A quick lesson on heat treating.

Heat treating can be the most critical process in making a custom knife blade. The following is an outline of the steps required and a basic explanation of what and why.

Knife blade steel is supplied in the annealed form. That means it is soft so that it can be drilled, filed, ground and shaped into a knife blade. To make an effective cutting tool it has to be hardened. The hardening process requires heat and specific lengths of time for each step. A precisely controlled furnace is necessary because a small difference in temperature can make a big difference in the final hardness. The steel must be isolated from the effects of the hot environment so that the carbon in the steel is not lost or burned out in the presence of oxygen. Steel is combination of Iron and Carbon and other alloys included for specific characteristics. If a significant amount of carbon is lost then the steel can not obtain full hardness. A final requirement is a hardness tester so that the "Rockwell" can be measured as the process goes along.

Step 1. Preheat

Some commercial heat treat furnaces have an inert atmosphere (nitrogen or argon) inside to prevent decarburization. This equipment is expensive and can only be justified for a large operation. For smaller operations the part can be wrapped and sealed in a protective stainless steel envelope. This is what most knife makers do. So for step one, the blade is sealed in a protective envelope and placed in a preheated furnace. The preheat temperature varies depending on the steel but is in the range of 1500 degrees F. for most stainless steel knife blade materials. The blade heats up from room temperature to 1500 degrees in few minutes but is held at that temperature for about 15 minutes. The preheat soak relieves mechanical stresses in the steel that are present from the grinding and drilling operations. When the stresses are relived then there is less tendency for the blade to warp when it is removed from the furnace.

Step 2. High temperature cycle

The furnace temperature is increased to 1800 to 2150 degrees depending in the steel grade. At this temperature the steel crystal structure is called Austenite. This is a time and temperature reaction and normally about 1/2 hour is required for this cycle.

Step 3. Quench cycle

The blade is quickly removed from the furnace and air or oil quenched down to room temperature. A crystal structure transformation occurs during this cycle. The objective is to get full transformation from the Austenite phase to the Martensite phase. Martensite is a very hard very high stressed crystal structure. Some of the high alloy stainless steels do not fully transform to Martinsite when cooled to room temperature. To complete the transformation the steel must be cooled down to at least -100 degrees below 0. The most convenient way to do this is to submerse the blade in Liquid Nitrogen. This is called a subzero cycle or cryogenic cycle.

Step 4. Tempering

If a subzero cycle is used the blade is removed from the Liquid Nitrogen and warmed up to room temperature. At this point it will be very close to the desired full Martensite crystal structure and will be very hard and very high stressed almost like glass. In order to be a useable knife blade it must be “tempered”, that is the Martensite structure must be modified to be less stressed and a little softer. This is done by heating the blade back up to some temperature less than about 1000 degrees F depending on the steel grade and the final hardness target and holding it for and hour or so. Normally this cycle is repeated a couple of times to insure the full transformation to the modified Martensite phase.

Molten salt is used in some heat treating shops to heat the steel. This is a very precise way to get even heating and precise temperature control. The disadvantage is that some salts especially the compounds needed for temperatures over 2000 degrees F. are toxic and not friendly to work with or to dispose of. As a result most knife makers use furnaces similar to a ceramic kiln. The interior temperature control for these types of electric element furnaces is not precise. Final hardness can vary with each blade. Therefore the ability to measure the hardness at each point in the cycle and make adjustments along the way is important in order to get a quality blade of known hardness.