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12

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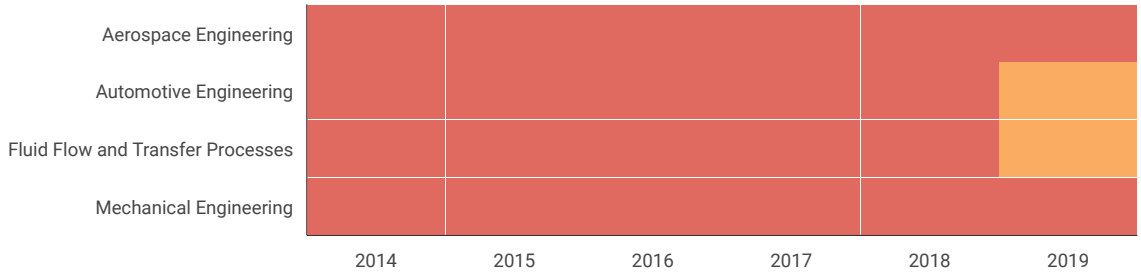

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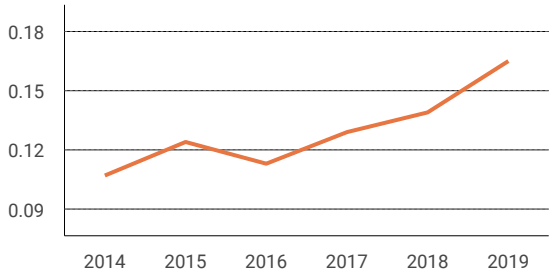

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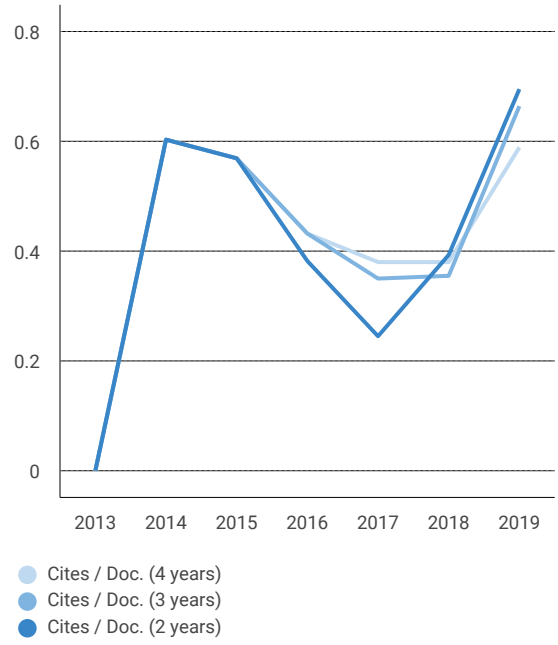

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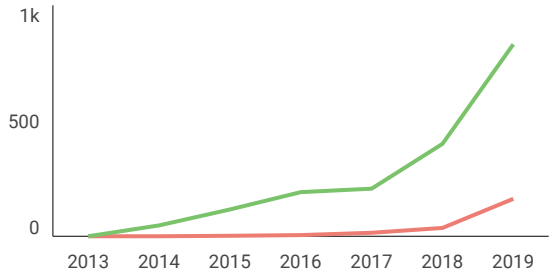

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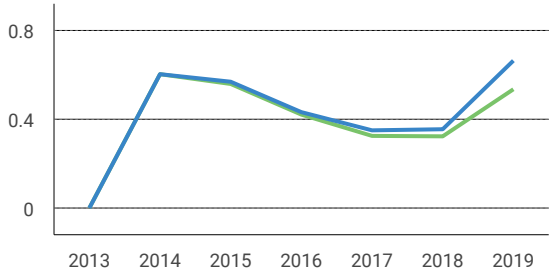

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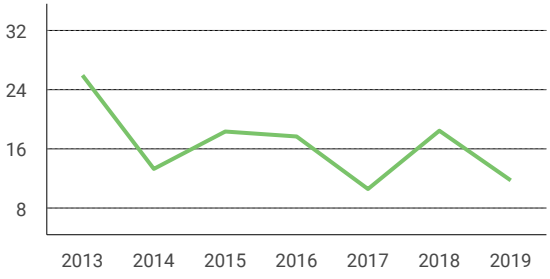

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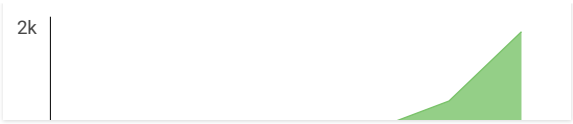

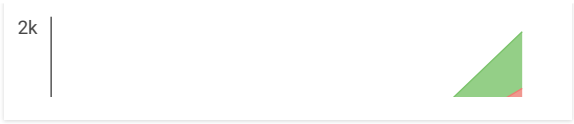

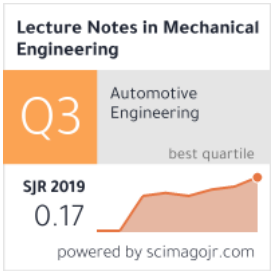

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Lecture Notes in Mechanical Engineering

Ubaidillah Sabino
Fitrian Imaduddin
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Proceedings of the 6th International Conference and Exhibition on Sustainable Energy and Advanced Materials

ICE-SEAM 2019, 16–17 October 2019, Surakarta, Indonesia

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Contents

Ceramic Jewelry with Texture and Ornament Islamic Pattern and Batik Indonesia—Design, Manufacturing, and Fabrication

P. K. Fergiawan, P. W. Anggoro, A. T. Yuniarto, K. B. Purwanto, and O. D. W. Widyanarka

Abstract The development of science and technology has become important to grow the manufacturing industry in Indonesia and this is characterized by high consumer demand for customized product designs that are precise, accurate, and detailed on complex ornaments or textures and have high selling value in the industrial market. This paper discusses and demonstrates the application of modern computer-aided engineering system (CARESystem) technology in the process of designing—manufacturing ceramics jewelry at the ceramic company PT. Indonesian Nuanza porcelain. Batik and Islamic patterns are chosen as the basic texture for pendant products. The design process uses Zbrush to get 3D CAD models for ceramics jewelry. The process of manufacturing optimization on CNC machines using computer-aided manufacturing (CAM) software PowerMill 2016 and Rhinoceros 4.0. The results of the research show that the optimal processing time and quality of machining in CNC machines is the use of a toolpath strategy horizontal roughing, and parallel finishing in Rhinoceros 4.0 for roughening and semi-finish processes. Toolpath strategy model area clearance, optimize constant z, and step and shallow finishing at PowerMill 2016 for the finishing process. Production time can be increased to twice compared to manual technology.

Keywords Jewelry ceramics · CARESystem · CAD · CAM · CNC

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1 Introduction

The Ministry of Industry of the Republic of Indonesia in 2018 stated that the development of science and technology became important in order to grow the manufacturing industry and this was marked by high consumer demand for customized, accurate, and detailed design of customized products against ornaments or complex textures and had high selling points in the industrial market [1]. Manufacturing industries include machine tools, aircraft, automotive, ceramics and so on. The ceramics industry in Indonesia, in general, is an industry that is growing quite rapidly and promising, especially industries that make ceramic products that give different touches with the addition of textures or ornaments with varied motifs [1]. Ceramics took from Greek, namely "KERAMIKOS" which has the meaning of burning material. In general, ceramics have refractory properties that can maintain their properties which are useful in very severe conditions due to high temperatures and contact with corrosive materials compared to superalloy materials which tend to have brittle properties. This property arises due to the mixing process of kaolin, quartz, feldspar in the heat treatment process that occurs at high temperatures (firing) [2]. The use of ceramics in everyday life is increasingly developing and varied and influences the lifestyle of the users. This happens because ceramic materials can produce products that are unique, competitive, precise, accurate and can be combined with various colors and other aspects of life according to the development of current technological advancements [3].

Manufacturing of engineering ceramics extends beyond the pure processing science which is specific for different materials. Manufacturing must equally respect economic and technical boundary conditions to select a processing cycle capable of producing ceramic components based on a set of requirements predefined by the application in terms of reproducibility, performance, and cost. The science of ceramic manufacturing in a competitive global environment must thus combine elements of basic material science, engineering and business economics [5].

Previous researchers [4] successfully combined artistic ceramic process technology to create jewelry manually which was not based on artistic computer-aided design (ArtCAD). This merger connects the unique technological variations (narikomi technique) from artistic ceramics with metal material in the development of the bird ring jewelry product. But the design process from it is not based on the use of artistic CAD technology that is capable of producing designs jewelry in many variations and precision and accuracy. The product formed is indeed unique and artistic, but if done in bulk, the geometric quality that the customer wants is impossible to achieve.

This research wants to demonstrate the ability of modern artistic technology based on a computer-aided reverse engineering system (Art CARESystem) in the process of designing—manufacturing—fabricating ceramics jewelry in Indonesian ceramic companies. The products produced in this research are jewelry necklaces with texture motifs typical of Islam and Indonesian batik but are produced in large quantities with texture geometry that is precise, accurate and complex in detail. This paper also explains the real problem conditions faced by PT Nuanza Porcelain Indonesia,

an Indonesian national ceramics company that seeks to develop rapidly as a creative industry to produce unique ceramic products, has high selling value, is able to compete in the global market and always prioritizes the aspects of the womb local Indonesian by giving unique characteristics of textures and ornaments to each product (ceramic tableware, ceramic tile, and ceramic jewelry).

2 Material and Method

3D CAD artistic models of ceramic jewelry done in this paper are shown in Fig. 1. Three materials used in the processing of jewelry ceramic products, namely yellow gypsum, white gypsum, and china ash bone (see Fig. 2).

Gypsum material with a size of 350 mm × 250 mm × 15 mm if you experience the combustion process with a temperature of 1250–1400 °C, the characteristics change with a smooth, white, and hard texture [2]. Gypsum which is burned with low temperature is called soft gypsum (white) while the one that is burned with high temperature is called hard gypsum (yellow). Gypsum is a material that is often used in the ceramic industry because this material has a good strength structure [2]. Yellow gypsum is used to create jewelry ceramic mold master patterns, while white gypsum is used to make jewelry ceramic mold patterns. The china ash bone [2] material is white, with a smooth profile, and is strong with transparency. This material has fewer plastic properties which result when the material is processed by casting techniques,

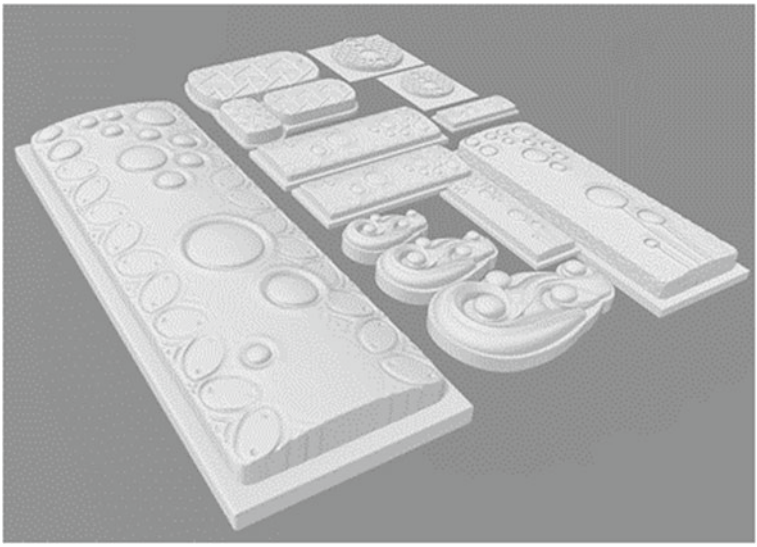

Fig. 1 3D CAD master pattern of jewelry ceramic molds

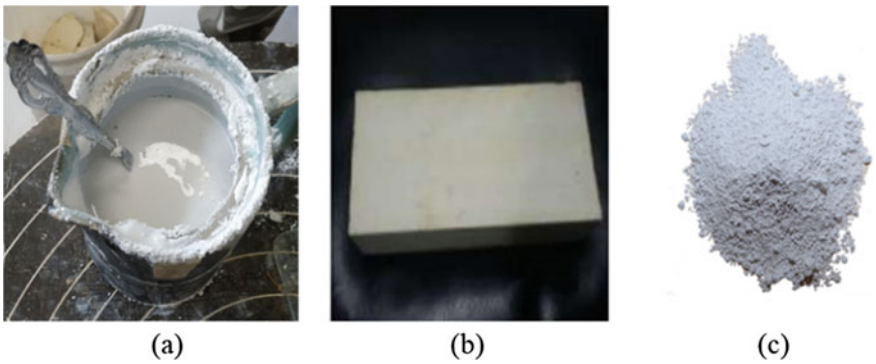

Fig. 2 Material of jewelry ceramic: **a** white gypsum, **b** yellow gypsum, **c** China ash bone

this material has difficulty. This material is used to make the pendant through the combustion process at a temperature of 1040–1080 °C.

Fabrication of jewelry ceramic products in this paper starts from the stage of making 3D designs using CAD z-brush software. The output generated is a 3D CAD model in the .stl file format. Providing work axes in 3D CAD models is necessary for research so that designs in CAD can be manufactured using CAM software (Rhinoceros 4.0 and PowerMILL 2016). Work axis granting verification is done using Netfab 2017. In this paper, the master machining process of the Jewelry Ceramic mold pattern (see Fig. 3) uses a CNC machine (see Fig. 4a) and two type cutter milling,

Fig. 3 Master pattern of jewelry ceramic molds

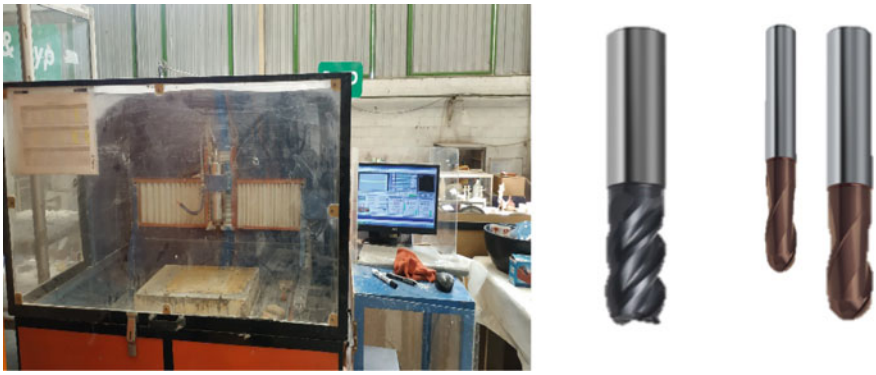

Fig. 4 Machine and tooling research: **a** CNC machine; **b** End Mill; **c** Ballnose

namely Endmill (see Fig. 4b) and Ballnose (see Fig. 4c). This mold pattern will later be poured white gypsum material into the pattern of jewelry ceramic prints (see Fig. 5). The pattern of the mold is then in the oven to be hard and can be used repeatedly.

The process of pouring china ash bone (liquid) into the pattern of jewelry ceramic prints takes 15 min and is heated for 4 h until it becomes a pendant. The final stage of the fabrication process is to assemble the pendant with Korean rope, and other additional accessories. The stages of the design, manufacturing, and fabrication of ceramic jewelry in this paper are presented in Figs. 6 and 7.

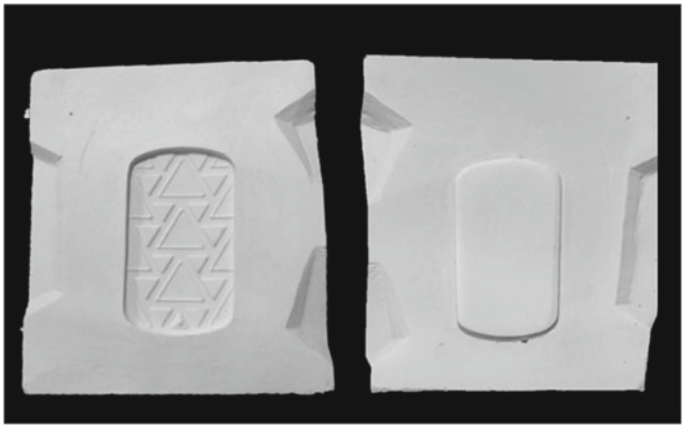

Fig. 5 Patterns of jewelry ceramic molds

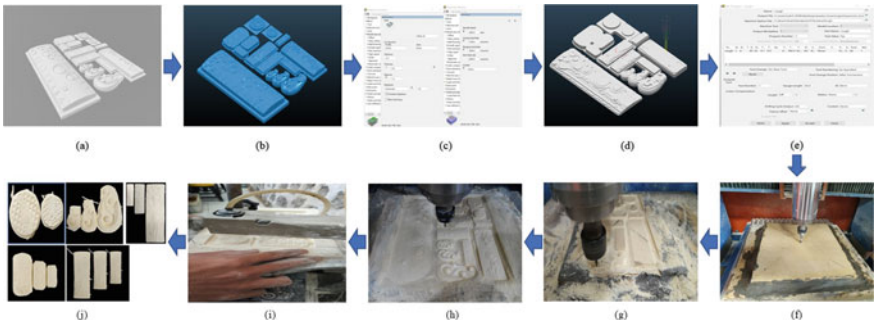

Fig. 6 Manufacturing process of jewelry ceramic using PowerMILL 2016: **a** 3D CAD Jewelry Ceramic, **b** import Model to PowerMill 2016, **c** input parameter condition, **d** simulation in PowerMill 2016, **e** process NC-Code, **f** roughing process with CNC milling retrofit, **g** semi-finishing process with CNC milling retrofit, **h** finishing process with CNC milling retrofit, **i** cutting process master patterns of jewelry ceramic molds with sawing machine, **j** results of the master pattern of jewelry ceramic mold that have been cut

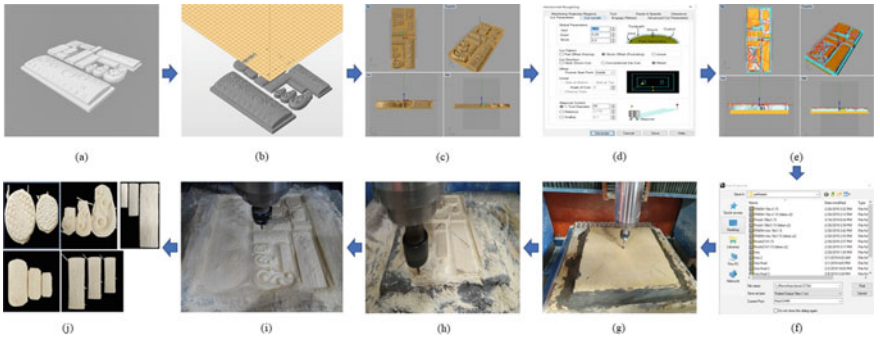

Fig. 7 Manufacturing process of jewelry ceramic using Rhinoceross 4.0: **a** 3D CAD Jewelry Ceramic, **b** import Model to NetFabb 2017, **c** import model to Rhinoceros 4.0, **d** input parameter, **e** condition simulation in Rhinoceros 4.0, **f** input NC-Code, **g** roughing process with CNC milling retrofit, **h** semi-finishing process with CNC milling retrofit, **i** finishing process with CNC milling retrofit, **j** results of the master pattern of jewelry ceramic mold that have been cut

3 Result and Discussion

This paper demonstrates a stage of the manufacturing process—fabrication of CARESystem-based ceramic jewelry [3, 11]. CARESystem technology infrastructure consists of two units, namely the mold pattern master formation unit (see Fig. 3) including Artistic CAD (Zbrush); Manufacturing optimization uses two CAM software (PowerMILL 2016, Rhinoceros 4.0) and retrofits CNC machines. The second unit is ceramic fabrication technology with kiln kitchens (see Fig. 8). The textures of the Islamic pattern [5] and Indonesian Batik have more floral patterns displayed by researchers on both surface jewelry ceramics (see Figs. 3 and 5). Figure 2.5D CAD

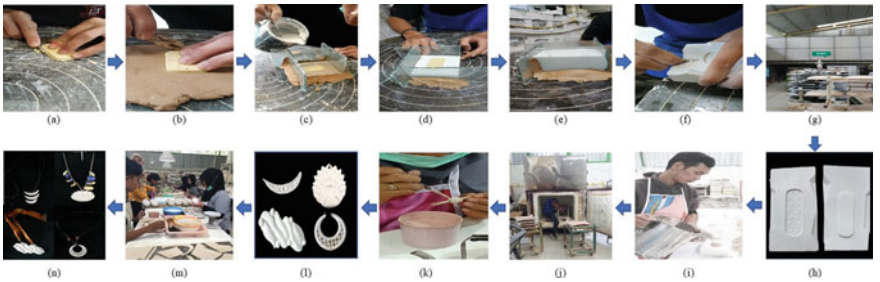

Fig. 8 Fabrication process of jewelry ceramic: **a** cutting process master patterns of jewelry ceramic molds with the contours, **b** cribbing process master patterns of jewelry ceramic molds on clay, **c** White Gypsum pouring process on the master pattern of jewelry ceramics molds (Core), **d** cribbing process the bottom of master patterns of jewelry ceramic molds, **e** White Gypsum pouring process on the master pattern print (Cavity), **f** process of making a Champers and locks in a molds, **g** Combustion Process 1, **h** Core and Cavity Jewelry Ceramic products, **i** China ash bone pouring process on the jewelry ceramic molds, **j** Combustion process 2, **k** glazing process, **l** Leontine of jewelry ceramic, **m** assembly process, **n** jewelry ceramics product

texture models can be displayed with perfect results thanks to the use of Zbrush CAD artistic software (Fig. 7).

The stages of jewelry ceramic design take patterns with Islamic pattern textures as they were successfully introduced by [6] and presented in Fig. 9, and Indonesian batik is done using CAD Zbrush 4R7 software. This software has advantages in the scaling process quickly, precisely and artistically compared to other CAD software: artCAM, Autodesk fusion 360, solid work, master cam. ZBrush is an artistic CAD software that can support users can draw illustrations in the form of 2.5 dimensions and 3

Fig. 9 Examples 3D CAD model with Z-brush

dimensions where the techniques applied in this software are sculpting techniques. Sculpting techniques are the process of product design such as sculpting sculptures, artistic ornamental objects (see Fig. 9) and having the function of creating objects that can display details of products that cannot be used with 3D modeling techniques [7].

In this paper, the CAD design process is different from that done by Kutsenko and Arventyeva [4] where here the direct physical model was designed using Zbrush by a CAD engineer at PT. NPI until 3D CAD models were obtained in the .STL format. Using the right artistic CAD software like Zbrush can optimize and improve the product before the machining process. The form of products with ornaments or textures as desired by the customer can be quickly done by the CAD engineer until the manufacturing stage in CNC or 3D printer machines. High-tech computer technology can increase the speed of 50–70% in the development of ceramic products [8]. The care system application in this paper can improve the design time of ceramic jewelry products less than 50% better than with manual methods.

This paper also demonstrates the stages of the CAM-based manufacturing optimization process using PowerMill 2016 and Rhinoceros 4.0 (see Figs. 6 and 7). The use of PowerMill was conducted by researchers to obtain a surface quality of jewelry better than Rhinoceros 4.0 as had been done by [11, 12] in the optimization of manufacturing insole made from EVA Foam rubber. Modern CAM systems (PowerMILL; Solid edge; MasterCAM, SolidCAM) can produce tool paths based on the conditions of the most constant geometric bonds that may occur in addition to conventional predetermined trajectory divisions [9, 10]. The selection of PowerMill in this paper is due to the needs of the NPI which wants the surface quality to be smoother and more assertive, in addition to the many choices of tool path strategies displayed by PowerMILL compared to other CAM software.

In this paper, the path strategy tool used is divided into three stages, namely roughing, semi-finishing, and finishing [11, 12]. Model area, Raster Finishing Clearance, and Step and shallow were chosen as the optimal path strategy tool in the execution of the master pattern master ceramics jewelry. These three strategies have also been used by [12] with success in carrying out shoe last made from Ebalta wood with the results of 95–98% geometry following the 3D CAD model shown. As a comparison to show the quality of machining results, we also use the path strategy tool from Rhinoceros 4.0, i.e.: Horizontal Roughing, and parallel finishing [13, 14]. Deepa and Jayesh [13] also uses these two Rhinoceros strategies in their research in ring jewelry machining processes based on CAD 3D jewelry. Toolpath of the two software simulations is able to display the best workmanship quality in CNC machines, but after testing on retrofit CNC machines in PT. NPI, proven Roughing Horizontal strategy, and parallel finishing of Rhinoceros used for roughing and semi-finish work to catch up time the manufacturing process and dept of cut are high, while the pursuit of the target surface is smoother and the contours of the texture built can be in accordance with the 2.5 CAD image used Step and shallow at Power mill 2016 as a toolpath strategy for Finishing.

CNC Retrofit machines (see Fig. 4a) are used in this paper to process yellow gypsum as raw material into master mold patterns (see Fig. 2b) ceramics jewelry

with a variety of textures that can be displayed. For the milling chisel movement to be controlled properly by CAM and able to get the textural quality as desired, a communication bridge is needed in the form of a post-processor on a CNC machine. This bridge is in charge of reading the NC Code [15–20] which has been copied by CAM. The language displayed in this NC Code can move the cutter milling to process the grinding of workpieces according to the toolpath designed by CAM engineer PT. NPI.

Ceramics jewelry is a type of product with complex and complex contour detail. To obtain the surface geometry quality that is following the results of the drawing, machine tools are needed with good manufacturing subtractive technology. The use of CNC high-speed machining machines as has been done [8, 15] in this paper is used to maximize engine speed to obtain products with a fast time and the best product quality. The CNC HSM engine is usually in the range of RPM 10,000 and above, while the CNC retrofit in this paper is capable of reaching 23,000 rpm. Antunes uses HSM to obtain ceramic tableware and sanitary products, while research is being carried out at this time to obtain master pattern prints for ceramics. This research also demonstrates the application of machining process techniques using subtractive manufacturing technology which aims to reduce machining time and the quality of machining results on CNC product surfaces (texture and ornaments produced in more detail, precision, and precisely by following 3D artCAD images).

Mater mold pattern (see Fig. 5) then carried out the fabrication process with modern casting technology at PT. NPI as shown in Fig. 8. The final result of the fabrication process is a pendant (see Fig. 10) which is then assembled with several supporting components such as Korean rope and accessories become pendant necklaces (see Fig. 8n). The Glassing technique is also used in this paper to beautify the shape of the pendant so as to increase the selling value of the product (see Fig. 8k). The work on ceramics jewelry using manual technology at PT. NPI currently takes 7–10 days per one design model (design-manufacturing-fabrication). After the use of modern

Fig. 10 Examples of jewellery ceramic pendants

CARESystem technology, the process of jewelry ceramic takes only 3 days, resulting in a reduction in the production time of around 50% and an increase in production to double than before.

4 Conclusion

The modern CARESystem technology in this paper can increase product design—manufacturing—ceramics time around 50% compared to the manual technique that has been used by PT. NPI and other traditional ceramics industries in Indonesia.

Products made with CARESystem technology can produce products with detailed and precise contours when mass-produced, when compared to using manual technology. The results of this research can also be used as a reference in the construction of other ceramic-based products such as tableware, sanitary, wall ornaments.

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