Practical Applications of Heat Treatable Platinum

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Heat treatable platinum experences a significant increase in strength and hardness because of microstructural transformations brought about by thermal processing during manufacturing procedures. Conventional platinum alloys derive their increased strength and hardness solely from work hardening during cold forming. Platinum alloys generally classified as heat treatable are based on varying additions of tungsten (W), gold (Au), gallium (Ga), indium (In), palladium (Pd) or copper (Cu) according to industry sources. (1-7) Information on these alloys was derived from studies in the late 1970's (6), published in 1990 (1). Certain patents on their application were obtained in the mid 90's. This class of materials was marketed and sold in Europe in the late 1980's. Based on international hallmarking standards requiring a minimum of 95% content for unqualified designation as platinum jewelry, the simultaneous control of chemistry and thermal processing affords a means of manipulating physical properties over a broad range. The inherent low hardness and wear resistance of certain platinum alloys can be overcome with heat treatable platinum. Recent publications have focused on properties and processing issues with limited discussion of potential usage (1998, 1999). Emphasis on actual jewelry production applications will cover the following spectrum:

- Designer Investment Cast and Bi-metal Rings
- Designer Wrought Assemblies with Diamonds
- Mass Production Stamped Findings
- Mass Production Machined or Engraved Seamless Bands

Following the convention established in other industries with similar materials, heat treatment terms used throughout the document are defined as follows:

Solution Treated or Soft Annealed: the phase state that exists within an alloy after treatment at an elevated temperature followed by a rapid quench to room temperature in some media. This treatment is done to encourage the formation of a ductile solid solution amenable to further cold working. Properties such as hardness, tensile and yield strength are generally at a minimum for the alloy system, resulting in maximum workability.

Artificially Aged or Precipitation Hardened: the phase state that exists within an alloy after heating a solution treated material to an elevated temperature followed by slow cooling. This treatment is applied to encourage the separation of an alloy into two phases on a microscopic level. The incidence of a second phase within the alloy generally increases hardness, tensile and yield strength.

Over Aged: the structure of coarse second phase aggregates that occurs when thermal processing during aging is continued over an extended period of time. A measure of ductility is restored while hardness decreases towards the solution treated state.

PROPERTIES OF HEAT TREATABLE PLATINUM:

A variety of physical properties define the attributes of a specific alloy or heat treatment state. Abbreviations used cover the following properties:

- UTS = Ultimate Tensile Strength which is the maximum load attained in a tensile test
- YS = Yield Strength is the load below which a sample deforms elastically
- HV = Vickers Hardness scale is an indirect reading scale from soft fine platinum (HV40) to hard tool steel (HV700)

Properties of heat treatable platinum are compared to industry standard 95% Platinum 5% Ruthenium, 95% Platinum 5% Cobalt or 90% Platinum 10% Iridium alloys.

MELTING TEMPERATURES & COLOR

Alloy: 95.2% Pt - 4.8% (Ga, In, Cu)
Liquidus: 1650°C (3002°F)
Solidus: 1550°C (2822°F)
CIELAB color coordinates:
83.1 L* - 0.1 a* - 4.6 b*

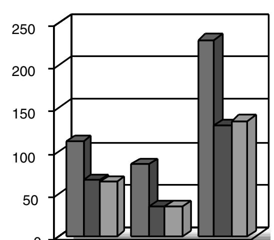
95.2% Pt - 4.8% Ru
Liquidus: 1795°C (3263°F)
Solidus: 1780°C (3236°F)
CIELAB color co-ordinates:
84.2 L* - 0.0 a* - 4.1 b*

Alloying additions required to impart response to heat treatment reduce the melting range of 95% Pt materials substantially (145°C). The melting range is broad at 100°C compared to the narrow 10-20°C typical of most platinum alloys. Care and attention to this unique melting range must be exercised when using brazing or self welding methods for assembly. Color characteristics indicate a quality platinum shade. The lightness value (L*) matches well. The overall color difference vector value (DE) is 1.21 indicating a very close match between the standard and heat treatable materials. The human eye can barely discern color differences that approximate 1 DE value. The abbreviation HTA™, short for heat treatable alloy, is used throughout the remainder of the document.

AS-CAST PHYSICAL PROPERTIES:

Table 1 summarizes the physical properties comparison between 95Pt HTA, 95PtRu and 95PtCo for the investment cast state.

Table 1: Cast Properties



	UTS (ksi)	YS (ksi)	Hard-ness (HV)
95Pt HTA	112	85	230
95 Pt Ru	66	35	130
95 Pt Co	64	35	135

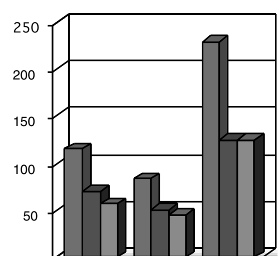
The cast hardness of heat treatable platinum is 100 HV higher than conventional materials. Likewise, the strength of heat treatable platinum is considerably higher (YS 85 ksi vs 35 ksi). This means forces required to close settings are higher, but the result is more secure. Polishing times are significantly faster for the harder heat treatable material. Scratch and wear resistance are also much improved from the elevated hardness. For more details on this see reference 7.

WROUGHT PHYSICAL PROPERTIES:

Table 2 summaries the properties comparison between 95PtHTA, 95Pt5Ru and 90Pt10Ir after annealing at 1100°C. Similar trends to the investment cast data prevail. Heat treatable platinum has a significantly different response to cold working compared to conventional materials. In general, strengths of heat treatable platinum greatly exceed what can be obtained in conventional materials. This is especially true with the yield strength where an elevated value is critical for spring like properties. These enhanced properties can be obtained through cold working, heat treatment alone or a combination of both.

Even with a 75% reduction in thickness through cold work, the yield strength of standard 95Pt-Ru

Table 2: Soft Wrought Properties

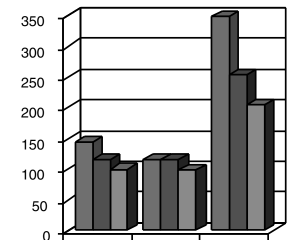


	UTS (ksi)	YS (ksi)	Hard-ness (HV)
95Pt HTA	115	83	230
95 Pt Ru	70	50	125
90 Pt 10Ir	57	45	125

alloy cannot approach the levels attained from correct hardening of heat treatable platinum. Table 3 summarizes the strength of heat treated 95Pt HTA versus cold worked conventional alloys.

Heat treatable platinum hardness is 95HV higher than heavily cold worked 95Pt5Ru. Heat treated strength exceeds the possibilities

Table 3: Heat Treated vs. 75% Cold Worked Properties

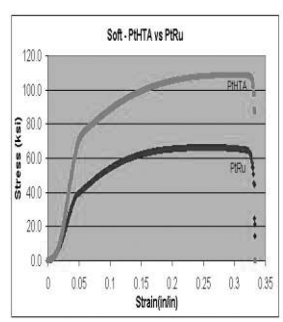


	UTS (ksi)	YS (ksi)	Hard-ness(H
95 Pt HTA	145	117	350
95 Pt Ru	116	115	255
90 Pt 10 Ir	100	99	205

achieved through cold working conventional materials.

All of this additional strength and hardness is achieved without sacrificing ductility for forming operations. Consider the tensile test results shown in Figure 1. Both 95Pt HTA and 95PtRu exhibit over 32% elongation in a standard test. The heat treatable material has a much higher yield strength. This combined with a high work hardening rate in the elastic range indicates superior spring properties. The area under the tensile curve is an indication of the amount of energy required to deform a material.

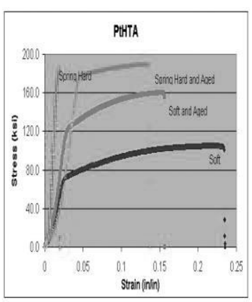
Figure 1: Stress/Strain Curve



Heat treatable platinum requires more energy to deform than conventional materials. This implies it absorbs more energy before deforming plastically, thus exhibiting superior spring properties. Figure 2 shows the diverse range of properties possible with the various forms of heat treatable platinum. Spring hard material subjected to an aging heat treatment exhibit a high level of strength (UTS 175ksi) with almost 15% elongation or ductility. This is similar to a spring steel. Likewise, the aged soft material has ductility with strength. The soft material exhibits maximum ductility (~25%) for forming operations.

Combinations of rolling and aging treatments can be applied to provide a wide range of properties to suit most forming operations. This diversity of strength and ductility simply cannot be achieved with conventional materials.

Figure 2. Range of Properties



APPLICATIONS:

Investment Cast Articles:

Heat treatable platinum exhibits a lower melting point, superior strength and a high hardness to enhance wear resistance while reducing polishing time. All of these attributes can contribute to unique design options for investment cast applications. Care must be taken to compensate for the reduced melting range during assembly brazing or welding operations. With double the hardness and yield strength, a high level of setting skill is required. Superior strength provided security for the diamond shown in Photo 1. The inlayed material on the shoulders of the ring shown in Photo 2, has never required additional work or tightening after initial assembly. Elevated as-cast hardness provided superior wear resistance for the heavy means ring design shown in Photo 3. The ring was worn everyday without repolishing for an entire year. The photos reinforce the compatibility of heat treatable platinum with gold in bi-metal designs.

Photo 1: Courtesy of Creole Carmichael Designs

Photo 2: Courtesy of Creole Carmichael Designs

Photo 3: Courtesy of Creole Carmichael Designs

Hand Forged Wire Assemblies

Delicate, high strength designs can be hand forged from heat treatable platinum wire. Superior strength provides security for the stones incorporated into designs such as the pendants in Photos 4 & 5.

Photos 4 & 5:
Courtesy of Tom Kruskal Designs

Cold worked strength in the broad forged sections is superior using heat treatable platinum.

Conventional materials were damaged during fabrication procedures.

The bracelet design shown in Photo 6 cannot be made with low strength conventional materials. Using heat treatable platinum, cold working by hand forging to the unique shape followed by restoration of ductility and springiness through heat treatment allowed for this unique lightweight design. The material shape and spring properties provide the basis for closure. The brazed joints holding the stones at the top are actually stronger than the thinner forged body sections. Initial fabrication in 95Pt5Ru did not function properly because of inadequate strength limited to cold working during shaping. The delicate thin sections and curves must be struck from a relatively thin wire gauge. The rapid work hardening rate of heat treatable platinum in combination with a hardening treatment produced unparalleled strength. Similar to the bracelet, the necklace shown in Photo 7 capitalizes on the superior strength of heat treatable platinum for the thin forged sections. These designs, and others like the one shown in Photo 8, were attempted in 95Pt5Ru, but were unable to withstand the rigors of manufacturing and wear because of inferior strength limited to cold working. All brazing assembly work did not compromise the strength of the hand forged workmanship. Using a 1400°C platinum solder the joints must be allowed to slowly air cool. This technique enhances material hardness, just like an age hardening treatment. In 95Pt5Ru, the hardness achieved through cold working would have been lost since 1400°C easily anneals conventional platinum materials. Hardening and softening of heat treatable platinum is completely reversible. Hand forging to the limit of ductility and strength can be followed by a solution anneal at 1200-1300°C with a rapid quench in water. Further working or hardening can be done afterwards.

Photo 6: Courtesy of Tom Kruskal Designs

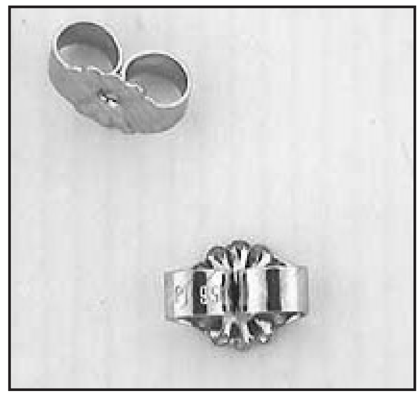
Photo 7: Courtesy of Tom Kruskal Designs

Photo 8: Courtesy of Tom Kruskal Designs

Findings and Hardware:

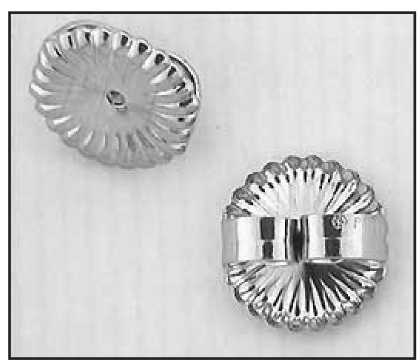
Heat treatable platinum has found increasing application in the area of jewelry findings where superior spring properties are required for functionality. Earnuts, as shown in Photo 9 & 10, are a prime example where strength and lightweight design combine to make a better product.

Photo 9: Courtesy of B.A Ballou



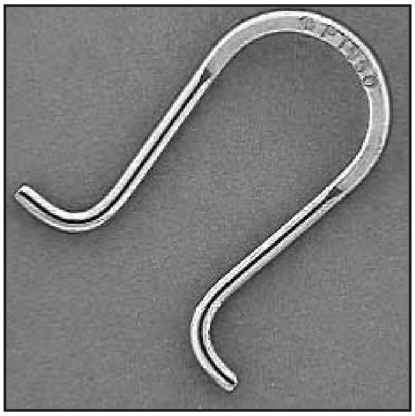
Heat treatable platinum has sufficient ductility to allow for patterning of the earnut base, while still having strength and springiness for holding power.

Photo 10: Courtesy of B.A. Ballou



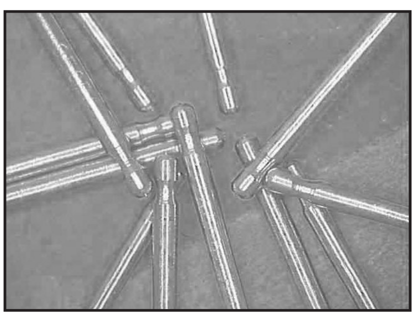
Wire forms also take advantage of heat treatable platinum springiness for clips like the one shown in Photo 11.

Photo 11: Courtesy of B.A Ballou



Superior strength and wear resistance can be achieved through a combination of cold work and heat treatment for notched posts, as shown in Photo 12. Conventional 95Pt5Ru suffered from excessive wear and galling when repeatedly rubbed by a matching earnut.

Photo 12: Courtesy of Stuller Settings



Heat treatable platinum also acts as a spring clip and frame in the heart pendant shown in Photo 13. This unique application involves a thin frame and protruding latch to provide strength and support to the broad heart while ensuring secure closure through many cycles.

Photo 13: Courtesy of B.A Ballou

Seamless Bands:

The unique machinability of heat treatable platinum provides numerous applications for machined and engraved seamless bands.

Conventional platinum alloys are tough on milling and engraving tooling. Rapid chip hardening and self welding tendencies limit design options or cause excessive manufacturing time to be devoted to tooling changeovers or sharpening. With heat treatable platinum, many of these difficulties are reduced. Tool life can be 5-10X longer. This is especially advantageous for CNC work where re-setting tooling amounts to expensive downtime. Diffusion bonding can be performed under the same conditions as conventional alloys as illustrated in Photos 14 & 15.

Photo 14: Courtesy of Sandberg & Sikorski

Milling the deep slot in the ring to accommodate the diamonds shown is an ideal application for heat treatable platinum. Cutting of a small square slot involves the same performance requirements.

Photo 15: Courtesy of Sandberg & Sikorski

Engraving performance, as shown in Photos 16 & 17 is also achieved with reduced tool wear. This is especially significant for eternity band styles where metal removal approaches 50% of the initial starting band section. Drilling of multiple small diameter holes with minimal concern for tool binding and breakage is a significant improvement possible when using heat treatable platinum compared to conventional alloys.

Photo 16: Imperial Smelting

Photo 17: Courtesy of Atlantic Engraving

The 1998 & 1999 presentations on heat treatable platinum outlined a number of manufacturing issues and potential applications for the material. Virtually all of the proposed techniques and products have become reality over the past three years. Properties manipulations through the combination of cold working and thermal processing provide a range of elevated strength and hardness that cannot be achieved with conventional alloys such as 95Pt5Ru and 90Pt10Ir. Many of the obstacles in primary manufacturing processes that effected the size and weight of stamping coils have been surmounted by incorporating specific heat treatments into unique schedules. This means specially cast thin billets weighing 500 t.oz can be processed into strip coils in excess of 125 t.oz to assist high volume stamping demand. Likewise, tube billets of the same size contribute to 200 t.oz lots of finished product for volume seamless band demand. Wire coils 250 t.oz in weight can be produced at a variety of sizes. Research efforts continue to develop techniques that improve the surface finish quality and properties uniformity for reproducible performance in demanding secondary manufacturing processes. The application of heat treatments enhances the properties, wear resistance and functional life of finished products. This enhancement can be achieved through mass production atmosphere belt furnaces common to the jewelry trade or torch heating by hand on an assembly bench. The material responds to a broad variety of treatments to achieve increased hardness. Specialty over aging treatments to create a free machining microstructure or provide properties uniformity to stamping coils require specialized equipment and techniques.

SUMMARY:

- Heat treatable platinum has a higher as-cast hardness than conventional materials. This enhances retention of a bright polished finish. Manufacturers have noted a 40% reduction in finishing times compared to 95Pt5Ru for the same styles.
- Work hardening occurs at a much faster rate with heat treatable platinum alloys. They can achieve a higher hardness and yield strength than conventional alloys with superior spring properties. Mass produced findings take advantage of these attributes.
- Correct heat treatments increase hardness and yield strength about 60% above the soft state. Final properties are double the strength of conventional materials such as 95Pt5Ru or 90Pt10Ir. Hand forged designs capitalize on this behavior.
- A broad range of hardening treatments from torch heating fo lowed by air cooling to travel through an atmosphere belt furnace will cause a significant increase in physical properties.
- Performance during machining operations is substantially better with the free machining microstructure compared to conventional materials. Stone set and engraved seamless bands take advantage of these attributes of heat treatable platinum.
- Bi-metal seamless bands can be diffusion bonded just like conventional materials
- Superior engraving performance of heat treatable platinum enhances productivity for eternity band styles of rings.

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