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

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Abstract

A great deal of misunderstanding exists as to the effects of steel ball burnishing on the surface quality of "as cast" gold and silver jewelry. This presentation will explore, in detail, the use of four types of finishing equipment (vibratory, disc finishers, magnetic pin and roll burnishers) and focus on the resulting smoothness and hardness, as well as visual perception of finish resulting from the use of these systems.

There will be an in-depth review of how the surface finish is affected when "as cast" pieces are prepared, employing the use of vibratory, disc finishing, magnetic pin or roll burnishing equipment for the ball burnishing process.

Finally, the paper will touch on the benefits and drawbacks of utilizing a burnishing procedure prior to wet-cutting operations or final hand buffing.

Burnishing Definition

Steel media has been used for brightening metal surfaces since early in the manufacturing industry. Jewelry manufacturers have used steel media to produce a shiny, bright finish to their earrings, pendants, chain, etc., to enhance their visual appeal to the consumer.

Generally speaking, a wrought or cast piece of jewelry has a dull appearance when first formed. The act of rubbing, rolling or hammering a jewelry piece with a highly polished, hardened ball will reduce the average height of the microscopic peaks of the metal's surface. By doing so the surface becomes more reflective of light and hence brighter to the eye. Brightness, however, cannot be confused with smoothness. A smooth (level) and bright surface is far more appealing than brightness alone. Brightness achieved by ball burnishing usually has an overall "orange peel" surface profile. Through the history of jewelry manufacturing, ball burnishing has had decreased use for high-end jewelry finishing, being replaced by hand polishing or wet and dry mass finishing.

This research is to explore a side benefit of steel ball burnishing that has been used on the industrial side of surface finishing. Steel media weighing about 300 pounds per cubic foot (about three times heavier than any other media) impinges on the surface of the work piece, imparting a compressive stress that work hardens the surface.

This compression and hardening of the surface may be beneficial in mechanically reducing surface porosity and imperfections by compressing the grain structure of the surface of the metal. Subsequent mass finishing and/or hand polishing with the proper abrasives *may produce a better finish with less metal removal*.

Objective

The subject castings will be processed by means of several different types of burnishing equipment, after which the following observations and measurements will be taken:

- Visual inspection
- Microscopic surface inspection
- Surface profile measurement
- Surface hardness measurement

The subjects* were cast by means of the lost wax method. The star-shaped design was chosen for its slightly convexed surface as well as its rather large cross-section. The gold is a 14kt alloy and the silver is 925. After casting, the only operations that were done were de-spruing and grinding the gate. No other surface imperfections were removed so as not to disturb the "as cast" grain structure.

Procedure

Four types of equipment were used to accomplish the burnishing operations. Test samples marked with #2 were processed** in a vibratory finisher. Samples marked #3 were processed in a roll burnisher. A centrifugal disc finisher was used for samples #4 and finally, #5 samples were processed with a magnetic pin finisher. All the products 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.

Because of the difference in material hardness, the silver samples were processed for one hour while the harder, 14kt gold samples were processed for two hours.

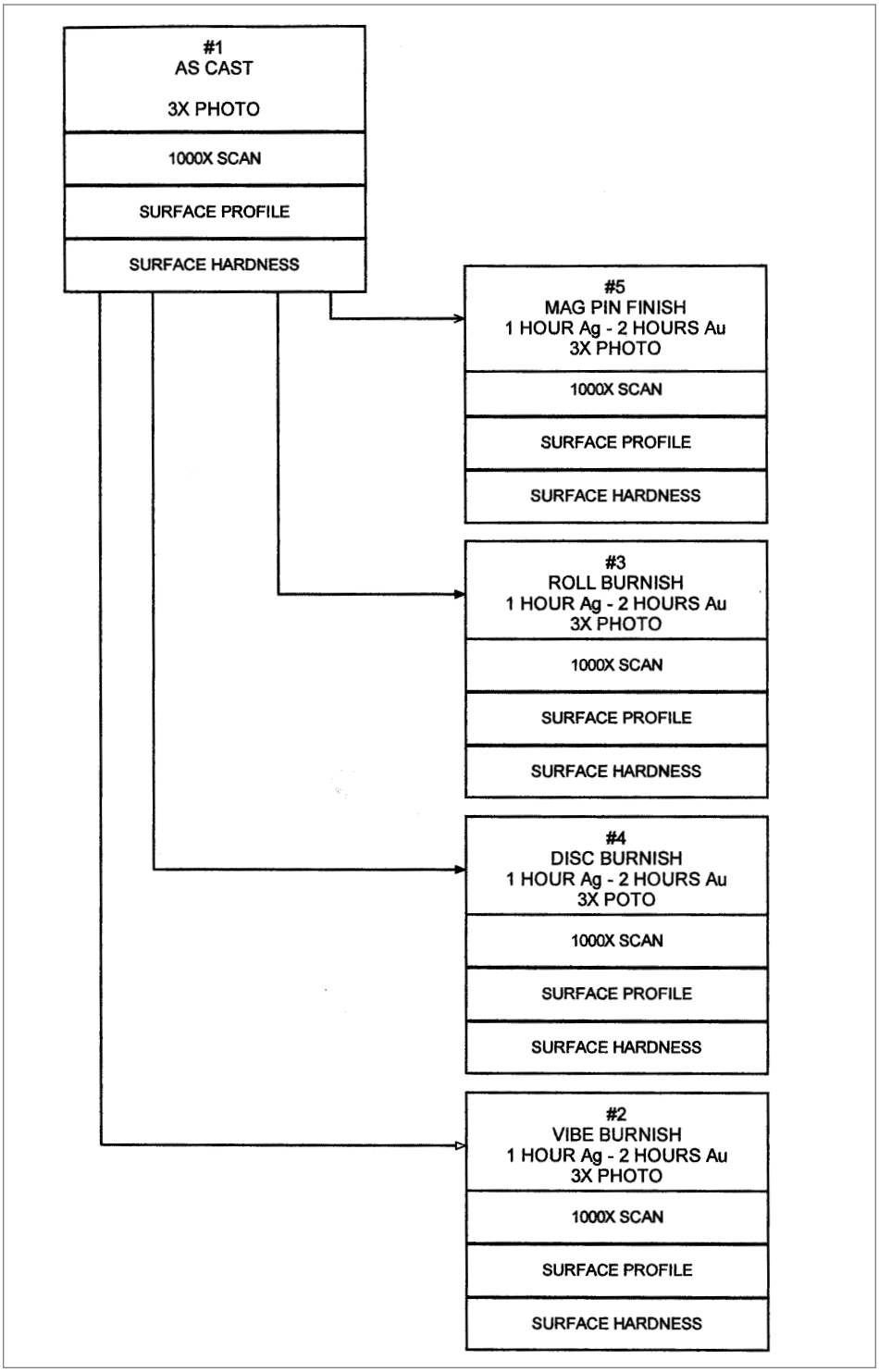


Figure 1 *Flow chart*

Results

The results of both the silver and gold samples are relatively parallel. The measurements and observations are presented as follows:

Visual of Surface:

Here we see the effects of burnishing as is evident from the photographs showing the raw casting as compared to the four samples that have been burnished. The visual appearance of jewelry, as you know, is the essence of its appeal. In photographs Au1 and Ag1, we see the "as cast" pieces appear very dull. This finish is an example of how a surface with minute hills and valleys diffuses the light, giving the effect of a matte finish. Photographs Au2 and Ag2 represent a vibratory ball-burnished finish. We see that there is more reflectivity and the surface appears brighter; however it seems that the length of time or the machine amplitude was not enough to reduce the differential of the hills and valleys to what we had hoped. Photographs of pieces processed in a disc and roll burnisher (Au3, Au4, Ag3 and Ag4) are by far the brightest and most appealing finishes, while pin-finished pieces (Au5 and Ag5) are diffusing the light again and appear matte.

Au1

Au2

Au3

Au4

Au5

Ag1

Ag2

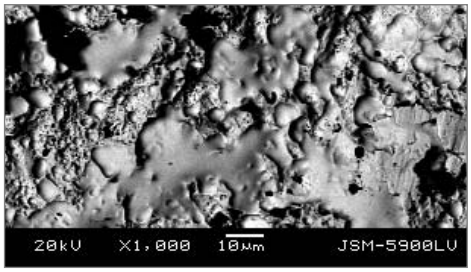
Ag3

Ag4

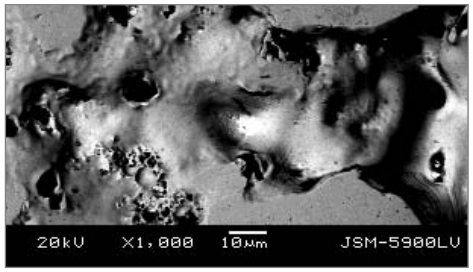
Ag5

Microscopic View of Surface:

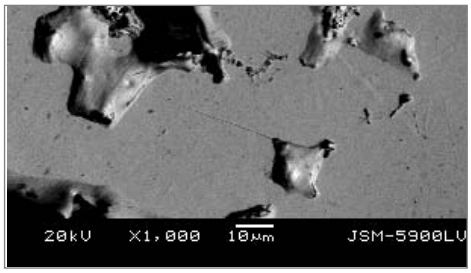
Using a scanning electron microscope (SEM), we examine about a 1mm square area of surface at 1000X power. The dark areas on the scan represent valleys for the most part (we detected some silica in the dark area of the silver samples), and the light areas represent the hills. These scans show the reduction of the surface texture in Au3, Au4, Au5, Ag3, Ag4 and Ag5 so as to reflect more light. We have greatly reduced the percentage of dark area, which directly corresponds to the reflectivity demonstrated by the photographs. Scans Au5 and Ag5 show the surface to be greatly reduced; however, we notice a series of 10 x 20 micron dents formed by the impingement of the pin-shaped media, thus reducing the reflectivity. The question of "what height and geometry of hills and valleys will be more reflective?" needs to be researched further.



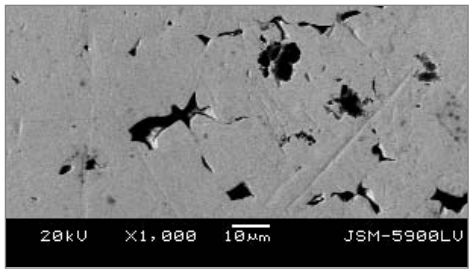
SEM Au1



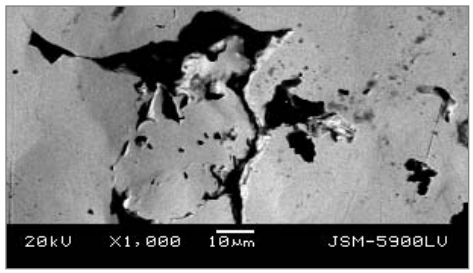
SEM Au2



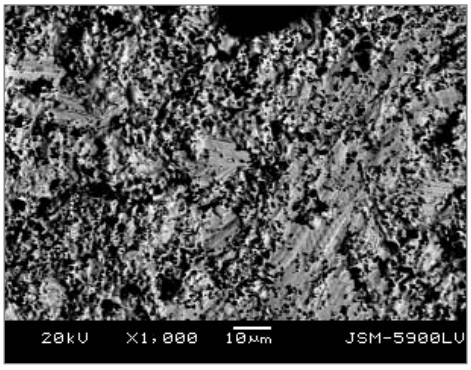
SEM Au3



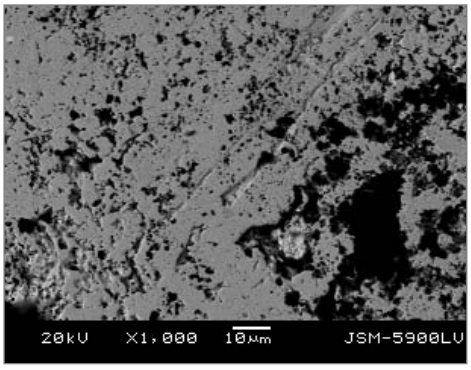
SEM Au4



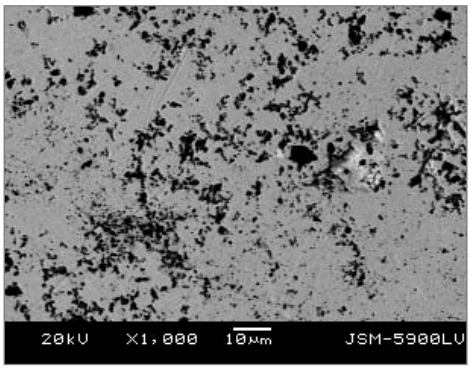
SEM Au5



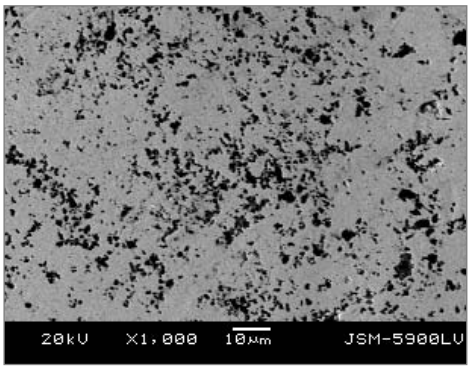
SEM Ag1



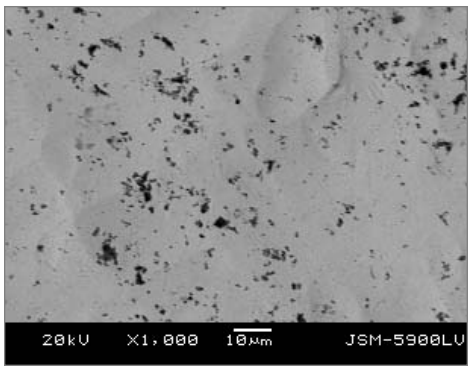
SEM Ag2



SEM Ag3



SEM Ag4



SEM Ag5

Surface Profile:
Typically, the uneven surfaces of jewelry items do not lend themselves to surface measurements. These particular jewelry items were chosen specifically because of their broad, slightly convexed surface area. A Sloan Dektak II Profilometer was used to profile the surface morphology of the specimens.

Both the silver and the gold samples started with a net difference of about 150,000 Angstroms between the peaks and valleys of the surface.

As expected, all four burnishing methods greatly reduced this value to an average of 25,000 Angstroms for silver and 50,000 Angstroms for the gold sample.

The results of the surface profiling correspond to the visual inspection, in that the disc finisher and the roll burnisher produced the best surface. The pin finisher was much less effective in reducing the surface of the softer silver alloy.

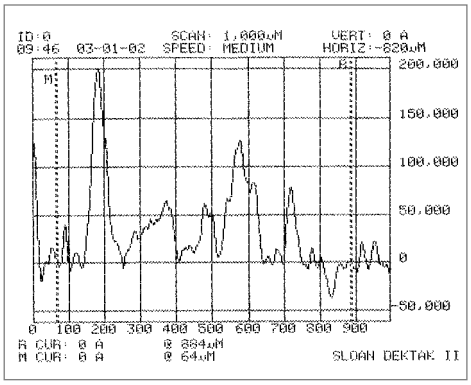


Figure 2 Ag1

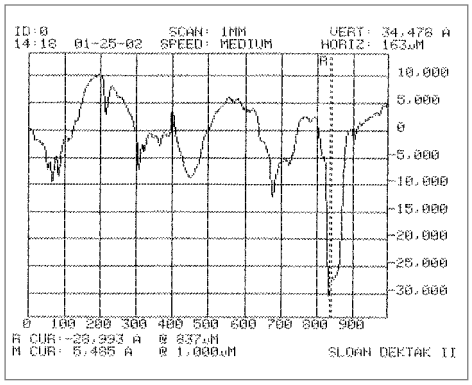


Figure 3 Ag2

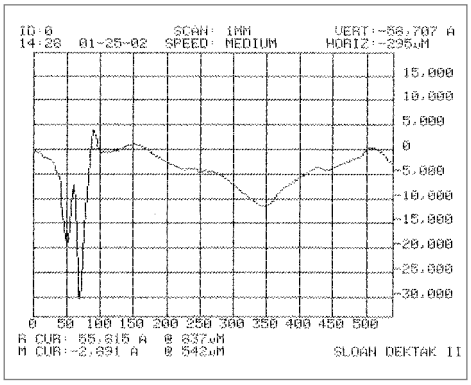


Figure 4 Ag3

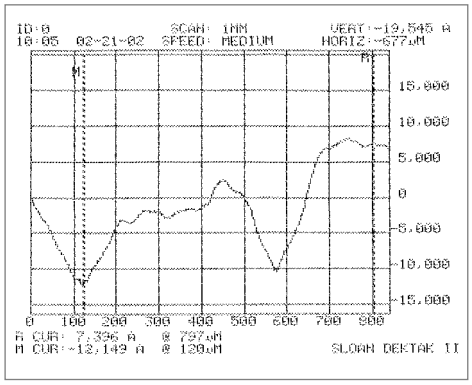


Figure 5 Ag4

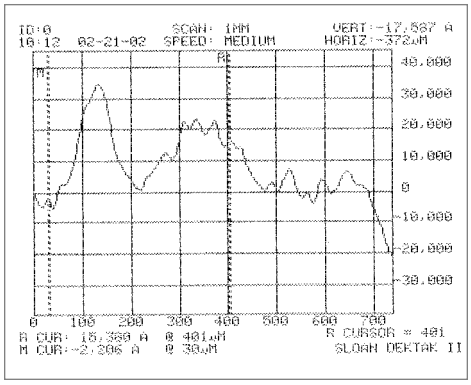


Figure 6 Ag5

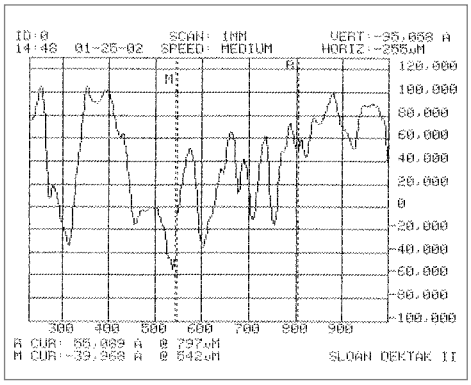


Figure 7 Au1

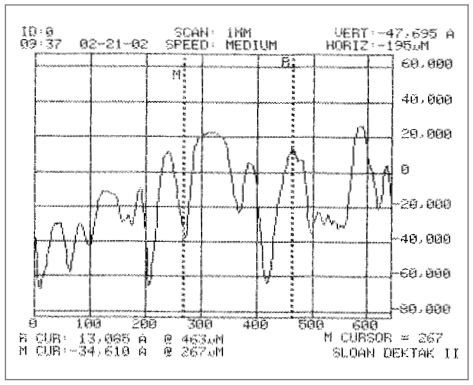


Figure 8 Au2

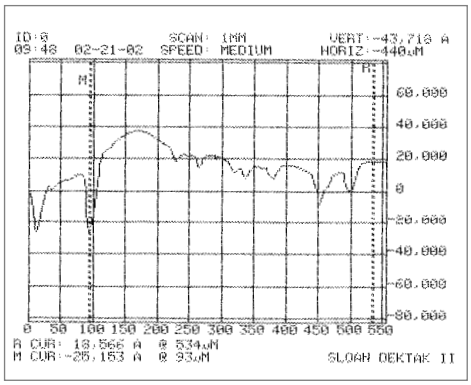


Figure 9 Au3

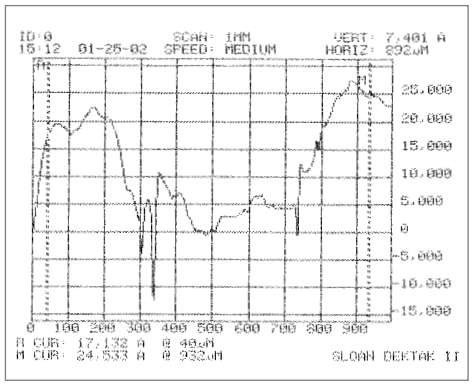


Figure 10 Au4

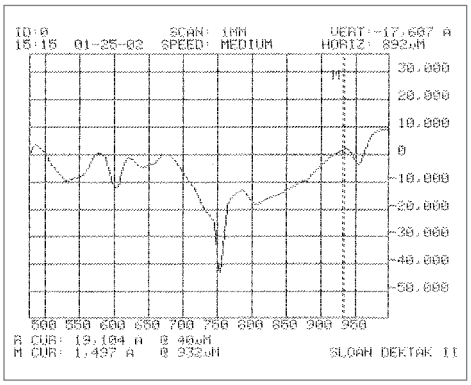


Figure 11 Au5

Surface Hardness:
A Rockwell hardness tester with setting and tip of 30NT was used to measure the hardness of the surface prior to and following the burnishing operations. Four readings were taken for each sample. The highest and lowest values were eliminated and an average value was used for comparison.

All methods of burnishing increased the surface hardness of both the gold and silver samples. The surface hardness of the silver was increased by an average of 22% using vibratory, roll and pin burnishing and 13% using disc burnishing. The hardness of the gold was only increased by an average of 8% using vibratory, roll and pin burnishing, and only 2% using the disc. It appears, in this test, that the disc finisher was slightly less effective in hardening the surface, yet was effective in achieving a good bright finish.

Ag	Meas. 1	Meas. 2	Meas. 3	Meas. 4
1	35.2	26.9	28.4	25.6
2	32.6	37.4	32.9	38
3	26.3	31.5	39.4	40.7
4	29	34.6	25.9	38.1
5	35.8	35.1	34.6	35.8

Au	Meas. 1	Meas. 2	Meas. 3	Meas. 4
1	64.4	65.3	70	63.1
2	67.3	68.7	70.4	68.8
3	66.2	73.4	70.8	70.7
4	71.1	67.1	65	61
5	66.7	70	71.7	74

Remove High & Low Figure

Ag	Meas. 1	Meas. 2	Meas. 3	Meas. 4	Average
1		26.9	28.4		27.7
2		37.4	32.9		35.2
3		31.5	39.4		35.5
4	29	34.6			31.8
5	35.8	35.1			35.5

Au	Meas. 1	Meas. 2	Meas. 3	Meas. 4	Average
1	64.4	65.3			64.9
2		68.7		68.8	68.8
3			70.8	70.7	70.8
4		67.1	65		66.1
5		70	71.7		70.9

Figure 17 *Rockwell Hardness 30NT*

Conclusion

During the burnishing operation we reduced the peak-to-valley relationship of the surface profile and we increased the hardness of the surface, substantially more to the silver samples. Aesthetically, for this type of broad surface, we achieved a better finish using roll burnishing and disc burnishing. Microscopically, pin burnishing reduced the valleys to a greater degree.

The Scanning Electron Microscope illustrates the effect that burnishing has on broadening the peaks of the surface. This effect should reduce the amount of material removal needed to achieve the light reflectivity of the surface. The hardness and depth of hardness still remain an issue with regard to its effect on polishing and mass finishing (generally speaking in metal working, the harder the surface, the higher the polish one can achieve). Pin finishing and roll burnishing should be the choice if the goal is to achieve surface hardness prior to subsequent finishing. Roll burnishing is the method of choice if hardness is considered detrimental. The correlation between burnishing and hand polishing and mass finishing remains an issue, and final conclusions were not reached in this research.

Overall, this research should be viewed as a brush stroke on a large canvas. The conclusions put forward in this presentation were reached on very limited, but nonetheless valid, experimentation.

Acknowledgements

* Samples supplied courtesy of National Chain Co., Warwick, RI.

** Vibratory samples were processed courtesy of L.D.C., North Providence, RI.

SEM, Dektak and Hardness measurements provided by Sensor and Surface Technology Partnership, University of Rhode Island.

Future Research

Hypothesis #1: Subsequent finishing of silver castings would best be achieved following a 1- to 2-hour roll or disc burnishing operation (after major casting defects have been removed).

Hypothesis #2: Subsequent finishing for gold castings would best be achieved following a 2- to 3-hour disc or pin burnishing operation (after major casting defects have been removed).