

Annealing Copper Wire by Marty Weiser

Work Hardening

Copper has a cubic crystal structure. It is the particular variation (face centered cubic) that gives it its extreme ductility so that you can bend a wire into really sharp curves. Aluminum, silver and gold, among others, have the same crystal structure. Bending a copper wire work-hardens it which introduces defects, known as dislocations, into the structure.

These defects interfere with further deformation and make the copper hard and strong so it is not easily re-bent. This is why copper is so good for bonsai - it bends easily the first time, but then holds its shape. Aluminum work-hardens less than copper while gold barely work-hardens at all.

Annealing

Annealing the copper eliminates the dislocations so that the copper is once again composed of nice perfect crystals. This allows the copper wire to be re-used since it is now soft and easily bent. Generally, annealing is done at greater than 1/2 of the melting point on the absolute temperature scale. Copper melts at 1083 degrees C = 1356 degrees K so the annealing is done at greater than 678 degrees K = 405 degrees C = 761 degrees F. However, it will take a fairly long time at the lower end of the range so it is more common to anneal at about 700 degrees C to 800 degrees C. The copper can be worked and annealed many, many times for the purposes of bonsai since we really don't need tightly controlled properties. The properties will degrade with repeated cycles for various reasons - oxidation being the most obvious.

The copper will maintain its soft crystal structure after annealing at any realistic cooling rate from very slow (like letting the fire die down) to fast (like throwing it in a bucket of water). Generally, I would suggest water cooling to prevent excessive oxidation of the surface. Steel (iron + carbon), on the other hand, will change its properties dramatically upon rapid cooling. However, it is possible to cool copper fast enough to make it into a brittle material. This normally involves cooling rates of greater than 10 million degrees Celsius per second, which can only be obtained by spraying a very thin film on to a very cold surface (this equipment is very expensive).

For bonsai wire, it is generally not necessary to take strong measures to prevent oxidation unlike jewelry or electronics where a precise part is being made. Go ahead and heat it, with whatever safe form of heat you have, to a dull red glow. The wood stove, the barbecue, a torch, or the gas stove will work just fine. Just remember that the copper will be hot enough to ignite most flammable objects if you set it down on them and it will give you a nasty burn if you are not careful. In addition, copper is an excellent heat conductor so heating one end of the wire to red hot will quickly result in the other end getting hot too.