Optimization of Gating System in Jewelry Investment Casting: A Review

Jyotsna Sinha[1], Nilesh Ghongade[2] & Madhukar Sorte[3]

[1] P.G. Student, SCOE Kharghar, Navi Mumbai, INDIA
[2] Asso. Professor, MHSSCE, Mumbai, INDIA
[3] Asso. Professor, SCOE Kharghar, Navi Mumbai, INDIA

*[*] Correspondence: E-mail: sinhajyotsna2003@gmail.com*

ABSTRACT: Investment casting is a foundry process specially applied to jewelry and for complex metallic shapes to be produced in volume. As the metal and materials used in this process are very precious so getting defects after casting is huge loss to the company. Raw metal and materials used are usually gold, diamond and platinum. This paper deals with to control the casting defects by controlling the parameters applied to the jewelry investment casting. There are many defects like shrinkage porosity, gas porosity, inclusion, nonfills and cracks occurred during casting. Gating system is one of the very important parameter to control the casting defects.

Keywords: Feeding system; Investment process; Burnout cycle and Shrinkage porosity.

INTRODUCTION: In investment casting, a wax tree is invested in gypsum bonded slurry and after burnout a cavity is formed and the whole wax pattern is changed to gold pattern after casting. It is also called lost wax process. Molten metal is poured into the cavity in the vaccum assisted bottom pouring casting machine. The main defect in investment casting is shrinkage porosity which is entirely related to the directional solidification of metals. For removal of shrinkage porosity considerable knowledge of reservoir is required by the caster. Necessary steps to be taken to control the casting defects by controlling the parameters applied to it. Parameters to be controlled are gating system, flask temperature, casting temperature, investment process, reusability of gold and its scrap. Simulation is applied during casting to observe the filling process and solidification process. For studying the filling and solidification of casting Computational Fluid Dynamics (CFD) is used. A simulation technique is applied to investment casting to grasp casting process and to reduce production cost as well as to increase yield.

MATERIAL AND METHODS: In jewelry only way of inspection is visual inspection and is entirely based upon the experience of the inspector and tool only used is magnifying glass. To take corrective and preventive action design wise and to set process parameter accordingly to reduce the defects. For corrective and preventive action root cause analysis is implemented. Process parameters are gating system, burnout cycle, investment process and casting simulation.
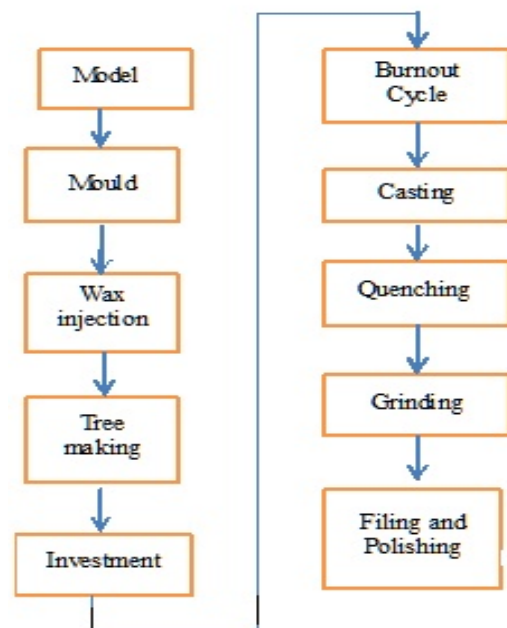
Flow Chart of jewelry Investment Casting

Feeding System:

- Gating System in investment casting process is used for passage of wax to the design during wax injection.
- It is used to drain out the wax during burnout cycle in the furnace.
- Acts as a conduit for molten metal during casting.
- Helps to reduce shrinkage porosity and also filling of the cavity into the mould

- Additional feeder is always given to the place where shrinkage porosity is observed. And it is to be shortest distance to the main sprue of the pattern.
- Always to prefer cylindrical sprue rather than flat sprue for better filling and to avoid shrinkage porosity in the pattern.

Investment:

- Before investment, in tree making the patterns are always joined at an angle of 45^0 to easily drain out the wax and also better filling of the metal during casting.
- In investment process water to powder ratio plays very important role, it is usually 40:100 and the ratio varies with design, wax set (stone in place) and handset patterns.

The defects occurring due to investment are flash, rough surface and inclusion.

Burnout Cycle: Burnout cycle is the temperature set into the furnace with ramp and soak for removal of wax at initial temperature and as the temperature increases refractory hardening takes place with a cavity which is filled with molten metal during casting.

Simulation techniques: CFD applied to jewelry industries for the reasons given below:

- To check gating system of virtual casting and process design.
- CFD and numerical solution are applied during solidification of casting and to check the temperature gradient.

Case Study:

- Removal of porosity from solitaire ring(18K white gold)
- Reduction of gold loss from 20.74% to 6.78%

Figure 1

This design was never ok for last two years and atleast 6 – 7 times casting was done to complete the order that to with too many rework in polishing stage to remove the shrinkage porosity from the shoulder area from the ring.

Gating System as shown in the figure:

Figure 2

Parameters used for the casting are:

- Flask temperature 620° C with handset burnout cycle and temperature raised to 720° C and hold there for 3 hrs for complete burnout.
- Extra runner attached for the shortest distance from the main sprue of the ring so that during solidification excess molten metal to be available to avoid shrinkage porosity.
- Casting temperature taken 1030° C.

After casting the filing and polishing process was done and the result was not a sign of single shrinkage porosity on the ring and the solitaire ring was completely okay.

For comparing the gold loss from previous design history:

Date 22.02.16
Bag no16/ws/40728, design 50883-A size k
Grinding wt-4.55
Polishing wt-3.50g (loss -1.05g)
Due to heavy rework in polishing due to shrinkage porosity

Gold Loss-23%

Date 22.08.16
Design 50883-A size k
Grinding wt-4.25
Polishing wt-3.98g (loss -0.27g)

Gold Loss-6.78% that is a huge saving to the company and also the quality of the ring was very much enhanced because there was no rework at polishing stage.

RESULTS AND DISCUSSION: Minimization of casting defects. Quality of the gold jewelry will be enhanced. Reduced rejection of the gold jewelry. Reduced repair in filing and polishing due to defect free casting. Gross gold loss of the company will be reduced as well as the net loss of the company. Timely delivery to the customer. Productivity will be increased. Diamond breakage will be reduced.

CONCLUSION: All the referred papers give general overview of casting defects, simulation techniques

applied to jewelry investment casting. Not much research work has been done in the field of precious metals like gold, platinum and silver casting.

- No research papers on reduction of diamond breakage during waxset (stone in place) casting.
- Above research papers do not discuss the effect of quality of casting on reduction of gold loss of the company.
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