THE USE OF COMPUTER AIDED TOOLS FOR PROTOTYPING IN TRADITIONAL CERAMICS PRODUCTION IN MALAYSIA.

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ABSTRACT

A prototype is often used as part of product design to allow engineers and designers the ability to explore design alternatives, test theories and confirm performance prior to starting production of new product. The use of computer applications has impacted significantly in the execution of technological innovation in almost all the spheres of industrial design products development. Computer aided design (CAD) in ceramics production has been expressed through conceptualization of ideas to realization of processes in the production of ceramics prototypes that utilize drawing seed, quality production, quick modification, production innovation, cost and time effectiveness.
Therefore, this paper attempts to review how computer aided applications have become very relevant in area of ceramic manufacturing such as traditional ceramics. It illuminates on the viability of computer aided tools in enhancing prototyping in traditional ceramic production. This was achieved by first visiting three ceramic factories in Kelantan, Malaysia so as to know the conventional method they used for prototyping. This method was then reviewed by integrating CAD tools into the development cycle.
The exploration and development of the vast potentials of computer aided tools for ceramic design and manufacturing will in no doubt fast-track the development of local ceramics production in Malaysia. Besides, the product from well-conceived design ideas and computer aided ceramic manufacturing will contribute significantly to the development of built environment.

Keywords: Computer Aided Design, Prototyping, Traditional Ceramics

1. Introduction

According to 3D Vision Technologies (2008), Physical prototyping can be a major bottleneck, slowing down the product development process and seriously constraining the number of design alternatives that can be examined. Gary Hawley (2012), a designer in Denby Pottery Company said, “Despite the prodigious skills of the company’s carvers, some having more than 25years experience; the process of physical prototyping was time consuming and never produced 100 percent accurate models”. As a result, it was hard for the clients to fully understand the concepts being proposed. Also, the fact that their prototypes take as long as four weeks to be created made them too careful about introducing new products.
Many manufacturers easily accept that eliminating physical prototypes equates to shorter or shortened product development cycle time and also a competitive strategies for reducing development cycles and getting products to market faster. However, the reality is that many product development teams are still forced to include physical prototyping in the design loop to verify proper functionality and ease of assembly. Some manufacturers feel there are still valid reasons to keep physical prototypes in the design loops.
So, while the use of physical prototypes is still a necessity for many product developers, replacing more and more physical prototyping and testing with digital methods, and better coordination of physical test and measurement with digital modelling and simulation is seen as an approach that can save millions in development costs while slashing months off product development schedules (3D Vision Technology, 2008).
Research from the Aberdeen Group[1] shows that manufacturers that use Digital Prototyping build half of the number of physical prototypes as the average manufacturer, get to market 58days faster than average, and experience 48 percent lower prototyping cost (Aberdeen Group, 2006). Instead of needing to build multiple physical prototypes and then testing them to see if they’ll work, companies can conduct testing digitally throughout the process by using Digital Prototyping to catch design problems up front, therefore manufacturers often can reduce the number of physical prototypes they need to create before a product can be manufactured, reducing the cost and time needed for physical prototyping (Aberdeen Group, 2006).
Therefore, this paper seeks to illuminate on the viability of computer aided tools in enhancing prototyping in traditional ceramic production. The paper reviewed how computer aided applications have become very relevant in area of ceramic manufacturing such as traditional ceramics.

2. Background of Study

2.1 Ceramic Overview

Ceramics is the art and science of making useful products for man from inorganic, non-metallic materials by the action of heat and subsequent cooling (CTIOA, 2011). It can also be defined as heat-resistant, non-metallic, inorganic solids that are generally made up of compounds from metallic and non-metallic elements. Although different types of ceramics can have very different properties, in general ceramics are corrosion-resistant and hard, but brittle. Most ceramics are also good insulators and can withstand high temperatures. These properties have led to their use in virtually every aspect of modern life.
The two main categories of ceramics are traditional and advanced ceramics. Traditional ceramics are produced from materials that are obtained from common, naturally occurring raw materials such as clay minerals and quartz sand (Encyclopaedia Britannica, 2012). Traditional ceramics include objects made from clay and cements that have been hardened by heating at high temperatures. These include dishes, crockery, flowerpots and roof and wall tiles. Advanced ceramics includes carbides, oxides,

[1] Aberdeen Group Inc. is a provider of fact-based intelligent research, founded in 1988 trying to understand the implications and results of process innovation and methodology. They own Harte-Hanks Company (a marketing company, established in September, 2006).

nitrides and many other materials including the mixed oxide ceramics that can act as superconductors. Advanced ceramics requires modern processing techniques, and the development of these techniques has led to advances in medicines and engineering. The Figures below illustrates the difference and relationship between traditional and advance ceramics;

Figure 1: Illustration of the differences between Traditional and Advanced ceramic

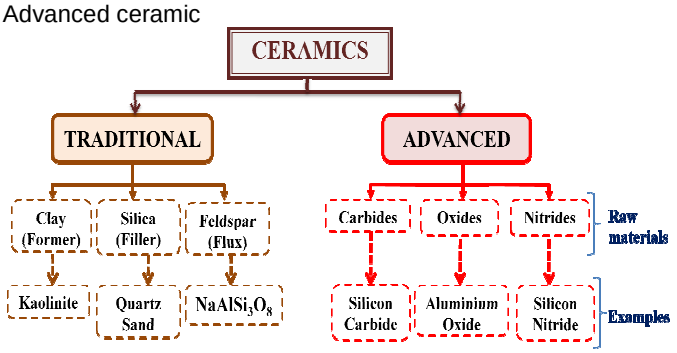
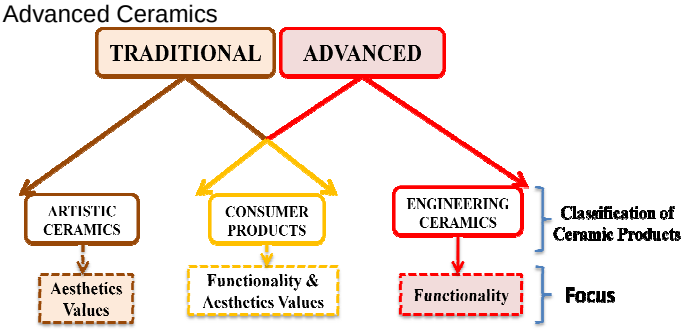


Figure 2: Overlapping relationship between Traditional and Advanced Ceramics



2.2 Historical Perspective of Computer Aided Ceramic Design

The concept of digital prototyping can be said to have being around for over a decade, particularly since software companies such as Autodesk began offering computer aided design (CAD) software capable of creating accurate 3D models (Wikipedia, 2012). According to John Terseko (2004), "Product Lifecycle Management (PLM) is an integrated, information driven approach to a product's lifecycle, from development to disposal". A major aspect of PLM is coordinating and managing products data among all software, suppliers and team members involved in product's lifecycle. While the concept of digital prototyping has been a longstanding goal for manufacturing companies for sometimes, it's only recently that digital prototyping has become reality for small to mid-size manufacturers that cannot afford to implement complex and expensive PLM solutions (Wikipedia, 2012).

According to Woodward (1996), as early as 1985, a research project was launched between Helsinki University of Technology and Oy Arabia Ab, the leading Scandinavian manufacturer of ceramic table wares, in order to apply computerised design techniques for Arabia's ceramic production. It was taken as a specific goal to produce a 3D CAD system to be used directly by the designers, instead of having to involve computer engineers in the creative design process. The 3D CAD system called Desk Artes IDS (Industrial Design System) was developed in co-operation with the design artists and tested during 1986-90 in several design exercises and authentic design projects. The software was commercialized by Desk Artes Oy in 1991 and it is now used by most leading ceramic table ware companies in Northern Europe (examples are Wedgewood, Royal Worchester, Royal Daulton, Denby, Rosenthal, Hutschenreuter, and Tools & Technologies), as well as glass table ware manufacturers around the world.

CAD is an extremely powerful and versatile tool at the disposal of today's designer. This is being used as and when appropriate for design process, involving the initial concept sketches where designer struggles for a solution while satisfying the constraints introduced by marketing and production. It features through presentation of drawings and visualizations; general arrangements and fully dimensioned detail drawings. Pipes (1990) observes that the integration of CAD into the design process at every stages as an enabling technology with enormous potential will transformed the role of designers, restoring to them the control and breath of perception over their design.

3. Prototyping

Prototyping is a fundamental design initiation which involves the construction of working models of conceived products for mass production (Adelabu, 2010). A prototype is the first or original example of product that has been or will be copied or developed; it is a model or preliminary version (Chua C. K. et al, 2003). According to Wikipedia (2011), a prototype is often used as part of product design process to allow engineers and designers the ability to explore design alternatives, test theories and confirm performances prior to starting production of a new product. For example, some prototypes are used to confirm and verify consumer interest in a proposed design whereas other prototypes will attempt to verify the performance or suitability of a specific design. Prototypes are also used to revise design for the purpose of reducing cost through optimizations and refinement.

There are two main modes of prototyping; Visual/Virtual Prototyping and Physical Prototyping. Visual Prototyping is the process of simulating the appearance, colour, size or shape of the intended design visually while physical prototyping is the building of a real model. The diagram below illustrates the types of prototypes described along the three aspect of implementation, form and quality.

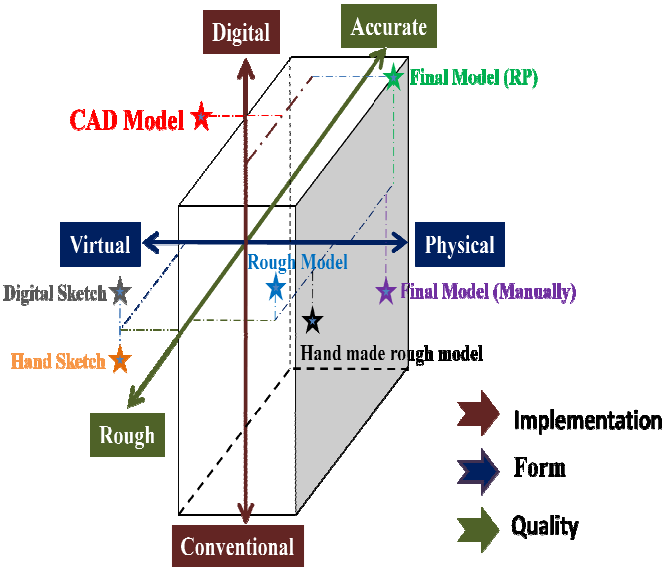


Figure 3: Types of prototypes described along the three aspect of implementation, form and approximation.

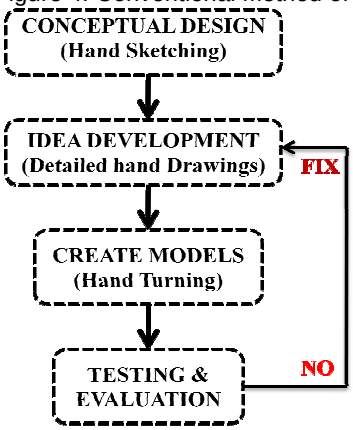
The roles Prototypes play in Product development Process includes;

- Experimentation and learning
- Testing and proofing
- Communication and interaction
- Synthesis and integration
- Scheduling and marketing

4. Conventional Method of Prototyping in Traditional Ceramic Production

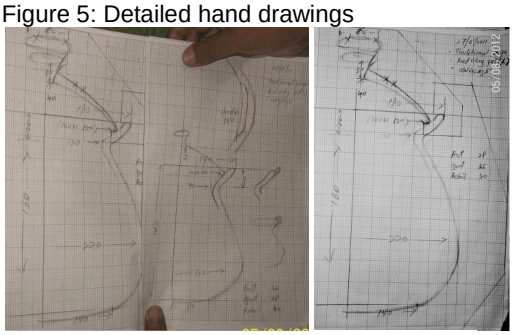
Conventional method of prototyping is the manual method used in product development. A visit to three ceramic factories in Kelantan state, Malaysia revealed that most traditional ceramic factories in Malaysia still use manual/conventional method for product development. The ceramic factories visited include; KESDEC Ceramic Factory in Pulai Chondong; Zutah Ceramic in Ceribong and Belipot ceramic in Bunut Payong. The three factories use the same conventional method for prototyping. The chart below illustrates the conventional method of product development used in the ceramic factories visited.

Figure 4: Conventional Method of Ceramic Product development



- Conceptual design: this is the first stage of product development process used in the three ceramic factories; it involves hand sketching of the conceptualized product idea.
- Idea Development: this is the second stage where the product idea is brought out into well dimensioned detailed drawings. The diagram below shows an example of detailed hand drawing developed at KESDEC ceramic factory.

Figure 5: Detailed hand drawings



- Creating Models: this is the stage where the physical models/prototypes are built using the detailed drawings produced at the idea development stage. Here, the three factories use hand turning method for creating models. The material use for creating models is plaster and they use turning wheel to bring out the shape. Fig 6 is the pictures of the turning wheel used and the prototypes created from the turning wheel.

Figure 6: Turning wheel and prototypes produced with it.

- Testing and evaluation: At this last stage, the models created are tested and evaluated by using it to product mould that will be use for mass production. If it removes easily from the mould, then it is ok if not, they iterate by going back to idea development stage to fix and rebuild the models.

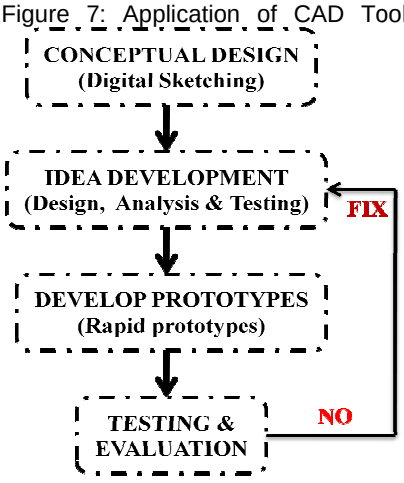
The brief participation, observation and interview at the three ceramic factories revealed that the conventional method used is time consuming, less accurate and also due to the hand turning method (subtractive method) used in creating models/prototypes, it waste a lot of materials and this directly or indirectly has effect on development cost. Also, the hand turning method used restricted them to only perfect round shapes for their product. This is because; other shapes will not be possible with this method. For them to create other shapes such as irregular curves or straight parts, they will have to use hand building method which is more time consuming and not accurate. Therefore, they produce ceramic product of circular and perfect round shapes.

5. Application of CAD Tools in Traditional Ceramic Prototyping

Computer Aided design (CAD) also known as Computer Aided Design and Drafting (CADD) is the use of computer technology for the process of design and design documentation (Wikipedia, 2011). It is a computer application developed as a form of automation that help designers prepare drawings, specifications, parts lists and other design related elements using special graphics and calculation intensive computer pragrams. This technology is used for wide variety of products in such fileds as architecture, engineering and industrial design.

The use of computer aided tools has impacted significantly in the execution of technological innovation in almost all spheres of industrial design products development. Computer aided designs (CAD) in ceramics production has been expressed through conceptualization of ideas to realization of processes in the production of ceramics prototypes that utilize drawing seed, quality production, quick modifications, production innovation, cost and time effectiveness (Woodward C., 1996). The scope of CAD tools has been extended to include the whole spectrum of design initiation and decision making through to technical design, with the subsequent link to the production plant and machinery (Online Columbia Encyclopedia, 2008). The chart below illustrates the application of CAD as tools in product development process in trditional ceramic.

Figure 7: Application of CAD Tools in Ceramic Prototyping

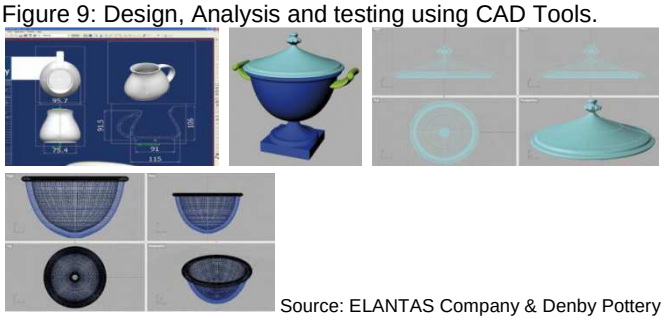


- Conceptual Design: At this first stage, with the aid of sketchpad, digital sketching can be use (see fig. 8). It's more easier, convenient and accurate.

Figure 8: Digital Sketches with sketchpad

- Idea Development: with the application of CAD tools such as Solid works, Solid Edge, AutoCAD etc; the product idea can be easily develop. This will include designing of the models (CAD Model), analysing and tesing the design to detect if there is any problem. The diagram below illustrate how idea development can be achieved with CAD application.

Figure 9: Design, Analysis and testing using CAD Tools.



Source: ELANTAS Company & Denby Pottery

- Developing Prototypes: Here, instead of using hand turning used in conventional method, rapid prototypes can be generated from RP-machine. Rapid prototyping is the automatic construction/fabrication of physical objects directly from CAD data sources, using additive maufacturing technology. Table 1 illustrates the different prototyping technologies and their base materials.

Table 1: Prototyping technologies and their base materials.

Prototyping Technologies	**Base Materials**
Selective Laser Sintering (SLS)	Thermoplastic & metal powders
Direct Metal Laser Sintering DMLS)	Alloy metals
Fused Deposition Modeling (FDM)	Thermoplastic, eutectic metals
Stereolithography (SLA)	Photopolymer
Laminated Object Manufacturing (LOM)	Paper
Electron Beam Melting (EBM)	Titanium alloys
3D Printing (3DP)	High performance composite

With the using of rapid prototyping, more accurate and perfect prototypes can be produced which will make final out product more competitive in the market.

- Testing and Evaluation: the rapid prototypes can then be tested and evaluate at this stage. Most times, this stage is not always necessary in digital prototyping since the design has been earlier analyzed and tested at idea development stage of the development process.

6. Potential of CAD Tools in Ceramic Prototyping

6.1 Introducing Better Modelling Techniques

CAD tools have now made it possible for ceramic designers to define their product ideas from the initial design stage when the ideas are conceived to the production stage when the idea is being executed.

Most of the CAD applications have been configured with a wealth of editing tools that support the generation of different shapes and curves at the most convenient level to interact with. With the way 3D CAD is made easy, most of the modelling interaction being concentrated in creative form is generated within the platform of the free-form curves. Therefore, product development is not restricted to some certain shapes.

6.2 Reduction in Development Cost and Time

According to Jeff Rowe (2006), digital prototyping changes the traditional product development cycle from “Design-Build-Test-Fix” to “Design-Analysis-Test-Build”. Instead of building multiple prototypes and then testing them to see if they’ll work, manufacturers can conduct testing digitally throughout the process by using digital prototyping to catch design problems up front. Therefore, by simulating and validating the real world performance of a product design digitally, manufacturers can reduce the number of prototypes they need to create and directly reducing the cost of product development and time.

6.3 Enhanced visualization

The appearances of ceramic products through CAD have been greatly improved for visual appreciation. In the marketing of ceramic products, computer graphic applications have been used particularly to improve presentation and communication. A visual image that bears a close resemblance to the finished product enhances the communication between designers and buyers, between sales and marketing, between buyers and stores and within departments and organizations.

6.4 Quality Models

The possibility of subsequently linking CAD data to rapid prototyping machine will greatly help in generating more accurate and perfect models. Also, object of geometric complexity or intricacy can be generated by the machine without need of final assembly.

7.0 Conclusion

The significance and modern applications of ceramic resources towards enhancing the built environment have been expressed through the potentialities of computer aided design packages. It is evident that there lie abundant ceramic raw materials in Malaysia which could be harnessed toward building a better environment (Ariffin K., 2009). With the current wave of technological advancement, these vast ceramic resources in Malaysia will remain grossly underutilized if computer aided design tools are not fully embraced and applied in ceramic production process.

With the various applications of CAD to ceramic designs, the abundant ceramic resources in Malaysia can be better explored with possibilities for improved performance in design processes and quality product delivery from the ceramic industries. This will position the industries to generate products that will compete favourably in the market in terms of functionality, ergonomics, aesthetics and other qualities that will also contribute to building a model environment. The proficient utilisation of the untapped treasures around us will certainly spur fresh discoveries that will break every barrier to innovation and hence accelerate product development towards a sustainable environment.

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