

A Study of Resin as Master Jewelry Material, a New Alternative Material to Perform Higher Complexity and Surface Quality of Jewelry Master using CNC

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Abstract. Resin material for jewelry master is widely used in the application of 3D printing, but the surface quality is limited and long processing time. On the other hand, jewelry modeling wax is commonly used in conventional jewelry carving, so that high quality master is made with fully controlled process from skilled person. The need of production speed requires tools that work automatically such as CNC. Problems occur when speed and high surface quality is required. In that condition high speed spindle is used with low feeding speed, as a result is high temperature in cutter-material area will melt the wax and create a built-up edge (BUE) on the cutting tool. Due to the existence of BUE, the cutting tool will no longer cut the wax but sweep it, as a result the wax will then melt due to friction and break the relief. Research is then conducted to solve problem and use resin to replace the use of wax. CNC is used to cut resin as comparison of 3D printing, and as a result better quality of surface and detail relief can be perform but another problem occurs such as dusty, bad smell, and other environmental problems.

Keywords: CNC, jewelry, jewelry master, jewelry wax, resin

1. INTRODUCTION

In a jewelry production which use investment casting process, a master is a most important part. The master product should have high quality either on surface or geometry. Traditionally a master is made by a high skilled craft man, but recently it is made by using a CNC or rapid prototyping machine.

In a product which have small sized, complex and detail relief, high quality surface finished is very difficult to achieved. Due to material properties, brittleness and melting point and grain size is sometimes become obstacles.

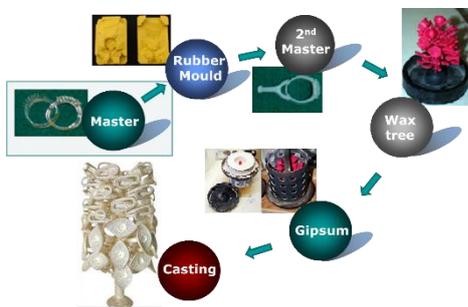


Figure 1: Jewelry production process using investment casting (Puspaputra 2012).



Figure 2: Sample of complex and detailed relief ring.

A simple method that usually used in jewelry production is by using rapid prototyping machine or 3D printer.



Figure 3: Jewelry master using rapid prototyping machine (Digital Wax 2016).

It is shown that 3D printer can realized complex and detail relief, but if we see more detail, due to its process, the surface finished is restricted by the step or layer thickness. The thinner the layer, the better the surface finish but the longer process is needed.

Another alternative is by using CNC. Complexity of product that could be realized using the CNC are depend on the axis number of CNC, supporting jig and also machining strategy that defined by operator.



Figure 4. Jewelry master using CNC machine

2. MASTER MODEL OF JEWELRY

Master model is one of the most important parts of the jewelry industry. A good model maker must know all the processes of jewelry manufacturing, including design, cast, polish, and stone setting (Goulds Jewelry, 2016).

All of those parameters should be taken into account, design, stone setting, and cast must be analyzed in the design process either using engineering intuition or application software such as computer aided engineering (CAE). Since jewelry is made of precious metal, it is required to minimize polishing process to achieve its surface quality.

From the illustration above, high quality surface is very important for a jewelry master model. It is not only reducing

the polishing chip, but also improving the relief quality.

2.1 Master Model Manufacturing

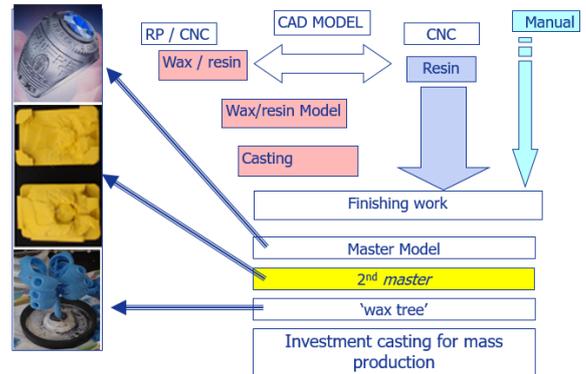


Figure 5: Jewelry master making alternatives.

Master model of jewelry can be made by using the process shown in fig. 5. above. Depends on the relief complexity and production schedule, a wax (or resin) master can be prepared by manual, CNC or rapid prototyping machine.

In CAD/CAM based application, jewelry making is started using modeling wax or resin as material after its model is developed using digital modeling. Most are using rapid prototyping (RP) machine since it is very simple in implementation. The disadvantage is that the price is high and surface quality depends on its layer thickness. Thinner layer is better in surface quality, but thinner layer is longer time processing which will affect production time.

Another way is using the CNC machine. Compared with RP machine, this machine price is not expensive but it need high capability operator to handle. It can also produce product with better surface quality than those with RP machine.



Figure 6: Jewelry master preparation process. (Crow) (Ganoksin).

In process which surface quality is not enough, master

jewelry preparation need further process to achieve its surface criteria as shown in fig. 6. Things that should be note here is that there are possibilities in dimensional changes that may affect relief geometry as well as stone setting due to thermal deformation and finishing process.

In the utilization of CNC machine. Jewelry master can be produced directly after machining, so that deformation and relief geometrical changes can be minimized (puspaputra 8797).

2.2 Jewelry Master Model Material

In the utilization of CNC machine. Jewelry master can be produced from resin or mostly modeling wax.

2.2.1 Polyester and Polyurethane Resins



Figure 7: Sample of resin products (Art Mold 2016)

According to Art Mold 2016, Polyester and polyurethane resins are the most commonly used casting material available. The polyester resin used in the molding application is a viscous liquid requiring the addition of catalysts and accelerators to complete the curing process. Polyester resins are contact products which require no pressure to cure and can be cured from a fluid or solid state.

The advantage of polyester resin is that it is easy to use and is the lowest cost resin among resin products. However, there are a number of critical disadvantages in lack on mechanical properties and are less water resistant than polyurethane resins. The flash off of styrene during the curing process causes a fairly large degree of volumetric shrinkage, the full extent of which is often difficult to predict. Styrene emissions are also harmful and may necessitate the institution of specific, often expensive, environmental safety measures balance off ease of use, low cost, and positive physical characteristics.

In many cases, polyurethane resin is produced in a liquid form and can be poured into molds.

There are many advantages to polyurethane resins. It can

be formulated to create pliable rubber molds such and then be made into a hard plastic casting material or a water clear casting material. Though polyurethane costs a bit more to manufacture, they have significantly better mechanical properties (stronger and more tear resistant), more importantly the emissions are extremely low when curing, and thus far safer to be around.

2.2.2 Jewelry Modeling Wax



Figure 8: Types of Jewelry modeling wax (Freeman 2016)

Most of commonly used material for Jewelry CNC is wax. Most CNC cannot produce product as it is designed, hence further process is needed to meet the design with real product. Using wax material, improvement can be easily done.



Figure 9: Sample product using jewelry wax (How I Made Things Project 2016)

Disadvantages of jewelry wax is that there is electrostatic that is produced during machining process, so that the chip stuck in the product, and demagnetization is necessary to remove the stuck chips from product. The other important is that wax is fragile, so that high clamping force will break it.

2.3 Research and Experiment



Figure 10: Digital model to be machined

Due to their material characteristics, machinability, and geometrical parameter, it is studied performance of resin vs modeling wax to be used as jewelry master for high detail and complex geometry. The main criteria to be achieved is achievement of geometric, and surface quality. The cutting tool that used in this machining is end mill 3mm in diameter for roughing processes and conical tool with 7 degrees in half angle with 0.1 mm tip diameter for finishing

2.2.3 Wax Machining

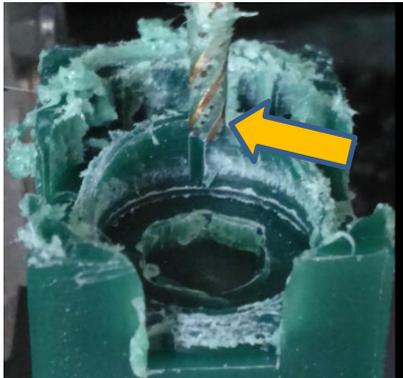


Figure 11: Build-up edge and melting phenomena

Machining wax for complex surface found problems from roughing to finishing. Roughing process is done to cut as fast as possible to achieve closest required geometry. Problems found when end mill with 4 flute is cutting the wax. The temperature occur during machining is higher than melting temperature, so that built up edge (BUE) is formed and cover the cutting edge of the tool. Due to the BUE, the friction is increase and material is melt as shown in figure 11.

To avoid that condition cutting speed is then decreased, but due to the machining process which achieved final form, the material become thinner and cannot hold the clamping force. Crack due to clamping force occur and broke the relief.

If clamping force is reduced to avoid crack than cutting force will push and shift the work-piece make it broken also.



Figure 12: Crack due to over clamped

2.2.3 Resin Machining

Learning from the experience, the use of resin was tried to realize the design, and the result is shown in fig. 13.



Figure 13: Machining result with resin as material



Figure 14: Dirty and dusty environment due to resin chip.

It can be seen that resin can perform design very closed and clear to the digital model, but environmental problem appear since resin chip is very dusty and may dangerous to the working environment.

Resin material is result of solidification process of viscous resin, hence it become dust when it is cut. The dust either in small grain or flying grain. The small grain can easily be collected in a container, but the flying grain may enter to the respiration apparatus of human.

Vacuum cleaner cannot be used to overcome this problem because the flying grain can pass through the cleaner's filter and move-out through motor fan and fly again. They are not only make the environment dirty but also dangerous for the respiration of human around them.

3. Conclusion

The use of resin as jewelry master material can replace the wax successfully to perform geometric requirement, but environmental and safety problem occur due to its flying grain.

4. Future Work

It is necessary to overcome the flying grain by making research to "catch" the grain and move it to the container.

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