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Digital Prototyping: A Case Study on its Viability in Enhancing Small and Medium Ceramic Industries

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(Only author names, for other information use the space provided at the bottom (left side) of first page or last page. Don't superscript numbers for authors)

Abstract Small and Medium Industries are important to almost all economies in the world, particularly to developing countries and, within that broad category, especially to those with major employment and income distribution challenges. They contribute to the output and creation of jobs; also they are a nursery for the large firms of the future. Hence, this paper seeks to explore further on findings from previous research work which experimentally investigates the viability of digital and rapid prototyping in small and medium scale ceramic industries. The findings from the research revealed that digital and rapid prototyping are viable in reducing development time and improving prototype accuracy; however, the research shows that rapid prototyping is an expensive approach and thus, proposed conventional method of prototyping (hand turning and carving) to be still valid in small and medium ceramic industries. Therefore, based on these findings, this further research seeks to explore how digital prototyping can be used to enhance conventional method of prototyping. Rather than replacing conventional method with digital and rapid prototyping, this research tried to enhance the conventional method by integrating it with digital prototyping. The findings from this further research revealed that the conventional method of prototyping can be enhanced by integrating digital prototyping (3D CAD model) into development process as this will help designers/carvers to visualize products digitally throughout product development process, thereby communicating the whole concept and idea being proposed. Also, this will build their creative skills and make them think "outside the box" thereby making them capable of producing innovative and exclusive prototypes/products.

Index Terms— Ceramics, Computer Aided Design, Digital and Rapid Prototyping, Hand Turning and Carving, Pottery, Small and Medium Industries.

1 INTRODUCTION

Small and Medium Industries (SMIs) are important to almost all economies in the world, particularly to developing countries and, within that broad category, especially to those with major employment and income distribution challenges. They contribute to output and creation of jobs; also they are a nursery for the large firms of the future. SMIs are, on average a good deal less complicated structurally than are corporations and other large firms. Small and medium ceramic industries are firms that manufactures structured clay products, e.g. pottery, clay roof and floor tiles, clay bricks, e t c [1]; however, this research will focus on pottery wares (such as table wares, kitchen wares, and decorative wares). Pottery products play a very important role in our daily life. This is because, apart from their decorative look, they are primarily hygiene products. This is one of the chief reasons for their wide usage in homes etc. Therefore, pottery is seen as a sector which is able to generate local community economy as well as nation's economy.

The pottery industries has a long history, with the first instance of functional pottery vessels being used for storing water and food, being thought to be around since 9,000 or 10,000BC. However, the industry has been modernizing continuously, by newer innovations in product design, quality etc. Hence, the sector has a multi-business potential that are yet to be fully explored. Thus, this paper seeks to investigate how small and medium scale pottery industries can be enhanced with the application of digital prototyping. The research is a further study on findings from previous research work which experimentally investigates the viability of digital and rapid prototyping in small and medium scale ceramic industries. The findings from the research revealed that digital and rapid prototyping are viable in reducing development time and improving prototype accuracy; however, the research shows that rapid prototyping is an expensive approach and thus, proposed conventional method of prototyping (hand turning and carving) to be still valid in small and medium ceramic industries. Therefore, based on these findings, this further research seeks to explore how digital prototyping can be used to enhance conventional method of prototyping. Instead of replacing conventional method with digital and rapid prototyping, this research tried to enhance the conventional method by integrating it with digital prototyping. The findings from this further research revealed that the conventional method of prototyping can be enhanced by integrating digital prototyping (3D CAD model) into development process as this will help designers/carvers to visualize products digitally throughout product development process, thereby communicating the whole concept and idea being proposed and also help them to identify possible faults at the early stage of product development. Application of digital prototyping will also improve the prototype accuracy, build designers/carvers creative skills and make them think "outside the box" thereby enhancing them to be capable of producing innovative and exclusive prototypes/products.

2 Computer Aided Design

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 [2]. 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 [3]. 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 [4]. The application of CAD as tools in ceramic prototyping includes digital and rapid prototyping.

2.1 Digital Prototyping

Prototyping is a fundamental design initiation which involves the construction of working models of conceived products for mass production [5]. 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 [6]. Digital prototyping helps product developers to design, iterate, optimize, validate and visualize their products digitally throughtout the product development process [7]. Companies often adopt digital prototyping with the goal of improving communication between product development stakeholders, getting products to market faster and facilitating product innovation. Some of the CAD softwares used by designers for digital prototyping includes; AutoCAD, Siemens NX CAD, Auto desk Algo, Solidworks, Auto desk Inventor, Iron CAD, EPLAN Platform, Pro ENGINEER, Solid Edge, Catia.

2.2 Rapid Prototyping

Rapid prototyping is the automatic construction/fabrication of physical objects directly from CAD data sources, using additive maufacturing technology. These systems add and bond materials in layers to form objects, and they are known by the name additive manufacturing, additive fabrication, three dimensional printing, solid freeform fabrication (SFF) and layer manufacturing [8].
With this additive technologies, object can be form with any geometric complexity or intricacy without the need for elaborate machine setup of final assembly [9]. Also, rapid prototyping systems reduce the construction of complex objects to a manageable straight forward and relatively fast process. This has result in their used by engineers as a way to reduce time to market in manufacturing, to better understand and communicate product designs, and to make rapid tooling to manufacture those products. Surgeons, architects, artist and individuals from many other disciplines also routinely use the technology.

3 PREVIOUS RESEARCH

The previous research used Kelantan traditional pottery production as a case study, it investigated and illuminate on the systematic process used by Kelantan Potters for production. This was achieved by several visit to three pottery centre in Kelantan and the outcome of this revealed how Kelantan potters create models by hand turning or carving the concepts in plaster (POP) using turning wheel [10]. However, despite the prodigious skills of the carvers, the method never produced accurate models [11]. Therefore, the researcher proposed that replacing the conventional method with digital and rapid prototyping will help to reduce the development time and also improve the prototype accuracy. In order to test the viability of this proposed method, digital method of product development was developed which has four stages has illustrated in Fig. 1 below, after which the method was used to develop and produce a ceramic product (see Fig. 2).

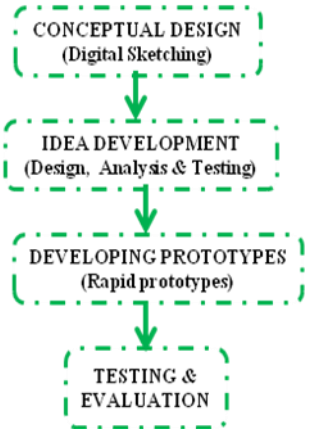

Figure 1: Digital method of product development

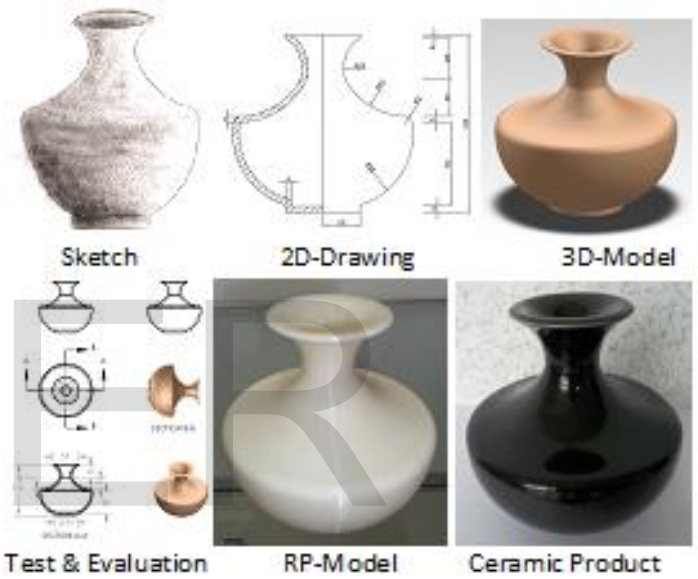

Figure 2: Picture illustrating the product created using digital method

The findings from this previous research revealed that digital and rapid technology is a viable tool for reducing development time and enhancing prototype quality (accuracy), producing exclusive designs and durable prototypes. However, the research shows that rapid prototyping is an expensive approach, and thus, proposed conventional method of prototyping (hand turning and carving) to be still valid in small and medium ceramic industries. Therefore, based on these findings, this further research seeks to explore how digital prototyping can be used to enhance conventional method of prototyping.

4 FURTHER STUDY

On the basis of these previous findings, further research was performed to explore how digital prototyping can be used to enhance the conventional method by improving the accuracy and also help designers in producing exclusive designs. This was achieved by first developing exclusive "handle free mug" design.

4.1 Design Stage (Using Solidworks software)

During the design process, there were several iteration before finally arriving at the final design (see Fig. 3). The first product idea produced was Design A, after which the design was improved on

and the result of the improvement is design B. However, after visualizing the design, few adjustments were made which result to design C. Design C was first taken as the final design, but during testing and evaluation, some fault were identified which will prevent it's manufacturability. Therefore, these faults were addressed and this brought about the final design (D). This is one of the advantages of digital prototyping because, it utilizes drawing seed, quality production, quick modifications, production innovation, cost and time effectiveness [3]. Therefore with digital prototyping, designers can visualize design, explore design alternatives, verify suitability of design, test the manufacturability of the proposed design and virtually explore a complete product before it's produced.

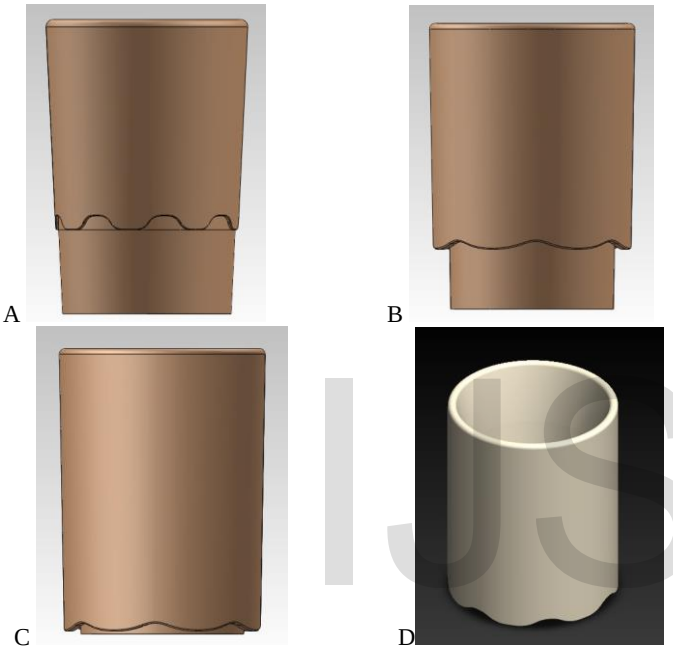

Figure 3: Pictures illustrating the development of product idea

4.2 Test and Evaluation

After creating three dimensional design of the product, they were tested and evaluated at this stage to determind their manufacturability. The test includes draft analysis which was done digitally using Solidworks software; the important of the draft analysis is to identify the possible fault that may prevent the model from demoulding during the casting process. Colours are used in draft analysis; green represents positive draft, red represents negative draft while yellow represents parts that needs draft. When the design draft was first analyzed, some parts were yellow which means they need adjustment for easy de-moulding (see Fig. 4). Therefore, the faulted parts were adjusted and re-analyzed (see Fig. 5).

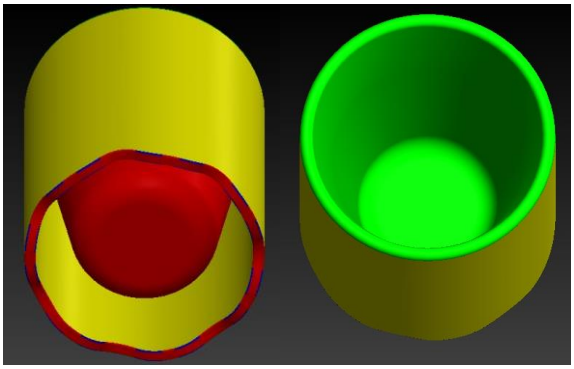

Figure 4: Draft analysis of design

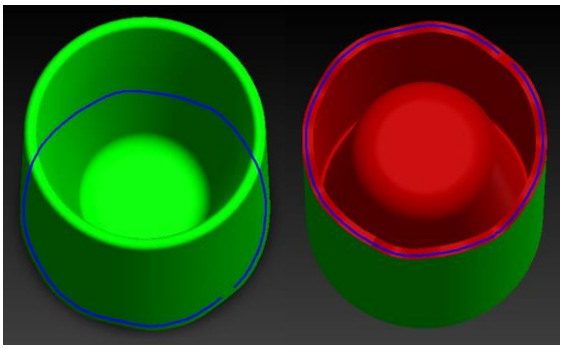

Figure 5: Re-Analyzed design

After the draft analysis, the design was evaluated by showing the different projections and sectional views of the design (see Fig. 6). After which the evaluated design was printed and given to the carvers to produce the prototype using conventional method.

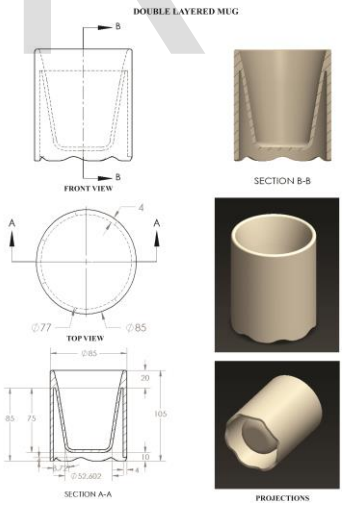

Figure 6: Evaluated design

4.3 Creation of the Model (using conventional method)

Due to the extensive drawing given to the carvers, they got the clear view of the design and were motivated to produce the prototype using conventional method. After producing the prototype, it was evaluated. The evaluation revealed some imperfection at the edges of the conventional model. Therefore, in order to address this imperfection, template of the product were designed with Solidworks, printed to scale on a cardboard paper and the paper was cut to the exact shape of the template (See Fig 7). Then, the paper template was folded round the model (see Fig. 8) so as to guide in cor-

recting the imperfection. After the corrections were made, the model was found to be almost 100% accurate (see Fig 9). The model was then used to create the plaster mould (Fig. 10) for mass production.

Figure 7: Picture of the paper template

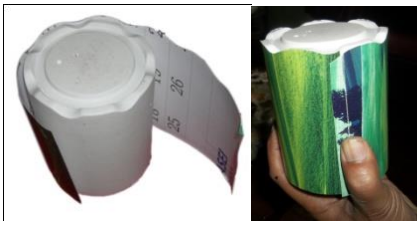

Figure 8: Template folded round the model.

Figure 9: Picture of the final model produced with conventional method

Figure 10: Picture of the Mould

CONCLUSION

Since building of rapid prototype from CAD model has been proven to be expensive in previous research; this research revealed that the conventional method of prototyping can thus be enhanced by integrating digital prototyping (3D CAD model) into development process. This will help designers to explore design alternatives, verify suitability of design, test and evaluate design to identify possible faults. It will also help in visualizing products digitally throughout product development process thereby communicating the whole concept and idea being proposed. This will build designer's creative skills and make them think innovatively, thereby making them capable of producing good and exclusive products.

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