Logic, Technology and Quality: Life as a Trade Caster

CHRISTOPHER J. CART
Technical Director, Weston Beamor Ltd, Birmingham, U.K.

Introduction

Weston Beamor is one of the largest jewellery trade casters in the UK, with over 300 customers and thousands of patterns cast daily. Due to the volume of product and delivery times, it is essential that certain measures are taken to ensure that Weston Beamor is capable of servicing customer requirements. Of these thousands of wax patterns, some are hand carved and most are next day delivery, so it is crucial that success is achieved in a predictable process.

As in all manufacturing facilities, it is important that evaluations and systematic process controls are applied to the daily workload. At Weston Beamor, we are constantly improving the quality of casting by logical evaluation, technical innovation and process control. Below is a list and description of the necessary process controls that we have implemented.

Master Pattern

Upon arrival at Weston Beamor, the master pattern is reviewed for best possible sprue (gate) placement that will not inhibit mould making or cutting. For example, if a collett or claw is sprued perpendicular to the collett wall or claws, mould pressure can cause distortion of the piece during wax injection, Figure 1.

The sprues for the model are also evaluated for best flow of molten metal into the investment cavity. What may suffice for 18kt yellow gold may not be adequate for 18kt white and additional feed gates may be necessary. It is not uncommon at Weston Beamor to add feed gates on waxes that were previously moulded, when a customer switches from 18ct yellow gold to 18ct white gold.

Mould making and Cutting

The rubber mould must be adequately and sufficiently packed to ensure perfect representation of the moulded piece. When cutting the mould, the mould cutter should cut the rubber by following lines that will hide any mould seams that occur, Figure 2. Air vents need to be adequate for proper airflow from the mould cavity during wax injection.

The mould is tested prior to production to establish the proper parameters (i.e. air pressure, dwell time and vacuum) for satisfactory wax injection. These parameters are then listed on the mould so that any operator can make the proper adjustments to the wax injector prior to wax injection.

Wax

At Weston Beamor, waxes are not only examined by the wax injection operator, Figure 3; they are given an additional inspection prior to the spruing process. This is done to ensure that the pattern is of good quality, Figure 4, for example, that all claws are intact, there are no distortions in pattern and no air bubbles. If air bubbles are present in the wax pattern, this air will be drawn out during investing of the mould, causing subsequent damage to the wax and, in turn, creating a poor mould cavity.

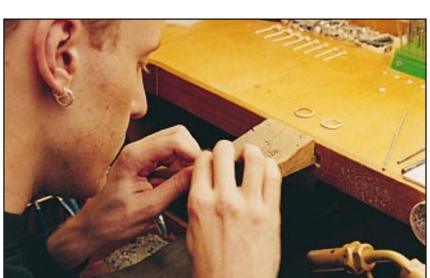

Figure 1

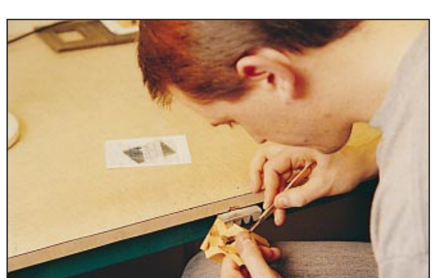

Figure 2

Figure 3

Figure 4

Figure 5a

Figure 5b

Figure 5c

Sprueing

Proper placement of the patterns on a sprue tree is important to ensure that a combined product tree will yield quality cast product, Figure 5a. The wax products are segregated into several categories, very fine to fine, fine to medium, medium to heavy and heavy products, Figure 5b. These segregated pieces can be mixed to some degree by placing them on different sections of the tree, very fine to fine at the top of the tree, fine to medium at the middle of the tree and medium to heavy at the base of the tree, Figure 5c.

However, the best segregation is performed by placing similar products (very fine to fine) on one tree and then designating an oven temperature for this flask, Figure 6. In a 'best case' scenario, one should weigh the waxes and segregate the product according to average weights and geometry. This promotes thermal equilibrium during burn-out, casting and the cooling process prior to investment washout.

It is also necessary to make sure that a high ratio of product weight to sprue (scrap) per flask is achieved. This is an economical use of metal and consumables such as investment and wax central sprues. One should always try to attain at least 60% of total metal as product weight per flask. However, one should not crowd product on the tree just to fill a flask, for this can lead to other problems. These problems can be manifested as investment breakdown, pieces touching each other or pieces being burnt and rough surfaces due to the thermal mass of the products not being able to dissipate the heat properly and the cooling of the metal becomes protracted.

Investment Mixing

All parameters of investment mixing need to be controlled and recorded. This includes investment type and batch number, water-to-powder ratio, water temperature and pH, slurry temperature and pH, investment temperature and set time, Figure 7.

One must always adhere to the investment vendor's specifications when mixing investment. It is also recommended to mix a sample of each new lot of investment powder that is received prior to putting it into production. This will alleviate any problems that could occur in production.

The use of distilled or de-ionised water is preferable when mixing investment, due to its purity and neutral pH, which will not adulterate the chemical balance of the investment powder.

All investing procedures should be conducted with adequate dust extraction in place. Mixing operators should wear adequate dust masks and eye protection.

Figure 6

Figure 7

Burn-out

The process of burn-out is normally achieved overnight and is controlled by a temperature ramping control device connected to a thermocouple, which is placed within the furnace. Due to this burn-out occurring during the night, it is best to connect the temperature control to a chart recorder. This will allow for documentation in the event of failure to burn-out properly.

This documentation can then be used to correct problems that can be caused by improper burn-out, such as investment breakdown, caused by too aggressive a temperature increase or insufficient burn-out.

A much more accurate form of burn-out control and documentation is the use of programmable logic controls (PLC). PLC's process electrical energy by percentage values, giving a much smoother temperature ramp, as compared to the standard ramping devices that give 100% energy to the furnace, causing over or under ramp in temperature during the burn-out process.

PLC's allow for data capture which can be downloaded to a computer for graphs and analysis and allows creation of a historical database for evaluating any anomalies that may occur in burn-out over the course of time.

The flask should be placed in the furnace with adequate space to allow for good air circulation and a balanced thermal equilibrium. If the flasks are overcrowded into a furnace, there may be problems with uneven temperatures and inadequate burn-out.

Metals

Although it is recommended to use a high ratio of fresh metal-to-scrap metal (70% fresh/30% scrap) in the charge when casting, as a trade caster this is not always an economical use of metal. In the event that one has to use high scrap-to-fresh metal ratios, it is recommended that the metal be held at superheat temperature for an extended time. This will allow impurities to burn off prior to casting, Figure 8.

Figure 8

It is also necessary to ensure that all scrap metal is exceptionally clean and free of foreign particles such as investment, oxides or acids. Failure to ensure the use of clean metals will inevitably lead to excessive casting failures, manifested as gas porosity, brittle castings and discoloration to the finished jewellery item. If a metal charge is suspected of contamination, it should be purged immediately from the casting cycle and all crucibles used for the suspect metal should be removed to ensure that the contamination is isolated.

Melting

It is desirable to have accurate measurement of melting temperatures, whether it is an immersion thermocouple or an optical pyrometer. Ensure that these temperature control devices are upgraded and calibrated on a monthly basis or as needed. With an immersion thermocouple, it is good practice to visually inspect the device for any physical signs of degradation at the beginning of the casting cycle.

Be aware that, with optical pyrometers, there can be a problem reading temperatures accurately of zinc-bearing alloys due to smoke emissions and dross across the top of the molten metal. Once the dross breaks to reveal the actual metal surface, the true temperature reading becomes apparent and is usually much higher than desired.

All crucibles should be inspected prior to being used to identify whether the crucible has sufficient structural integrity (wall thickness, eroded pouring nozzle, cracks, etc.). Also, inspect for residual metals and foreign materials to alleviate any possibility of cross-contamination. One should document the number of melts produced by each crucible. This will create a database to identify and establish at which point the crucibles have reached ultimate degradation.

Casting

At Weston Beamor, we are currently casting on static machines that supply pressure over vacuum, Figure 9. These machines are fully automatic, with the exception of the loading of the hot flask. All parameters are controlled by programmable logic controls (PLC) such as temperature ramp for melting, hold temperature during melting, vacuum, gas cover and pressure and dwell of gas pressure during melt and casting, Figure 10. These parameters can be adjusted during the casting process or locked in, once desirable casting results have been achieved, to keep the casting operator from arbitrarily changing parameters.

These casting machines have simplified the process of casting and have alleviated problems caused by eye fatigue of the casting operator and the 'morning after' syndrome (hard day's night). However, these casting machines do allow for the viewing of the melt prior to casting, which can be educational for the casting operator.

Having a modem connected to the PLC controls allows for downloading to a computer and calibration of the controls by the casting machine manufacturer without a site visit to your factory.

Figure 9

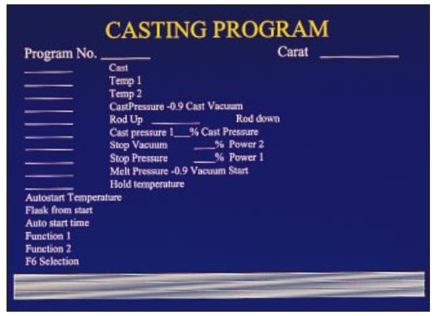

Figure 10

Washout

After casting, the hot flasks are left to cool until the metal is no longer glowing before quenching. Post-quenching, the cast trees are water blasted to remove residual investment and then immersed in sulphuric acid to remove any existing oxides. From the acid bath, the cast trees are neutralised and then wet bead blasted to brighten the metal, which is an aesthetic treatment for our customer base. After wet bead blasting, the trees are then submerged in an ultrasonic bath of water and ammonia to neutralise any residual acids and remove any investment that may be lodged in small pores on the surface of the cast metal.

All de-vesting should take place under adequate air extraction and de-vesting operators should wear protective eyewear. Investment particles (silica) become air-borne during the quenching process via the steam dissipating from the hot investment. These particles are extremely small and can remain air-borne over extended lengths of time (1).

Summary

Having applied these process controls, technology and logic over the last 18 months, Weston Beamor has seen a dramatic increase in quality of the product and the work place. In some cases, as in problematic metals, we have experienced at or near 50% reduction in recast work. However, as with all change, technical management must work together with the operations management to ensure that these changes do not impact negatively upon other areas of the company, such as protracted delivery of product. Working as a team is the ultimate in quality process management.

References

1 See: Paul Pryor, "Silica Hazards and Safety Procedures in Handling of Investment", Proc. Santa Fe Symposium, 1988, p131-144 and Paul Pryor, "Silica Hazards in Handling of Investment: Phase II", Proc. Santa Fe Symposium, 1989, p257-278, with Appendix-"Santa Fe Silica Project", Dave Schneller, p279-296.