Gold Jewellery Investment Casting

CURRENT RESEARCH REPORTED UPON AT A RECENT COLLOQUIUM

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Investment casting is in all probability the most important production technique for the manufacture of gold jewellery. However, few attempts have been made to investigate systematically the fundamental principles of the process as applied for this purpose, and very few publications describing such researches have appeared.

The review by L. B. Hunt of the history of the lost wax casting process in the preceding pages is an appropriate background against which to report briefly on some research results highlighted at the 'Colloquium on Investment Casting of Gold Jewellery Alloys' held recently at Schwäbisch Gmünd, in the Federal Republic of Germany. This meeting was arranged to mark the end of the first year of a research project on investment casting of gold jewellery alloys, which was commissioned by the International Gold Corporation Limited at the Forschungsinstitut für Edelmetalle und Metallchemie (F.E.M.). A total of fifteen papers were presented. The research results were introduced by Ch.J. Raub and D. Ott of the F.E.M., and current casting practice was the topic of a number of excellent presentations by speakers from all walks of industry.

Investments

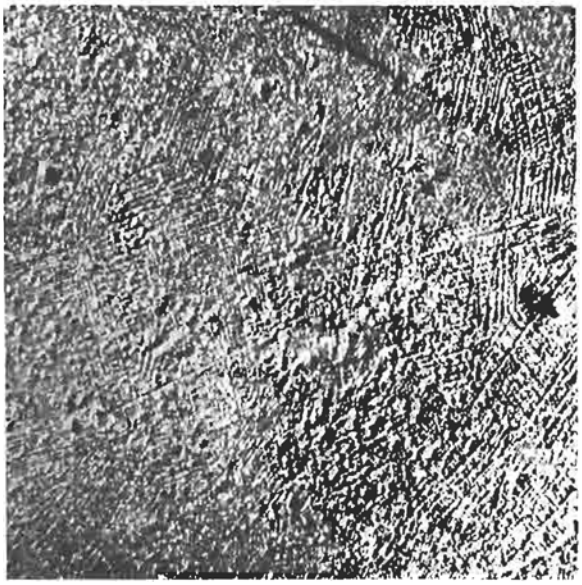
An investigation of the properties of investment slurries, and of set and fired investments, commenced with the assessment of procedures suitable for measuring those properties of gypsum-bound investment materials which influence the quality of the castings. Ott reported that the most important characteristics of the slurry are its viscosity, and its working and setting times. The viscosity of an investment slurry is a complex parameter which depends not only on the temperature, but also on the 'mechanical stress' and age of the mix at the moment of measurement. A rotation viscometer was used to measure the viscosity. The decrease of the viscosity of a slurry with increasing rate of shear might explain why vibration of the slurry during the investment of the wax pattern prolongs the working time and renders vacuum degassing more effective. A Vicat apparatus (DIN Standard 1164/5) fitted with a cylinder or needle was used to determine the working and setting times. The results were found to be in good agreement with the 'gloss-off' point (a visual assessment of the setting of the investment) and with the measured change of viscosity with time.

The working time of the slurry is most significantly affected by the mixing ratio (powder/water) and by the quality of the water. Thus, with one commercial investment, a change from distilled water and a ratio of 100/35 to tap-water and a ratio of 100/40 increases the working time by nearly 100 per cent from 9.5 to 17.5 minutes. These effects emphasize the need for jewellery manufacturers to determine regularly the working properties of their raw materials under workshop conditions. Initial attempts at quantifying the strength and permeability of fired investments indicate that meaningful measurements can be obtained at the actual casting temperatures only; the formation during cooling of microcracks in the investment was found to cause variable results at room temperature. The temperature gradients developing within a flask during cooling in air were also determined — for example, in the sprue at the centre of a flask the initial rate of cooling from a temperature of 740°C was about 4°C/minute, whereas at the wall the rate was 10°C/minute.

The Quality of Castings

The faithful reproduction of the surface of the pattern and the soundness of the metal are important criteria in determining the quality of a casting. Raub emphasized the need for standard patterns and tests to evaluate these criteria. Four basic patterns are now being used for the research project. A grid (developed by the dental industry), a stepped wedge with a highly polished surface, the sound track of a long-playing record and a dumb-bell-shaped pattern are used to assess mould cavity filling, dimensional accuracy, surface roughness and reproduction, and soundness of the metal. Gold castings of these patterns have been examined by a variety of techniques. The surface condition is best recorded using the Perthometer (a surface profile measuring device) or photomicrographs, and metallographic methods and scanning electron microscopy are used for structure analysis and to reveal internal flaws. Results to date have shown that the surface roughness of the castings increases somewhat with the thickness of the pattern, particularly when the casting temperature is too high, and that cavity filling, surface smoothness and

Coarse dendritic morphology of the cast metal, seen here, can greatly affect surface roughness. Casting conditions should therefore be such as to give fine-grained structures



reproduction of the patterns at the tip of the casting tree are measurably better than those near the entrance to the flask. Surface finish has also been related to the rate of solidification of the melt, which in turn depends upon the difference between the melt and mould temperatures and upon the surface/volume ratio of the pattern. The effects of any contaminants in the alloys on quality are being investigated using energy dispersive x-rays, as well as atomic absorption spectrometry; semi-quantitative results are being obtained spectrographically. A sound basis has thus been established for the quantitative assessment of the quality of castings upon which the future research can be built.

Static Casting Processes

The factors which influence most strongly the quality of castings produced by static methods were screened as a prelude to a more intensive investigation. Commercial casting machines were modified to allow melting and pouring in air, under a protective atmosphere (98 nitrogen/2 per cent hydrogen) and in vacuum, with provision for the application of an overpressure to the molten metal in the mould. Medium frequency induction heating was used throughout. Ott, in outlining the results which had been obtained to date for a common 18 carat yellow gold alloy (75 gold/16 silver/9 copper weight per cent, with a melting range of 895 to 920°C), stressed that in a process such as investment casting the effects of one variable should never be considered in isolation from those of other factors. Temperature has a major bearing on casting quality — for example, it was found that the useable range of melt temperatures for the alloy investigated is between 980 and 1100°C, with flask temperatures between 450 and 700°C. Generally, higher flask temperatures require lower melt temperatures and vice versa. The effect of pressure appears to be complex and both the absolute pressure during casting and the difference between the pressure on the base of the sprue and that on the outside of the mould affect the quality of the casting. Thus, it has been found that the minimum differential in pressure required for effective filling of the patterns decreases with the absolute pressure. The nature of the atmosphere over the melt also seems to play a role. When melting and pouring in air (vacuum-assisted casting), a considerable amount of gas porosity occurs just under the comparatively smooth skin of the casting. If, however, a protective gas is used, the pores are smaller and appear to be distributed throughout the casting. Under full vacuum, no pores are found, but a new phenomenon in the form of increased surface roughness is noted which was related to the dendritic structure of the cast metal. Ott posed the interesting question whether the gas pores in a casting do possibly not contribute to the smoothness of the surface by compensating for the shrinkage of the solidifying metal.

Metallurgy

Although this research project at the F.E.M. is not currently devoted to the metallurgy of gold alloys, Raub drew upon his experience in emphasizing the need for pure and clean metals in the preparation of casting alloys, so as to avoid difficulties in production. Gold, in particular, can be obtained in the form of powder, grain or sheet. Raub advocated using small snippets of gold sheet for alloying, since in this form it is less likely to be accompanied by contaminants such as oxygen or water. Furthermore, it was recommended that if there is any hint of difficulty, the gold should be pre-melted and rolled into sheet. Brittleness during rolling will be indicative of the presence of deleterious contaminants in the alloy. Raub warned against the folly of attempting to overcome difficulties in production by diluting contaminated alloys with impurity-free alloys.

While the research discussed at the colloquium is in its infancy, the first results already indicate that this project at the F.E.M. promises to provide fundamental and practical information relating to many aspects of investment casting. This should materially assist manufacturers in increasing the efficiency of the production of quality gold jewellery.