HEAT TREATING 154CM and ATS 34

I like to build fillet blades out of 154 CM and have worked out a heat-treating Recipe that yields a relatively tough, corrosion resistant, and high wear resistant blade. This grade of steel is basically 440C modified with molybdenum to provide some hot hardness. The chrome has also been reduced from 18% to about 14%. Chromium tends to decrease ductility at higher hardness, so a reduction of 4% allows this steel to be used successfully for working knives in a HRC 59 to 61 hardness ranges. The molybdenum also contributes to corrosion resistance and works to prevent pitting in use around salt water. The same recipe can be used for ATS34 since it has the same chemical composition.

The goal is to end up with a blade that has a low amount of retained austentite (less than about 5%) and has a hardness of 60/61. Experience has shown that edge holding falls off noticeably below 59 and ductility decreases dramictally above 61 with this steel. The 60/61 “sweet spot” is critcal for the performance of this grade in a knife blade application. Let me emphasize that this is my method and that similar results can be achieved by using different procedures. The heat-treating process outlined here works nicely with small batches of one or two blades at a time. It would be cost prohibitive for more than a couple because each blade must be handled individually throughout the cycle.
The “as quenched” (before tempering) hardness including the sub-zero cycle is about two points lower with an air quench. 154CM is a secondary hardening steel, that is, it has a hardness increase during tempering at around 975 degrees. If the air quench is used with tempering at the 975 bump, the final hardness will be in the 60/61 “sweet spot” range. This also insures that the “hot hardness” will be present. Hot hardness is desirable because a little overheat during the final grinding will not soften the blade. The Crucible Materials data sheet for 154CM cautions against using the higher tempering temperature because of a concern for loss of corrosion resistance and toughness. The difference in properties between the two methods is hard to detect in the field in my experience. The air quench batch type heat-treating method has been used for thousands of knife blades in the past and is a well-proven method. However, I have chosen to use the heat treat outlined herein because I want to err on the side of maximum corrosion resistance for the fillet knife application.
As we go through the heat-treating, steps below, I will offer additional information explaining why and how.

Spray blade with Turco to prevent de-carbonization

I like to use Turco rather than foil for this steel because it allows me to get the blade out of the furnace quickly and into the oil quench. The goal is to quench as close to the furnace temperature as possible. I got my Turco from K&G Finishing Supplies but at this time I would recommend checking with them to make sure they still carry it. Turco is a spray on or dip coating that has clay suspended in the matrix. When the blade is heated the clay glazes and forms a coating that protects the steel from the bad effects of de- carbonization. Blades must be thoroughly cleaned with solvent and blown dry to eliminate dust. I thin the Turco slightly and spray it on the blades with a “top trigger” type touch up sprayer that is available from the discount tool supply houses. Use several thin coats so it doesn’t run. It should end up a nice even gold color like anodized aluminum. The application of Turco takes some practice but works very well for this steel.

Preheat furnace to 1500

Insert blade and hold for 10 min to equalize at 1500. This is a strain
Relief to minimize warpage from the grinding stresses. It is also just within the critical temperature for this steel and starts the austentizing process.

Ramp furnace up to 2030

My furnace takes about 15 minutes to get up there from 1500. When 2030 is reached hold for 20 min. I have done a temperature survey in my furnace with a digital thermometer and type K thermocouple. Temperatures vary inside the furnance by 50 degrees or more. The temperature sensor in the furnace is usually remote from the steel being heated so you have to work out a blade placement and controller setting that gives you about 2000 at the blade. This happens to be 2030 for my furnace

Remove from furnace and quickly quench in oil

I use plain hydraulic oil at room temperature. An oil quench with light oil is dangerous so be very careful here. Immerse the complete blade below the surface of the oil in one fluid motion and work if up and down in a vertical line. Don't break the surface with a very hot blade since in will cause the oil vapors to "flash" and catch on fire. It's best to do this outside and wear hand and eye protection. Let blade cool in oil to below about 400 degrees before removing to prevent flash.

Remove from oil and straighten blade if necessary

If you have hardness tester take a quick check here. It should be about 61.5/62. It is important to keep the quench process moving. As soon as the blade reaches room temperature move to the subzero process. Even 5 minutes delay can allow the austenite to stabilize and make it difficult to completely resolve to martensite even in liquid nitrogen.

Directly immerse in Liquid nitrogen and hold about an hour

I do a sub-zero before a temper because it is the most effective sequence to transform retained austentite. The goal is to end up with an as quenched blade that is as close to 100% Martensite as we can get. This will enhance tempering response and provide a low internal stress and stable blade over time. A knife blade is very thin and will cool and equalize very quickly, so is not subject to the high differential stresses a large complicated piece would see. I have never had a blade crack or seen any evidence of temperature induced stress cracking with this method. If you chose to do an intermediate temper you may not get the same results described here in. The subzero cycle for this steel is very important. Without it, large amounts of retained austentite will be present (as much as 30%). Full hardness will not be realized and the austentite can transform by itself over time to martensite causing high internal stress that can weaken the blade and also cause dimensional changes. Multiple tempers will almost accomplish the same goal. Three or four will probably reduce the austenite content to below 10%. A full subzero however is the most positive and efficient technique and provides the highest confidence that retained austenite will be the minimum possible.

Remove and heat blade to room temperature in a bucket of water.

I like to warm up in water to accelerate the process. Warming in air accomplishes the same thing but the blade will hang there and smoke for a long time before its warm enough to handle. It's best to keep the process moving along. Check hardness here and you will find one point gain. It will be a solid 62/63. The retained austentite has transformed to martensite on the heat up to room temperature and the additional hardness due to the transformation is measurable.

Temper once at 400 to 425 for 4 hours.

The tempering temperature can be adjusted at this point to yield HRC 60/61. Access to a hardness tester is required for this final step because a 1 point difference cannot be detected with a file test. Use 425 to temper from HRC 63 and 400 from HRC 62.
As mentioned above, multiple tempers are not necessary since the retained austentite has been transformed in the subzero cycle. The blade will come down about two points to HRC 60/60.5, which is right on target.

Finish grind and polish.

It is a good idea to re-temper to remove any final grinding and finish stresses at 375 for one hour. Hardness will not change.

This heat-treating method has been tested in the field by me and many other users over the last couple of years. I have done some destructive testing on several very flexible fillet blades and have found that if flexed hard, well past the point where they would be used in the field that they will “bend” before finally breaking. This is evidence that even at this hardness they are exhibiting some plastic deformation and have adequate ductility (toughness) for a working knife. Many semi-custom knives are showing up with ATS 34 blades these days. 154CM and ATS 34 blades are very good performers and are currently the work horse steels for custom and factory blades. It is obvious that the steel grade just by itself does not insure a quality blade. Quality heat-treating is essential for performance and the sweet spot hardness range is critical for these category steels.