Which Silver for Whom?

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Abstract

Paul Revere, often known for his contributions during the Revolutionary War, was an excellent silversmith who was able to work with a variety of alloys. Depending on their composition, these materials had a series of advantages, both with regard to his customers and workers. Yet, Revere worked almost exclusively with sterling silver — a choice that served his purposes best: had he used different materials, he would have not been able to expand his business significantly in the time after the war.

Figure 1: spoons, respective copper content (processes), left to right: 4.5% (rolled), 4.5% (forged); 7.5% (rolled); 7.5% (forged); 9.5% (rolled).

High Copper Silver

Using alloys with a high copper concentration had a simple advantage: it decreased the cost of the material since less silver was needed. However, it also impacted the workability: hot forging resulted in age and work hardening, which often caused extensive cracking. As the material got harder it also become more brittle, which can be seen in the result of micro-hardness testing, which returned a value of 82 HV on the forged sample, much higher than any other value measured.

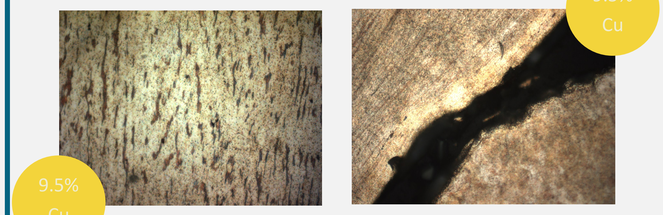

Figure 2: microstructure of high copper alloy, left to right: forged, rolled.

At the end of the 18th century, Revere was able to invest in modern technology like rolling mills which enabled him to work with hard materials more easily. Figure 2 shows a rolled sample next to a forged one: the copper precipitates appear now as prolate ellipses, instead of the more irregular shapes that are seen in the forged metal. The regularity of the material means that extremely localized forces in the material are less likely to occur and thus the material is stronger. In short, high copper alloys were particularly useful for a subset of products which underwent high stress, such as hinges.

Low Copper Silver

While silver alloys with a low copper concentration are more expensive than their counterparts due to the higher amount of silver, they exhibit a number of properties that are advantageous for silver workers.

This low copper alloy is less brittle and softer, because it lacked the large number of copper precipitates which contributed to the work hardening and age hardening found in high copper alloys. While work hardening clearly increased the hardness of the material, the material is speckled with precipitates, and largely dominated by white silver as seen in figure 3, producing the bright sheen of this alloy.

Customers certainly appreciated the shine of a low copper alloy. However, their silverwares could be easily damaged and would degrade quickly due to the material's softness. Thus, such alloys would be more suitable for fine, ornate pieces for the wealthier clients. Revere and his workers also appreciated how workable the material was, although its softness made it hard to polish.

Figure 3: microstructure of rolled low copper alloy.

Sterling Silver

Revere used sterling silver almost exclusively for his products. Relying on a single type of silver allowed him to focus his shop's production and, as a result, increase the output (a trend that was supported by the move towards standardization and mass-production after the war). Likewise, sterling silver was relatively easy to work with. Its copper content was just below the saturation limit of copper in a silver solution, 8.8%. When heated, the metal could become a homogeneous silver solution with copper dissolved in it; more copper would create precipitates causing a yellow coloring. Since sterling silver could be cast in a homogeneous state, the age hardening processes only produced very small precipitates, creating a final product with a color dominated by the white of silver as seen in figure 4. From the customers' perspective the color and durability of the sterling silver product was well balanced. From a worker's perspective, a homogeneous metal was more forgiving and therefore easier to work with. As Revere worked with cast ingots, he heated the metal for an extensive period of time causing age hardening along with work hardening. It also worked in his favor to create a brand that his customers could count on: his mark guaranteed a certain quality, not just from an artisan's perspective, but also with regard to the material used.

Figure 4: microstructure of forged high copper alloy.

Hardness Testing

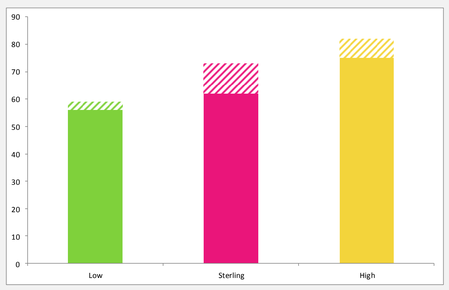

Figure 5: hardness testing results in HV; hatched mark indicates forged samples, solid mark indicates rolled samples.

Age Hardening

Silver copper alloys undergo a process called age hardening which occurs when the metal is heated till it is no longer a crystal but not yet liquid. When the material stays at this temperature the copper slowly precipitates out of the silver solution into a copper solution with silver dissolved in it. The copper solution precipitates in the metal can be seen as the slightly darker points in the microstructure. The boundaries between the copper and silver solutions hinders dislocation making the metal harder. Thus the total volume of the copper solution doesn't matter as much as the surface area and distribution of the copper solution in the alloy.

Work Hardening

In this process the material is deformed and dislocations are introduced, increasing the surface area of any precipitates. The surface area of the precipitates represents a phase transition with contributes significantly to the hardness of the material since phase transitions impede deformations, also the increased presence of deformations impedes the creation of new deformations. While these are effective hardening methods, if too many dislocations are introduced into the material then it becomes very brittle and breaks. Thus there is a maximum strength that a copper-silver alloy of a given mixture can have.

Conclusion

The lower than saturation copper content of sterling silver did not result in the discolorations seen in high copper silver while remaining fairly durable. Sterling silver was soft enough to be forged but would not be as easily damaged as low copper silver. It is unclear whether Revere took into account the factors discussed above when choosing what alloy to use. However, the evidence suggests that sterling silver balanced the needs of Revere's customers and workers.

Sources

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