The 16th Santa Fe Symposium on Jewellery Manufacturing Technology

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The 16th Santa Fe Symposium on Jewellery Manufacturing Technology was held at Albuquerque, New Mexico, USA on 19-22 May 2002. This Symposium was dedicated to the memory of Timo Santala who tragically died in the air crash in Queens, New York on 12 November 2001. Timo was a regular attendee and lecturer at previous symposia and he will be missed by many in the jewellery industry. Greg Silveri, a close friend and colleague at Jacmel Jewellery Inc gave the opening address and dedication.

Twenty-two papers were presented over three and a half days and these covered a wide range of topics of relevance to the jewellery industry. Although the number of attendees was down slightly this year, possibly as a result of the disaster on September 11 and the economic climate, it was generally recognised by those attending that this Symposium was of very high quality.

"Solidification and Casting"

Mark Grimwade, Consultant to the World Gold Council and the Worshipful Company of Goldsmiths, UK

This was the second presentation in a series on "An Introduction to Metallurgy" with particular reference to the metals, alloys and processes used in jewellery manufacture. The paper discussed the mechanisms of solidification and the sequence of solidification when casting in a mould. It included explanations of homogeneous and heterogeneous nucleation from the melt and the growth of nuclei to produce a solid three-dimensional polycrystalline microstructure of a metal or alloy. The factors governing grain size and its control were briefly discussed and examples given of typical grain structures obtained when casting in metal moulds for ingots and investment moulds for jewellery castings. In conclusion, the problems due to macro- and microsegregation and shrinkage were discussed.

Three papers were presented by Dr. Shankar Aital, Denis Busby, Patrick DuBois and John McCloskey of Stuller, Inc., USA. These dealt with the sequences of events during mould burnout and investment casting.

"Evaluation of Mould Burnout by Temperature Measurement and Weight Loss Techniques"

Presented by Dr. Shankar Aital

The burnout process in gypsum-bonded investment moulds, using both gas-fired and electric burnout ovens, was studied by measuring oxygen levels, temperature changes at 12 locations within the mould cavity on a typical tree, and changes in mould weight as time elapsed during burnout. Carbon analyses of samples collected from the cavity surface of three flasks removed at the start, during and at the end of a 1350°F (730°C) dwell were made in a separate experiment. To operate efficiently, gas-fired ovens should be used with a residual oxygen content of at

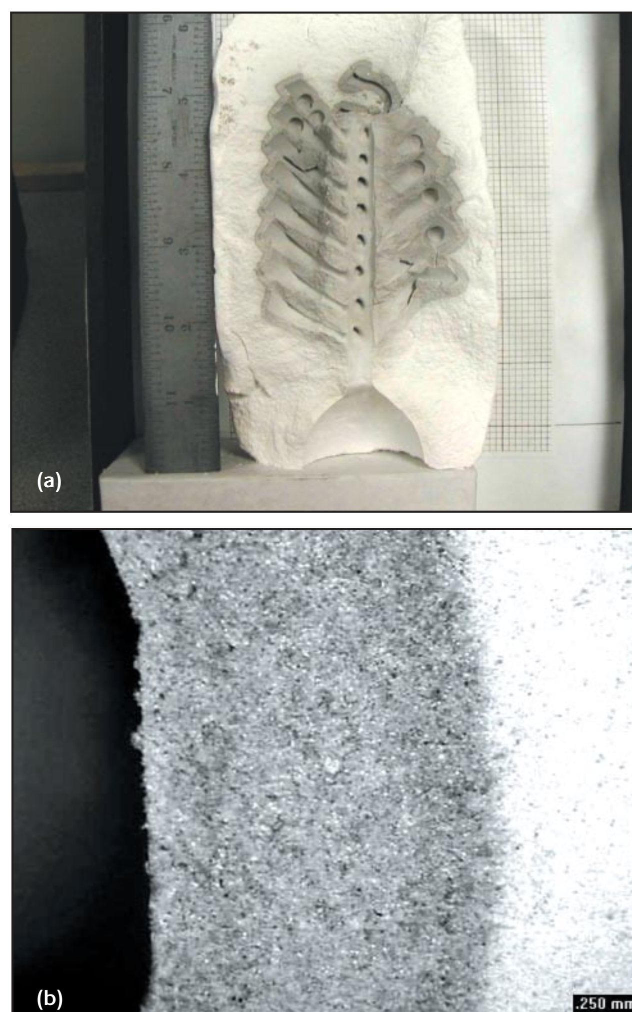

Figure 1 - Slit mould containing a wax pattern, removed from gas-fired burnout oven at start of 730°C/1350°F dwell.
(a) Entire mould (b) Close up of wax penetration into investment

least 10% at the dwell temperature. The residual oxygen level in an electric oven was at a minimum of 18% when combustion of melted wax was taking place, and this is advantageous. The temperature changes accurately sensed the melting of the wax and the removal of free water and chemically combined water from the mould. Well-ventilated flasks ensured a faster removal of water and prevented the build up of large temperature gradients. The weight loss measurements, made on flasks removed at intervals of time from the ovens and then returned, showed that wax removal takes place before free water removal and that weight loss occurred faster in a gas-fired oven than an electric oven. Experiments with wax and plastic patterns showed that the latter burned out better probably because the plastic is more viscous and doesn't wet and penetrate the investment to the same extent as wax, Figure 1.

"Temperature Measurements in Mould Cavities during Vacuum-Assisted, Static Pouring of 14K Yellow Gold"

Presented by Patrick DuBois

A high-speed data acquisition system (DAQ) was used to record the temperature changes during mould filling in casting at 12 locations strategically placed in ring cavities and the central sprue, Figure 2. The DAQ, which is described in an appendix, was required to scan the 12 locations at a rate of at least 100 scans per second. Metal stream velocities were calculated at three points along the central sprue and within the ring cavities from the temperature data and the dimensions of the cavities. Considerable temperature fluctuations of as much as 150°F (65°C) were recorded within the first second of vacuum-assisted static pouring of a 14ct yellow gold. It is thought that these fluctuations are caused by mechanical turbulence in the molten stream as it fills the mould. The turbulence arises from abrupt changes in the flow direction, the localised flow velocity and the aspiration of a gaseous phase into the liquid. The turbulence is more pronounced at the bottom of the flask and gets less as filling proceeds upwards towards the button. Liquid metal velocities were 1550-1700 mm/sec. during its descent into the sprue and in the range 60-560 mm/sec. at different locations as the liquid filled the cavities. In addition, temperature gradients of 0.5-7.0°F were measured in the castings during the process of solidification.

Figure 2 - Tree pattern with thermocouple attachments

"Temperature Measurements in 14K Yellow Gold during Counter-Gravity Pouring of Investment Casting Moulds"

Presented by John C. McCloskey

The speaker began by describing the counter-gravity mould filling technique in which the molten metal is lifted vertically through a pipe into the investment mould by applying a vacuum to the chamber containing the investment mould, Figure 3. Temperature measurements were taken at the same 12 locations and using the DAQ as described in the previous paper presented by DuBois. Metal stream velocities were calculated at selected thermocouple locations and compared with those obtained at the same sites for static vacuum assisted pouring. In all cases, the velocities were less for counter-gravity casting. Mechanical turbulence, as assessed by temperature fluctuations within the first second, appeared to be much less for counter-gravity pouring, Figure 4. Generally, temperature gradients during solidification were of the order 0.5-1.5°F and the results suggest that the heat of fusion released by the solidifying metal reduces the temperature gradients quite quickly once solidification starts. The experiments demonstrated that the gypsum-bonded investment has enough permeability to allow counter-gravity filling of the mould cavities by a vacuum applied to the outside of the flask.

Figure 3 - Counter-gravity mould filling of an investment casting mould by a vacuum technique

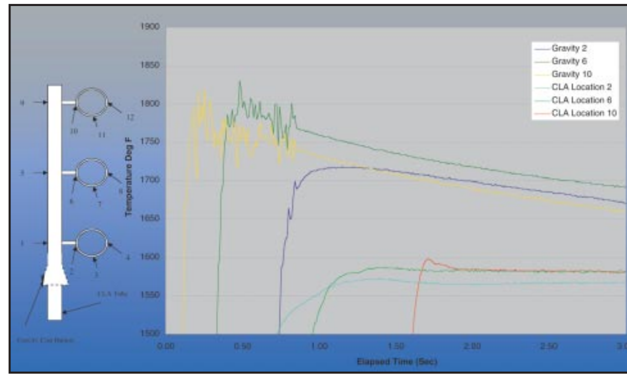

Figure 4 - Temperature versus time profiles in signet rings during gravity and counter-gravity (CLA) mould filling techniques

"Rapid Wax Elimination and Reaction Chemistry of Sulfate-Bonded Investment"

Tony Eccles, Apecs Investment Castings, Australia and Roland Loewen, Alchemy, Texas, USA

The paper was presented by Tony Eccles who began by describing the properties of gypsum-bonded investments and the physical changes that occur during dewaxing and burnout. This included a review of work presented in previous papers at the Santa Fe Symposia. The reactions at high temperatures between calcium sulphate and carbon residues from incomplete burnout were discussed. The experimental results that validate the proposed reactions and the formation of sulphides were explained. Earlier work had indicated that additions of nylon flock to the investment had assisted in the rapid removal of carbon. Further work using nylon was reported here and although it was successful in assisting the removal of carbon, there was some reduction in the surface smoothness of the castings. An addition of 5% barium nitrate to the investment was found to be beneficial in accelerating the rate of carbon removal. More testing is required to establish if there are any adverse effects created by its use. The greatest advantage of using barium nitrate is likely to be in the ability to shorten the burnout cycle, thereby saving energy costs. This may be of value to some casters but for the large, high-production shops the usual long overnight automated burnout may still be preferable.

"14-18K Yellow Gold Alloys for Investment Casting: A New Approach"

Andrea Basso and Massimo Poliero, Leg.Or. Srl, Italy

It is well known that additions of silicon (Si) to investment casting alloys confer benefits in terms of the production of bright oxidation-free castings together with improvements in molten metal flow and form filling. However, there are considerable disadvantages in that silicon promotes grain growth, brittleness if the Si concentration exceeds certain limits and the possibility of hot tearing if low-melting point Si-rich phases are present. Silicon also minimises the effect of grain refiners, such as iridium (Ir).

The new approach is based on the use of germanium (Ge) as a replacement for silicon as it is able to prevent oxidation of copper (Cu) and zinc (Zn). Unlike silicon, germanium is soluble to some extent in gold and silver. The real effects of the variable factors (Ge, Si, Zn) and the fixed factors (Au, Ag, Ir) together with their various interactions were measured using a two-level full-factorial statistically designed experiment. Hardness, grain size, tensile properties, thermal analysis and investment casting performance, in terms of form filling, pattern replication and surface quality, were assessed and the test alloys compared with conventional Si-deoxidised alloys.

The main conclusions were that Ge additions in the range 0-1.5% for 18ct and 0-2.5% for 14ct improved mechanical properties, although in combination with Si there was only an improvement in ductility. There was a beneficial effect on fluidity, pattern replication and polishing. Shrinkage porosity was lower and there was only a small influence on grain coarsening. Bright castings were not obtained with the Si-free alloys but the oxide layer was easily removed by pickling.

The encouraging results offer new possibilities for high-quality investment casting alloys and a reduction in the disadvantages commonly associated with Si-bearing alloys.

"Is it Possible to Recast Scraps? This is what Jewellers Ask"

Silvia Bezzone, Crova SpA., and Damiano Zito, Pro-Gold Srl, Italy

Two 18ct casting alloys, one containing silicon and the other an alloy grain refined with iridium, were evaluated and compared in an investigation on the utilisation of scrap in re-casting. Six casts were made in a sequence in which 50% new material was used with 50% scrap from the previous cast in the sequence. Alloy composition, grain size, form-filling, tensile strength, ductility, hardness, colour, density and melting range were assessed after each cast. The results are too numerous to detail here but the general conclusions were that:

- Using scrap from previous casting results in a lower level of physical, technological and mechanical characteristics,
- The degree to which the metal is degraded is relative to the number of times the alloy is re-cast using scrap,
- A balance must be struck between the economics of re-casting scrap and the quality of the castings,
- Scraps of both alloys can be re-cast provided attention is paid to the application for which the casting is made. For example, re-casting of scrap for rings with prong (claw) settings should only be done three times.

Although some of the trends experienced with re-casting were quite marked, this was not always the case and there is some doubt in this reviewer's mind as to whether some of the reported variations were statistically significant. It is appreciated that the experiments would need to be repeated a number of times to obtain sufficient data and to establish reproducibility. However, there is no disagreement with the general conclusions.

"Recovery and Refining of Gold Jewellery Scraps and Wastes"

Dr. Christopher Corti, Director, International Technology, World Gold Council, UK

The efficient recovery of gold from carat gold scraps and wastes is vital if jewellery manufacture is to be profitable. Much of the scrap generated in production can be cleaned and recycled, although there is a limit as to how much recycling should be done before refining is necessary. Low-grade scraps and wastes need to be collected and refined for technical and economic reasons. Dr. Corti reviewed the sources of scraps and wastes, their typical precious metal contents and their treatment prior to refining. The eight major refining techniques were described, together with their advantages and limitations and suitability for small in-house refining considered.

Cupellation is not recommended on health and safety grounds and the Miller Chlorination, Wohlwill Electrolytic and the Solvent Extraction processes are only suitable for large scale refining. The Pyrometallurgical Process is simple and effective in the production of a Au-Ag-Cu alloy suitable for re-alloying back to carat gold by jewellery manufacturers. The Fizzer Cell is suitable for very small scale refining. Inquartation and parting requires a feed stock of <25% Au if pure gold is to be obtained and the process is suited to a low-medium scale carat gold operation. The Aqua Regia Process is most suited to medium-large scale operations and is widely used for in-house refining as well as by the toll refiners. The silver content of the scrap should be <10% and typical batch sizes are up to 4 kg. The process, therefore, is most suited to medium-high scale carat gold scrap refining. The benefits of in-house refining must be weighed against the cost and yield of gold obtained when using toll refiners.

“Failures in 14Kt Nickel-White Gold Tiffany Head Settings”

Stewart Grice, Hoover and Strong, Inc., USA

Jewellers have found over many years that prong failures often occur in both die-struck and investment cast 14ct Tiffany heads and similar settings, usually during the final operation of stone setting, Figure 5. Examination of the failure reveals a brittle intergranular fracture typical of stress corrosion, Figure 6. This investigation was concerned primarily with Tiffany heads die-struck from wrought sheet. Other types of failure, namely, fire-cracking and quench-cracking, are known to occur in nickel-white golds and these, and other factors, have to considered when selecting an alloy for a particular application. The speaker reviewed the metallurgy of nickel-white golds before going on to discuss the theories of stress corrosion and crack propagation.

Figure 5 - A failed prong with stone still in place, 14ct nickel white gold

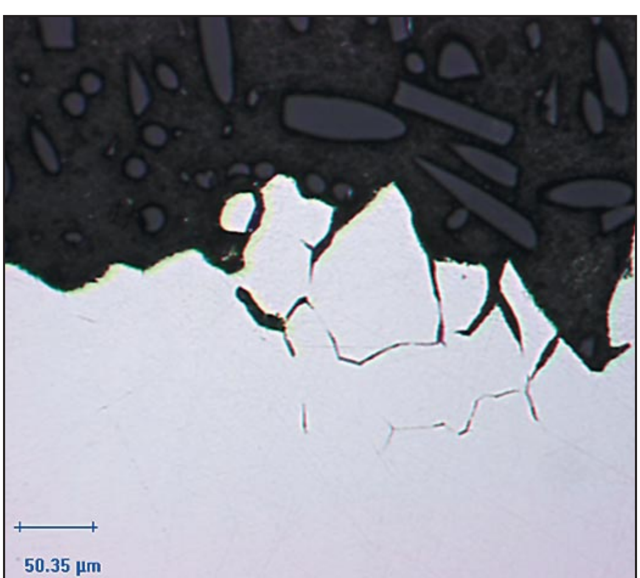

Figure 6 - Intergranular cracking, typical of stress corrosion, 14ct nickel white gold

The experimental work involved the production of three types of settings manufactured from selected 14ct nickel-white gold alloys. The settings with stones were suspended in a 10% ferric chloride ($FeCl_3$) solution to induce stress corrosion cracking and the times to fracture recorded. Settings were simulated also using both round- and square-section wire with a stress applied during immersion. Other processing variables, such as heat treatment, quenching and cold working, were included in the investigation. Comparisons were made with a 14ct yellow gold and a 14ct palladium-white gold.

In practical terms, the conclusions were that the cooling conditions from the soldering operation when joining the setting to the ring shank have a major influence on susceptibility to failure. Slow cooling, which is often used to prevent quench cracking, will decrease the resistance to stress corrosion because it will encourage nickel migration to the grain boundaries. Square or rectangular prongs are shapes offering least resistance and notching, to take the girdle of the stone, introduces a stress raiser. The main conclusion is that nickel-white golds are not suitable for this application and palladium-white gold settings must be used.

“Fire Cracking in White Gold Jewelry Articles”

Greg Normandeau and David Ueno, Imperial Smelting & Refining Co. of Canada Ltd., Canada

Fire cracking is the spontaneous fracture that may occur in nickel-white gold articles during heating in annealing after cold working, Figure 7. It is well known in the brass industry with so-called nickel silver alloys. These are copper-nickel-zinc alloys that are also, together with gold, the basis of nickel-white golds. The speaker gave an extensive review of the previous research on fire cracking and discussed the theory of and the metallurgical characteristics of fire cracking.

Examples of fire cracking were presented in a series of case studies from primary manufacturing operations and secondary manufacturing of jewellery articles. The failures were identified by metallography and SEM fractography. Additional experiments were done on stamped cups using two different nickel-white gold alloy compositions. The residual stresses were qualitatively

Figure 7 - Fire cracking in nickel white gold

evaluated on parted bands after subsequent forming operations and the corresponding fire cracking tendency assessed. Both alloys could be induced to fire crack at temperatures in the range 300-400°C. There was a relationship between the stamped cup geometry, dimensions and parted band length with stress magnitude and fire cracking tendency. Parting altered the complex residual stress distribution. Simple tensile hoop stress alone was not enough to induce failure and 13 mm long bands failed by fire cracking while 5 mm bands did not. Suggestions for further research work were listed.

"Precious Metal Tubing: Manufacturing Techniques and Applications"

Aldo Reti, Consultant to the Precious Metals Industry, USA

Dr. Reti began by listing applications of sterling silver and carat gold tubing. 'Ring-size' tubing is available in various sizes so that it can be sliced into bands from which rings are finished. Tubing can be cut, milled and engraved on CNC machines to produce rings and bracelets. Precious metal tubing has been made into flutes with reportedly excellent sound quality.

Tubing can be produced using any one of a variety of manufacturing techniques depending on the size, precious metal and application for which the tubing is required. The techniques of deep drawing, roll forming, spinning and tube spinning, extrusion, tube reducing (pilgering) and tube drawing were all described in some detail. Not all of these processes are suitable for jewellery applications because of the high cost of the machinery. Tube drawing can be achieved using one or more of four methods, namely, tube sinking, drawing with a moving mandrel, drawing with a fixed plug, and drawing with a floating plug. The manufacturer must develop a detailed process schedule capable of producing tubing with high quality and this involves choice of technique(s) and cold reduction and annealing schedules. The paper concluded with examples of the fabrication of 'very large size' silver tubing and platinum alloy tubing.

"Deep-Drawing for the Limited-Production and One-of-a-Kind Metalsmith"

G. Phil Poirier, Poirier Studio, USA

After a brief review of the history and development of the deep drawing process, the speaker went on to describe a relatively small and simple hydraulic press with plate dies made from mild steel that could be used for limited production or one-off pieces in a metalsmithing studio. The mechanism of sheet metal flow during drawing was discussed and particular reference was made to the wrinkling that can occur at the top of the cup as the flange is finally drawn into the die. The amount of wrinkling is dependent on the thickness of the metal, the punch-die clearance and the clamping pressure between the die and the blankholder.

After annealing, the drawn cup is placed back onto the punch to inverse draw the cup making it taller and smaller in diameter. When a shape other than a cylindrical cup is needed, step drawing is used with mushroom-shaped or horn-shaped formers pressing on the sides of the cylinder. Many examples were shown of artistically-shaped vessels, some of which made use of the wrinkling effect. It is claimed that these were made in a fraction of the time it would take using more traditional metalsmithing techniques.

"Advanced Technology for the Jewelry Industry"

Valerio Faccenda, Consultant, Pomellato S.p.A., Italy

The jewellery industry is always looking to develop innovative new products particularly for high-class jewellery. A recent trend is in 'black gold' jewellery. Dr. Faccenda discussed the three methods that are used to produce black coatings on gold items, namely, electroplating, controlled oxidation and vapour deposition of hydrogenated amorphous carbon (a-C:H). Controlled oxidation depends on heat treating 18ct gold alloys containing cobalt and chromium in an oxidising atmosphere to produce a black surface layer of cobalt and chromium oxides. However, these alloys are not easily investment cast or worked and, therefore, are not really suitable for the mass production of jewellery. The remaining two processes were evaluated by assessing characteristics of the black coatings, such as adhesion, hardness, colour, wear resistance, brittleness and reproducibility. The wear test was similar to that described in European Standard EN 12472 and this test was described.

The electroplating of carat gold items in baths based on ruthenium salts with proprietary blackening additives was explained in some detail. It is necessary to pre-strike to give a 0.1μm gold layer in order to obtain a black ruthenium layer with good hardness and adhesion, Figure 8 (right). The colour, which ranges from grey to anthracite black, and the wear resistance depend on the concentration of the blackening additive in the bath.

Figure 8 - Black gold coatings on 18ct yellow gold: *Left* - hydrogenated amorphous carbon (Blaktop®) *Right* - black ruthenium electroplate

The plasma-assisted chemical vapour deposition was developed for watchcases and watchbands. This is known as the 'Blaktop®' process. An amorphous, hydrogenated carbon can be deposited with a thickness range of 1-1.5µm and an appearance similar to that of Chinese lacquer, Figure 8 (left). A wide range of substrate materials can be used including the precious metals and their alloys. The coating has a high hardness of 1800-2000 HV.

Wear tests showed the superiority of the Blaktop® product, which kept its appearance after 4 hours of tumbling, compared with less than 30 minutes for the electroplated items. The main limitation to the Blaktop® process is that it can only be considered for jewellery without stones or the stones have to be large enough so that they can be easily masked.

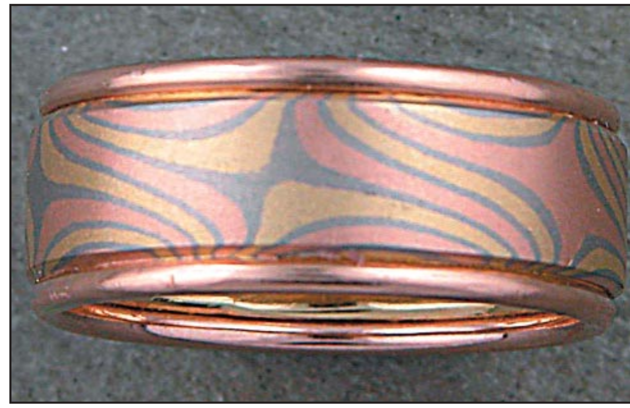

Figure 9 - Ring in 18ct yellow/14ct red/14ct palladium white golds

"Mokume Gane: An Ancient Technique brought into the New Millenium"

James Binnion, Owner, James Binnion Metal Arts, USA

Mokume Gane is a metal working technique developed in Japan approximately three to four hundred years ago. Layers of different colour metals and alloys are bonded together by diffusion welding using a combination of heat and forging to produce a laminated block. The term 'mokume gane literally means wood grain. By cutting into the block and twisting and further forging, the different coloured layers are exposed thereby giving the wood grain effect. The skill lies in the craftsman selecting the metal and alloy combinations for colour and malleability and in developing the various patterns by cutting and working. The pattern can be enhanced by patination using chemical agents or heat.

James Binnion reviewed the history of mokume gane before going on to describe modern studio techniques and the experiments he conducted to explore whether an electric furnace, typical of the type that a goldsmith may use, was a viable alternative to the use of a forge. He found that a proportional temperature controller was necessary to reduce the likelihood of overheating and melting the laminate. A reducing atmosphere was provided by enclosing the laminate stack in a relatively airtight box of stainless steel foil filled with charcoal. The process has been successfully used for a variety of metals including alloys of copper, gold, iron, palladium, platinum and silver. Examples were shown of objects such as wedding bands in 14ct and 18ct yellow, red and palladium white golds, Figure 9, and also including silver, Figure 10. It is worth noting that James Binnion has contributed to the book "Mokume Gane - A Comprehensive Study" by Steve Midgett, published by Earthshine Press ISBN 0-9651650-7-8.

Figure 10 - Ring in 18ct yellow/14ct red/14ct palladium white golds and silver

"The Effects of Burnishing on the Surface of Cast Gold and Jewelry"

Steven Alviti, President, Bel Air Finishing Supply, USA

Investment castings in 14ct gold and sterling silver, having a star-shaped design, were further processed using four types of finishing equipment (vibratory, disc finishers, magnetic pin and roll burnishers). All castings were burnished using the same liquid compound and the same size stainless steel media with the exception of those processed in the magnetic pin finisher. The finish was assessed by visual inspection, microscopic surface inspection, surface profile measurement and surface hardness measurement.

Visual inspection showed that the disc and roll burnishing gave the most aesthetically pleasing finish while pin finishing gave a matte appearance. Vibratory burnishing did not give a sufficiently good finish in a reasonable time. These results were confirmed by surface profiling. All methods of burnishing increased the surface hardness of the samples. Vibratory, roll and pin burnishing increased the surface hardness of 14ct gold by an average of 8% and 925 silver by 22% but only by 2% and 13%, respectively, for disc burnishing. Generally, the harder the surface, the better the polish that can be achieved in subsequent finishing and this tends to favour the use of roll or pin burnishing. Disc burnishing would be preferred if an increased surface hardness were regarded as detrimental.

"Finding Hidden Money in your Manufacturing System"

J. Tyler Teague, Consultant, JETT Research, USA

It is impossible to cover all aspects of this wide-ranging presentation within the confines of this brief review. The main thrust of the paper is that many manufacturing habits and processes waste time and money and that the application of some simple mathematics, chemistry and physics can save money. Many examples, based on the speaker's experience, were given of ways to improve the quality of castings and to reduce costs. Defect recognition and resolution at each stage of processing from wax production to burnout were covered in some practical detail. Using Pascal's Laws on the pressure exerted by a molten metal or alloy, he showed how significant savings can be made in reducing the amount of scrap metal from casting by re-designing the sprue and button system. All manufacturers of jewellery castings would find considerable benefit in reading this paper.

"How to Make More Money Right Now by Eliminating Barriers to Throughput"

Andrea Hill, Director, The Bell Group, Inc., USA

'Throughput' is defined as "the rate at which a system generates money through sales. Barriers, such as restrictive business policies, inadequate resources, ineffective processes and communication issues, prevent increases to throughput. The Theory of Constraints refers to these as 'bottlenecks'. Ms. Hill discussed five stages for identifying and eliminating 'bottlenecks'. These used 'Thinking Processes' which are the Logic Models:

- Current Reality Tree
- Future Reality Tree
- Evaporating Cloud
- Prerequisite Tree
- Transition Tree.

The presentation was illustrated with examples for a casting operation.

"Good Work Space Design = Better Quality Products = Better Profit"

Apollonius Nooten-Boom II, Managing Director, Hean Studio Ltd., UK.

This paper was concerned with how the work environment can be improved and production facilities made more efficient. Investment in the work environment has a positive effect on the workforce and productivity. The speaker described the architectural style of the building that he designed. He emphasised that good planning is vital for the interior, and this includes the reception area as well as the workshops, Figures 11 & 12. Innovative design with modern materials can achieve high levels of security while maintaining design aesthetics. It is not possible to do justice to the presentation in the space of this review because one would need to see the excellent series of photographs that accompanied the talk. These are published in the Proceedings. Needless to say, this refreshing approach to the design and construction of a manufacturing plant attracted many favourable comments.

Figure 11 - Group of 4 work stations. Services are routed from the floor up into the centre of the group

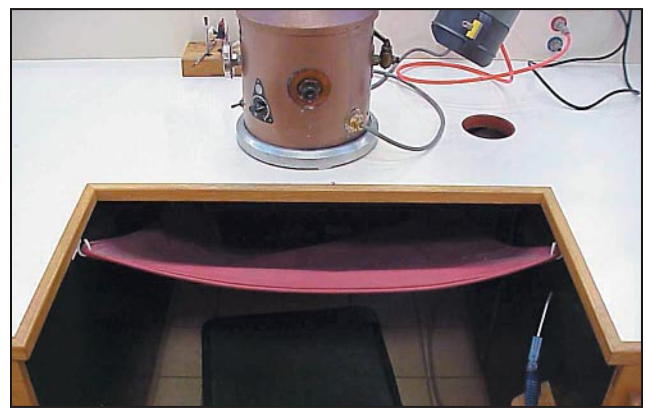

Figure 12 - Scrap wax capture with apron

"Casting Tree Design and Investment Technique for Platinum Induction Casting"

Jurgen Maerz, Director of Technical Education, Platinum Guild International, USA

Using actual examples, Jurgen Maerz showed how tall tree casting with platinum can be achieved using a thin centre sprue. The other new techniques he discussed included 'crooked tree' spruing where the rotation of the casting machine is taken into consideration to obtain maximum fill. The advantages listed are fewer investment cracks, fin defects, easier de-vesting and a higher yield at a lower cost.

"The Effect of Different Investment Powders and Flask Temperatures on the Casting of Pt Alloys"

Peter Lester, Auriel Alloys, Stephanie Taylor and Rainer Süss, Mintek, South Africa, (presented by Rainer Süss)

The interactions between three different investments and three common platinum casting alloys were investigated, each at three different flask temperatures. Two of the investments were developed for the dental industry and the other, a phosphate-bonded material, for the jewellery industry. In summary, it was found that Pt-5% Ru is not a good casting alloy whereas Pt-5%Co is very versatile. The dental investments have the advantage that they can be shock-heated, thereby cutting down on production time but they are difficult to remove. The jewellery investment can be quenched and is easily removed. However, it was stated that the dental investments are very flexible and can be used with lower flask temperatures.

"Chinese Jewelry through the Ages"

David Humphrey, David Humphrey Fine Jewels Ltd., USA

This paper was an overview of the development of jewellery in China from the Neolithic Period to the present. It included a discussion on the metallurgy and fabrication techniques as well as the types and sources of the materials used by the Chinese throughout their history. The presentation was illustrated both by photographs and by actual examples. There is an extensive list of references at the end of the paper.

"Gem Treatments: How do you know if the stones in your line have been treated"

Julie Nash and Arthur Skuratowicz, Anton Nash LLC, USA

The aim of this paper is to give manufacturers an insight into the microscopic characteristics that indicate or prove whether gemstones have been treated. The various techniques of heat treatment, diffusion treatment, fracture filling, irradiation, dyeing, laser drilling and high-pressure high-temperature treatment were described with examples given for commonly used gemstones. In conclusion, the attitudes of both retail jewellers and consumers to gem treatments were discussed. Full disclosure should be made so that consumers know exactly what they are buying.

Awards

Research Awards were given to Ian McKeer, Dieter Ott, Jörg Fischer-Bühner, Martin Moser, Greg Raykhtsaum and Dr. G. Ingo. Technology Awards went to Tina Wojtkielo, Sherris Cottier Shank, Massimo and Tiziana Aloisio, and Mark Grimwade. The Applied Engineering Award was presented to Dr. John Wright and an award for Collaborative Research was given to Jörg Fischer-Bühner.

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