porosity
  - High fired contraction
Layer shift
Dead swallows
Dead swallows
Dead swallows
Dead swallows
To improve the process

- Investigate particle size distribution
- Increase green strength of body
- Reduce binder saturation
- Reduce porosity and contraction
- Have ability to use wider range of ceramic bodies

- Decided to develop a process to adapt commercially available ceramic bodies for use with the Z Corp 3D printers
New body characteristics

- Ball milling of body to improve particle size distribution
- Improved binder in body mix to increase green strength
- Reduced binder saturation to eliminate layer shifting
- Adjust the body mix to reduce fired contraction
Firing contraction and porosity

Ceramic 3D Print Fired Contraction

Ceramic 3D Print Fired Apparent Porosity
Manta
3D printed in bone china
Removing from bed
Fired with setter
With coloured 3d prints
Trumpet sphere cad model
Urchin cad model
Trumpet sphere 3D printed
Urchin 3D printed
3D printed ceramic
Further developments

• Need to reduce the porosity and fired shrinkage
• Need to improve the green strength
• Need to improve printing performance and eliminate layer shift
• To achieve these aims it was decided to develop a new type of ceramic body and process methodology that would work specifically with the characteristics of the Z Corp 3D printing system
Future Developments

- Exhibition of 3D printed ceramic artworks
- Patent application
- License agreement with Z Corp.