3D Printing of Self-glazing Ceramics: An Investigation into Egyptian Faience

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Abstract

Stephen Hoskins and David Huson at the Centre for Fine Print Research at the University of the West of England are continuing their research into the 3D printing of ceramic bodies by investigating the possibilities of using techniques developed by the ancient Egyptians to produce a 3D printed ceramic body that will glaze itself during the firing process.

Egyptian faience was the first glazed ceramic material invented by man. Originating in the fifth millennium BC, Egyptian faience is not a clay-based ceramic but is composed of quartz mixed with alkali fluxes. In contemporary terms Egyptian faience is popularly viewed as a low plasticity turquoise coloured self-glazing low-fired body, used primarily to create ornamental objects such as beads and jewellery. In its original Egyptian context faience was a versatile material, used in a variety of ways and in a number of different forms, to create objects such as sculpture, cups, vessels, funerary figurines, tiles, boxes and body ornamentation all with a highly coloured lustrous glaze. The two methods used in ancient Egypt to enable self-glazing in one firing are efflorescence glazing and cementation glazing:

In efflorescence glazing soluble salts are introduced in to the body mix, after forming and during the drying stage these salts migrate to the surface of the formed article and during firing fuse and react with the body materials to form a glaze on the surface, by introducing colouring oxides such as cobalt, iron, manganese or copper into the mix a range of coloured glazes can be produced.

In cementation glazing the article that has been formed is surrounded in a saggar (a refractory box used to support and protect a ceramic object during firing) by a powder consisting of a glaze precursor, during the firing process a eutectic reaction takes place between the ceramic article and the glaze precursor powder and a glaze is formed on to the surface of the ceramic article, the firing temperature is below the melting temperature of the glazing powder so that the glazed ceramic article can be removed from the powder bed in which it was fired.

There is an interesting and coincidental synergy between the material properties of ancient Egyptian faience and the material requirement for the successful 3D printing of ceramic powders, this paper will describe the technical aspects of the ancient process and indicate how by using modern materials and methods the process can be replicated by 3D printing.

There are additional potential benefits for the arts and crafts sector as the process will enable the production of glazed ceramic articles with only one firing and at a much-reduced temperature than conventional ceramic bodies allow.

Introduction

The Centre for Fine Print Research at the University of the West of England has recently been awarded funding from the Arts and Humanities Research Council for a three year research project entitled "Can Egyptian Paste Techniques (Faience) be used for 3D printed, Solid Free-form Fabrication of Ceramics?"

This research aims to create a set of functional ceramic materials through a process based upon historic Egyptian Faience techniques, which will allow ceramic artists, designers and craftspeople to 3D print actual objects in a familiar material that can be glazed and vitrified in one firing; a breakthrough for ceramic design and manufacture.

Historical Background

The inspiration and background research for this project is based upon Egyptian Faience. "Faience was the first glazed ceramic material invented by man."1 Originating in the 5th Millennium BC, Egyptian Faience was not made from clay, but instead composed of quartz and alkali fluxes and is distinct from Italian Faience or Majolica, which is a tin, glazed earthenware. In its original Egyptian context Faience was a versatile material, used in a variety of ways and in a number of different forms, to create objects such as sculpture, vessels, funeral figurines, tiles, boxes and body ornamentation – all with a highly coloured lustred glaze.

Figure 1. *Faience Collar, Royal Ontario Museum, Toronto, Ontario, Canada*

The Egyptians referred to the material as Tjehenet "that which is brilliant or scintillating" 1. In contemporary terms Egyptian Paste has visual qualities desirable to many crafts practioners. This research project will develop a process based upon historic Egyptian Faience techniques, which will enable

ceramic artists, designers and craftspeople to print 3D objects in a material which they are familiar with and can be glazed and vitrified in one firing.

3D Ceramic Printing

The Centre for Fine Print Research has over five years experience in the 3D printing of ceramic materials. The first project undertaken was to investigate the use of 3D technologies by artists and resulted in the development of a patented ceramic body suitable for use in Z Corporation 3D printers. A follow on project has resulted in a modified ceramic body and the development of firing supports to enable thin section ceramic tableware to be produced for industry concept modeling. This new project will develop a range of self-glazing 3D printed ceramic bodies for use in the Arts, Crafts and Education areas.

Current research in the field of 3D printing concentrates heavily on creating functional materials. Our research aims to enhance this body of knowledge by creating methodologies for a self-glazing functional ceramic material that will be applicable to the arts and wider industries.

Research by Tite and Shortland 2, into original Egyptian recipes, describes three methods of glazing Faience

Application glazing: similar to modern glazing techniques where glaze slurry is applied to a body by brushing or dipping..

Figure 2. *Bird shaped faience Metropolitan Museum of Art*

Cementation glazing: where an unglazed article is fired, bedded in a glaze powder 3 (originally described by Wulf)

Figure 3. *Donkey beads Qom Iran*

Efflorescent glazing: where the glazing materials in the form of water soluble salts are mixed with the body. As the body dries the salts migrate to the surface forming a layer which fuses to a glaze when fired.

Figure 4. *Lion headed goddess Walters Art Museum Baltimore*

We will use these techniques as a basis for developing radical contemporary 3D printing alternatives.

Starting with ancient Egyptian recipes, 3D ceramic printing body powders will be developed. Using modern materials and firing techniques will give a wider palette of colours and more consistent and reproducible results. The aim of the project is to develop a series of self-glazing, low firing temperature bodies for 3D printing.

Preliminary Investigations

Early experiments have resulted in success with an Egyptian Faience body recipe produced by conventional ceramic forming techniques with a self glazed cobalt blue stained body being fired at 950 deg

Figure 5. *Egyptian Faience test body*

Initial tests with a 3D printed ceramic body and an efflorescent glaze system have given promising results.

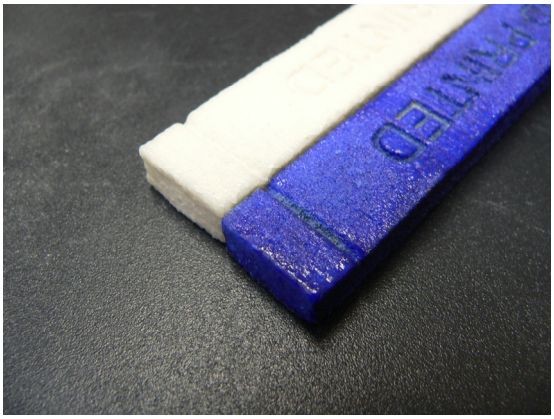

Figure 6. *3D printed test bars with efflorescent glaze*

Figure 7. *3D printed test bars with efflorescent glaze*

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Author Biography

Stephen Hoskins is Hewlett Packard Professor of Fine Print and Director of the Centre for Fine Print Research at the University of the West of England Bristol. Apart from being a practising printmaker, his primary areas of research are; the potential of 3D printing and related digital technologies for the arts, plus the tactile surface of the printed artefact and its consequences for digital technology. His latest book 3D Printing for the Visual Arts (Technology That Crosses Both Art and Industry) is due to be published by Bloomsbury in early 2013.