Heat Treating Music Wire

by Roy Vaillancourt

About the author:

Roy Vaillancourt is the president of Vailly Aviation, a part time venture, catering to giant scale enthusiasts. Roy and his wife, Nancy, have operated Vailly from their home since 1986. Roy, whose specialty is giant scale warbirds, is an active scale contestant who has competed regularly at the Top Gun and Scale Masters Championships for the past ten years. He is a frequent contributor -- on a variety of topics—to the major scale modeling magazines and to our own Articles and Tips department. A mechanical engineer with two advanced degrees and over thirty years experience in design and manufacturing, Roy works full time as a senior design specialist for Lockheed Martin.

The music wire used by sailplane modelers to make landing gear and cabin struts is medium carbon steel heat-treated to spring temper or about 45 on the Rockwell C scale of hardness (RC45). On this scale, RC20 is soft, RC45 is tough, and RC60 is hard.1 Tough wire can be bent and cut using the proper tools and techniques, but sometimes it's just too difficult to work with.

One way to soften steel music wire is to heat it, which makes it easy to bend and form. But after heating and forming, the subsequent cooling—often at an uncontrolled rate—can make the finished wire too hard or too soft since its hardness is determined by the rate at which it cools. For some parts, the final hardness isn't critical. But a landing gear formed from wire softened too much won't spring back to its original position; and a gear made from wire cooled to a harder than normal state will snap on its first use. To restore the wire to its original specific spring temper, it must be heat-treated a second time and cooled at a controlled rate.

Three Steps

To form wire easily, first anneal it; next, form or bend it to the desired shape; and then heat-treat the part back to spring condition—that is, temper it.

First the wire should be annealed2 at the location to be bent. To anneal it, heat the wire with a torch until it becomes a bright cherry red—about 1400 degrees Farenheit. Let it cool completely to the touch. Don't quench3 it or blow on it. Just let it cool naturally away from any drafts. The wire should now be in the RC25 soft range, and it will bend easily. After forming, once again heat the wire with a torch until it becomes bright cherry red, but this time quench it—that is, cool it rapidly by immersing it in room temperature water. Plunge the steel into the water with a twisting, swirling motion to keep water vapor from insulating the wire against the cooling action of the water.

At this point the wire should be very hard, probably above RC60. To test the hardness, try to make a mark on the worked area with a file. The file should slide off without cutting into the steel at all. If it cuts the wire, try the heat and quench cycle again. If the file still cuts the wire, it isn't high carbon steel. Get another piece of wire and start over -- you won't be able to add the necessary carbon to low-carbon steel.

When the file test signals success, the wire is ready for the final step, but not for use, because it's very hard and quite brittle, and will probably snap off.

The final step is to temper the wire back to the desired hardness. Tempering is a form of annealing but is controlled so that the steel achieves a specific hardness. Start by sanding the wire with steel wool or emery cloth. Then heat it gradually with the torch. Watch for the following colors as a guide: straw color (350 degrees), followed by dark blue (600 degrees), and then medium blue (750 degrees). At this point, remove the wire from the heat and allow it to cool slowly. Don't quench it or blow on it; just let it cool naturally in still air. Once the steel returns to room temperature, it should be at the target RC45 hardness, which has a good spring temper. Try the file test again. You should be able to make a mark now, but only with some effort. If it passes this test, the wire is properly tempered.

Besides parts for model planes, tempered music wire can also be used to make special purpose tools. Instead of tempering to 750 degrees (medium blue), stop at the straw color stage. The wire will be at about RC60, which is still very hard, but not brittle. Wire at this temper can be used to drill wood and plastics, and most aluminum and copper.

Notes

1. Rockwell hardness testing, named after Stanley Rockwell who made his first testing machine in 1921, is a general method for measuring the bulk hardness of metallic and polymer materials. Although hardness testing does not measure performance properties, hardness correlates with strength, wear resistance, and other properties.
   Rockwell hardness testing is an indentation testing method. An indenter is impressed into the test sample at a prescribed load to measure the material's resistance to deformation. A Rockwell hardness number is calculated from the depth of permanent deformation of the sample after application and removal of the test load. Various indenter shapes and sizes combined with a range of test loads form a matrix of Rockwell hardness scales that are applicable to a wide variety of materials. The Rockwell B and C scales are used for metallic substances. (Back to text.)
2. Anneal: To heat and then cool (as steel or glass) usually for softening and making less brittle.(Back to text.)
3. Quench: To cool (as heated metal) suddenly by immersion (as in oil or water). (Back to text.)
   Bibliography

For more information about working with metals in general and about hardness testing in particular consult these books by noted metallurgist, Harry Chandler.

Hardness Testing, 2nd Edition Harry Chandler, 1999.

Metallurgy for the Non-Metallurgist Harry Chandler, 1998.