Platinum Fabrication

Malcolm Warren • Heraeus

At Heraeus, all of the platinum melting and casting is done in a vacuum furnace. The minimum melt size for jewelry alloys is 200 troy ounces, and this is cast into an ingot using the Durville Process. The Durville Process is a process where the mold is attached to the top of an induction furnace and the entire assembly is rotated, transferring the molten metal from the crucible to the mold with minimum turbulence. This process is carried out in a vacuum chamber. After assay, the cast bars are heated to 1200°C and hot rolled for 50% reduction. This process welds any inter-dendritic shrinkage and produces better quality sheet and wire. The bars are then machined to remove any surface contamination from the hot-rolling process. Finally, the machined bars are cold rolled and annealed.

For the samples from which the following results were obtained, the bars were hot rolled, machined and cold rolled with a 70% cold reduction. The alloys tested were as follows:

95% platinum/5% cobalt
95% platinum/5% copper
95% platinum/5% ruthenium
95% platinum/5% iridium
90% platinum/10% iridium

The assay figures shown above have been rounded to the nearest whole number for ease of identification. The actual percentage of the 5% alloy was 4.9%, and the 10% iridium was actually 9.9%.

Cold working hardens metals, and while advantage is taken of this increased strength in certain applications, in other applications it is frequently necessary to soften the material by annealing to allow further processes to be carried out (e.g., deep drawing, wire drawing, etc.).

The study of the phenomenon of metal softening when being annealed has been researched by many eminent people in the early part of this century (J.E. Stead, JISI, 1898; Osmond & Werth, Paris, 1885; G. Charpy, Revue de Metallurgie, 1910, et al). From research performed in the early 1970s, it was found that the amount of cold work will affect the temperature at which a metal re-crystallizes or softens. I chose 70% cold work for this paper because it represents the point where no significant increase in hardness takes place on further reduction. The effect of time at temperature on hardness has also been well researched. Examples of this effect are shown when iron is annealed at 675°C. At this temperature, iron requires only

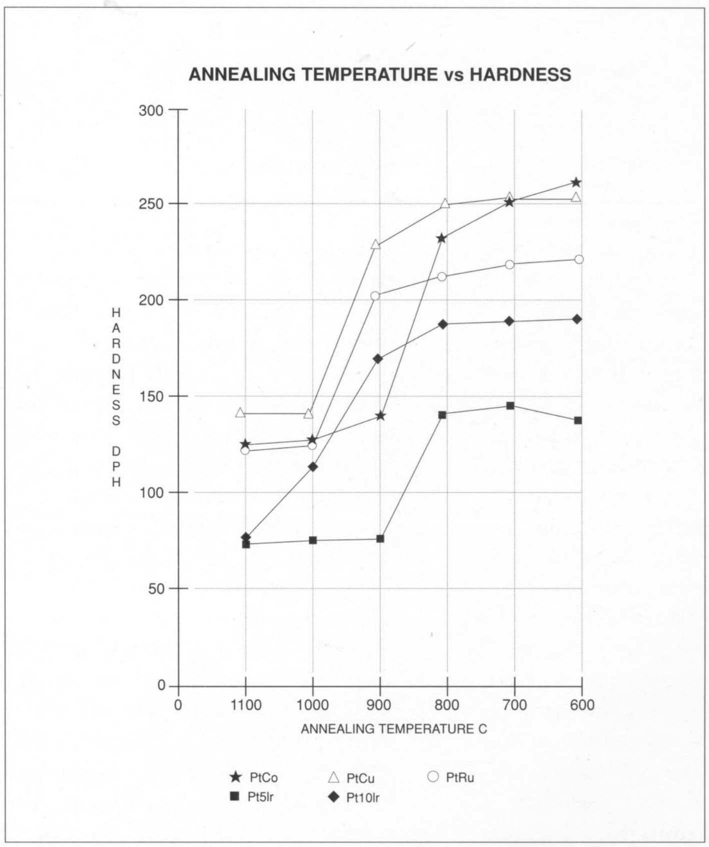

Figure 1

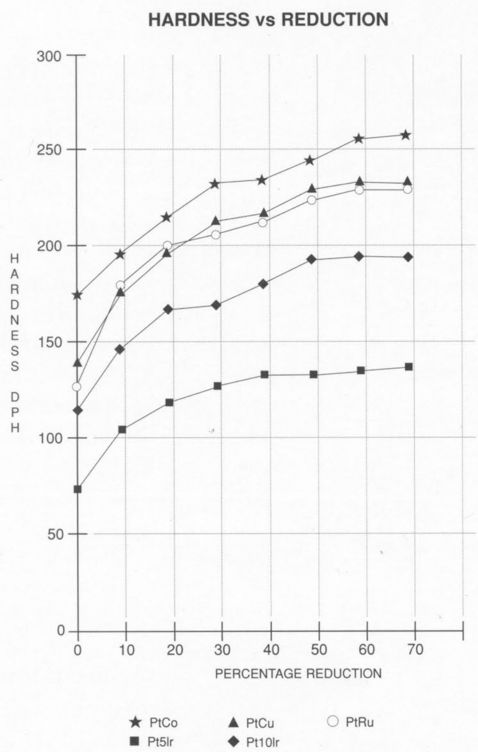

Figure 2

eight minutes to attain a constant grain size, but at 550°C it requires 32 hours. I chose 30 minutes as an acceptable manufacturing norm.

From each sample of the above alloys, six pieces were cut and one piece of each alloy was annealed at 600°, 700°, 800°, 900°, 1000°, and 1100°C for 30 minutes. The hardness of each sample is shown in *Fig. 1*. The graph shows the hardness falling rapidly after 800°C, and at 1000°C there is little further reduction in hardness. As can be seen, the optimum temperature is different for each alloy. In the 5% alloys, 1000°C is sufficient to fully anneal the metal.

It is interesting to note that all the annealing was carried out in air and that the 5% copper alloy turned black at about 800°C, leaving an oxide that was difficult to remove. The iridium alloys show a slight increase in hardness after the 700°C anneal. Examination of the thermal equilibrium diagrams that I have been able to obtain, shows a phase change similar to the one in the gold/silver/copper system, so it would appear that the platinum alloys for jewelry could be heat treated to obtain even higher strengths.

In my research, a plate of each alloy was annealed at 1000°C and then the hardness was measured. Each plate was reduced by 10% in thickness and the hardness was measured again. This was repeated for 10% through 70% reductions in thickness. *Fig. 2* shows the relationship between the reduction thickness and the increase in hardness for each of the alloys. As shown, the platinum/cobalt alloy rapidly work hardens. The platinum/copper also work hardens, but not as quickly as the platinum/cobalt alloy. The 95% platinum/5% iridium alloy has the lowest rate of work hardening. All the platinum alloys show no tendency to crack even if cold worked up to 90%, but as the hardness is leveling off after 70% cold work, it is not necessary to roll above this figure as further reductions do not give any significant increase in strength.

In comparing the hardness results from the platinum alloys to karat gold there appears to be little difference and conclusions may be drawn that the two could be readily exchanged in design criteria. But, in fact this is not the case, as the platinum alloys have a much higher elastic limit. The specific differences were shown in a presentation by John C. Wright at the 1994 Santa Fe Symposium titled "Platinum Alloy Properties and Jewelry Design."

Questions regarding the color of the different platinum alloys have been asked many times; I cannot see any startling difference in any of the alloys tested.

The unique properties of this metal should be taken into consideration and jewelry should be designed specifically to maximize these features. Lighter pieces can be produced, which could be more attractive to the market than merely using a design that has been successful in karat gold. ◆