9/28 UPDATE ON CPM420V (S90V) -NEWEST PARTICLE METALURGY STEEL

None of the popular steels in current use for custom knife blades were developed specifically for cutlery purposes. 154CM/ATS-34 (modified 440C) are offshoots of the aerospace industry for high temperature bearings in jet turbine engines. D-2 is a work horse die steel and 52100 has been the industrial bearing steel of choice for many years. The recent interest in the Particle Metallurgy steels from Crucible Materials Cooperation has come about because of the growing range of specialty tool steels available. With multiple formulations the odds are that one or two will stand out for custom knife blade applications. Crucible has also made the CPM steels available in relatively small quantities and has been very helpful with technical advice on heat treating for knife blade applications. Steel companies formulate new specialty steels for large sales potential. Custom knifes are a very small part of the market for these steels. It is therefore a happy accident when a new steel works out as a good blade material. CPM440V was one of those accidents, and it looks like CPM420V will be the best so far. CPM420V was developed as a high wear steel for the plastics industry. Plastic injection feed screws normally have a short life because of the abrasive qualities of the hot plastic material. The qualities that made this steel successful for this application (wear and corrosion resistance) are are the same qualities that give it the potential to be an excellent cutlery steel.

Note: this article was written in 1998 and was edited for this web site. CPM 440V is now called S60V and 420V is now called S-90V. Phil

It has been over a year now since Crucible introduced CPM420V as a upgrade for CPM440V. The initial results as reported in the article were encouraging. The edge holding was very good, the ductility was about as expected and the corrosion resistance seemed to be on a par with the other popular stainless knife blade steels. In addition in the article I asked for feed back from other makers and promised to report on the results from field tests on some of my earlier knives. I currently have 15 fillet knives, 6 kitchen knives and 5 hunting knives in the field with CPM420V blades. This steel is also now being used by several other makers as part of their production. The question is --now that information from the field is available and other makers have good working experience with it how is it performing? The reports that follow pretty much tell the story and in addition I would like to offer my own experiences in grinding, heat treating , and using blades made from this steel.

Wayne Goddard, Master Smith, Knife journalist, and full time veteran maker was intrigued by this steel when I first told him about. He has been doing comparison cutting tests on manila rope over the years on all of the exotic and work horse knife steels. He offered to evaluate 420V so I sent him a piece. He ground a test knife in his standard pattern and sent it to me for heat treat. I heat treated it with the formula and methods included herein and returned it to him. Rope cutting as a method of comparative testing on steels is tricky because there are so many variables. Wayne is very precise, uses a reference knife as a standard, always flat grinds his test knives and always sharpens using the same methods. I trust his results in this area over my own because he invented this test procedure and has been refining it for a long time. He consistently got 64 cuts on 1/2 inch manila rope with CPM420V. Not many steels go over 45, and most are down in the 30 range according to Wayne. He also reported that it was easy to get a very aggressive, extremely sharp edge on the test blade with a Norton Silicon Carbide stone.

Barry Gallagher, full time maker and Knife photographer came up with the same impressions independently. He has made several folders from this steel and emphasized that he is able to get a very sharp and aggressive edge on these blades. He also noted a dimension change between the annealed and heat treated state. This is most noticeable during construction of a folder where fine tolerances are necessary for the final "tuning" of the folding mechanism. Barry also mentioned something that mirrors my experience with grinding and finishing 420V blades. It is very difficult to get a decent finish on it. The alloy content approaches 20% in this steel. This translates to more abrasives and a lot more time invested in getting a decent hand rubbed satin finish.

P.J. Tomes, Master Smith, full time maker, mentor and gifted craftsman has also had considerable experience working with this grade. P.J. cuts cardboard while relaxing in front of the television. He reports that in his opinion this steel outcuts all others hands down. He also made the same point as Wayne and Barry did on the the extremely aggressive cutting ability and the ease of obtaining a very sharp edge on his blades. P.J. says this is the toughest steel to grind and finish he has ever worked with. He feels the results are worth the effort but he charges a premium because of the extra time and additional abrasives expended working this material.

The field reports are very interesting and informative. I made a CPM420V test knife for Rabbi Yurman. He is a Kosher butcher in Brooklyn New York. He is interested in steels and metallurgy as they apply to knife blades. He has used all the popular knife steels in his work and as a butcher is an ideal tester for a knife steel. The knife I made for him can best be described as a big straight razor. It was heat treated to RC56/57, and hollow ground to 0.006 at the cutting edge. He kills about a 1000 chickens a day with his knives. This is done with a precise neck cut so that the animal bleeds out completely. He sharpened it initially on a hard Arkansas stone and touched it up with a butcher steel occasionally as he was working. He said he uses the smooth steel more out of habit than necessity. He used the test knife during a full week and reported that it never really got dull. After a week he passed the blade on to his cut up department where heavier work

with larger animals around bones and joints are done. The report on edge holding from that department was about the same. The blade was steeled periodically and it just kept on cutting. The knife was returned to me with a half sized dime chip broken out of it. This was a concern because CPM420 was developed to be somewhat tougher than CPM440V. Was this the fault of my heat treating, a flaw in the steel or an indication of a brittle problem? The blade was heat treated to the formula included herein. I sent it to Crucible Headquarters in New York for inspection. They examined the knife and reported that there were no flaws in the steel. They felt that the heat treating was OK, and the failure was due to an over stress condition in the very thin blade. They suggested that this would be typical of any of the popular high alloy stainless steels in use and that it was not a condition specific to this particular grade of steel.

I made an CPM420V Ulu for Roger Rothschild and his wife Elena. They live in Bethel Alaska about 400 miles from Anchorage. Roger kept meticiouls records on Elena's work on preparation of Salmon for the smoke house. They work fish traps on the Bethel river and therefore have large amounts of fish to process at a time. Each salmon is prepared by removing the head tail and fins, is gutted and cut into chunks and strips for brining and smoking. Elena cuts against cardboard with a wooden backing. Roger reports that 75 large salmon were processed before Elena felt the blade needed re- sharpening. He went even further with this description and calculated the total length of actual cutting distance. It worked out to a surprising 4000 linear feet. He touched it up on a extra fine diamond stone and was able to restore the original edge quickly.

The fishing has been very good in Northern California this summer. I have had an opportunity to try this steel on large quantities of a variety of different fish. Albacore tuna have been especially plentiful. I was fortunate to have made an excellent catch of 22 nice tuna ranging from 12 to 35 lbs. I was involved with filleting and skinning these fish for almost 2 hours. I used 2 knives, a short 5 inch stiff fillet and a 9 inch fillet with medium flexibility. Both knives were CPM420V heat treated to RC 55/56. The shorter knife was used to make the initial cut down the lateral line and behind the head. The 9 inch was used to fillet both ways from the center lateral line on each side of the fish and then strip off the skin. You end up with 4 very nice fillets per fish. There is tough skin and heavy bones behind the head that must be cut through. This was done on board my boat and wash down was with salt water. At the end of the chore both knives were still cutting easily. The next day both knives would slice (skiv) very thin slices off a piece of leather and would still cut 1/2 inch manila rope easily. There was no sign of corrosion occurring during the filleting operation over the 2 hour time period.

In the time since I first reported on CPM420V (over a year and 30+ blades later) I have learned a lot about heat treating, grinding, polishing, edge holding and corrosion resistance on this steel. Some of it has come from others experience but a lot of it is hard won sometimes frustrating knowledge that I would like to pass along.

HEAT TREATING

The initial steel that I received about a year ago heat treated pretty much like CPM44OV. It came in bar stock 6 inches wide and about 4ft long. The thickness was 0.140 as it came from the mill. I had this material Blanchard ground to 0.125 for fillet knives and kitchen knives. The heat treat process for this steel is as described below:

1. Seal in foil for oxidation protection.

2. Insert in furnace heated to 1650 F, let temperature stabilize and soak for 15 min.

3. Ramp temperature up to 2000 F at 50 degrees per minute it takes 7 to 10 minutes to reach temp. Austenize at 2000 F for 40 minutes.

4. Air quench in front of fan and remove from foil as quickly as possible. Straighten blade as it cools to room temperature. Hardness will be RC 59/60.

5. Place directly in Liquid Nitrogen and soak for 2 to 4 hours. Up to 20 hours will not do any damage and could refine the grain structure and improve ductility. Note: Some steel data sheets reccommend one temper cycle prior to the Cryo treatment.

6. Double temper at 375 to 450F for 2 hours each cycle. Finish hardness will be RC 56 to 58. Low end best for ductility and fillet blades, high end for hunters with thicker edge geometry. A third temper after finish grinding at 350F to relieve any residual stresses from the finishing operation is a good idea.

NOTE: the hardness values indicated in this article are based on my hardness tester. I double check it with the local Metagraphical Lab periodically. There is a tolerance of plus or minus 1RC on most test blocks and machines can be out of calibration easily. Therefore my values may not exactly agree with yours. Use these values for reference only.

I bought some heavier stock (0.180 from the mill) for hunting blades and it acted somewhat different from that above. As quenched hardness using the formula above was down in the RC 52/54 range. At that point I talked with the Crucible Engineers and they recommended an austenizing temperature of 2150 F. I was limited by the foil to 2000 F so as an alternate did a double quench for 40 minutes each time. This brought hardness up to RC58/59 after the second quench. Subsequent Cryogenic treatment and tempering at 375 resulted in a RC 56/57 finish hardness. The steel performed very well at this hardness and exhibited all the characteristics described above. I concluded that I was having a quench rate problem with the thicker steel section. A quench in oil would probably also solve this problem and I plan to experiment with this in the future. Crucible has in the meantime fine tuned the chemistry for a snappier heat treat response even at lower austenizing temperatures. They have added a little more carbon and about 1% more chromium. I have not tried any of the later steel but conversations with some makers who have confirm the improved results. Note: The double quench is a non-standard process,

but worked for me in this case. It seems to be fine with CPM420V as long as the austenizing temperature is under 2000F.

Note: As written above when I first started using 420V (S90V) I was limited to about 2000 F by the furnace itself and by the stainless foil used to protect the steel from de-carbonization. I later built a high temperature furnace and found out about high temperature foil. I can now go to 2150 on a routine basis. The results are much improved, the finished hardness now for all my 90V blades is 60 to 61 Rockwell. The cutting and edge holding at the higher hardness is vastly improved over what is reported here. The toughness is still adequate for a working knife. (2006) Phil

GRINDING AND FINISHING

As mentioned above by Barry Gallagher and PJ Tomes finishing this steel is very tough. The initial grinding in the annealed condition with ceramic belts down to about 220 grit is about like CPM440V. Below 220 grit after hardening this steel will eat up a lot of belts. I have found Silicon Carbide to work the best in this range. A high wear resistant tool steel is going to be tough to finish. It's designed that way. This steel has a high percentage of very hard (RC85) Vanadium carbides in the matrix and fine grit belts tend to glaze over rather that cut.

EDGE HOLDING

Initially I was reluctant to report that edge holding on this steel is improved over CPM440V with out substantiation from other makers. It appears that my initial impressions were right. It is a matter of degree though. Both steels are very good with the differences hard to discern in the field. They all get dull and sooner or later have to be sharpened. The biggest difference is that CPM420V is a more aggressive cutter. I think this is because there is a higher percentage of very fine very hard carbides at the edge. When this steel is sharpened with a diamond stone or alum oxide stone a saw tooth effect is created. When sharpened with a finer grit stone the small dense carbide structure allows a keen shaving type edge.

Note: Edge holding of 420V (S-90V) at RC 60/61 is much improved over 440V (S-60V) . (2006) Phil

CORROSION RESISTANCE

CPM420V is formulated to have better corrosion resistance than CPM440V. Both are very good and differences are hard to detect. I use my knives in salt water and to date have not found any noticeable differences between the two. I clean the blades with fresh water and then spray with a vegetable base non stick product before placing knife back in the sheath.

DUCTILITY

This is one area that I still have some questions on. The Yurman test knife did chip under fairly severe use. On the other hand I haven't had any trouble with fillet knives or hunters,

nor have I received any negative reports from other makers in this regard. With high alloy tool steels we are trading wear resistance off with ductility. High wear resistant steel at high hardness are going to be somewhat brittle. As a result, to keep ductility reasonable for very thin fillet knives I have been heat treating to the lower end of the recommended hardness range for this steel (55/57). This has worked out very nicely for me because cutting ability and edge holding do not necessarily correlate directly with hardness on the CPM steels. The very high percentage of finely dispersed hard carbides do most of the cutting work. Until further information to the contrary is available I am concluding that ductility in practice for CPM420V at the hardneses referenced above is about like CPM440V.

Note: I now heat treat all my S90V blades to RC 60/61 and have no ductility problems even at that high hardness (2006) Phil

All the feedback from field tests and experience from other makers has been very valuable in characterizing this steel. My initial impressions when I first tried it have been validated by experienced makers and users. The reports are anecdotal and are not based on hard scientific evidence, but at this this point I don't think anybody has a "machine" that can objectively evaluate the performance of one knife against another. We therefore have to rely on perceptions and seat of the pants feel to evaluate performance. It is fair to conclude that CPM420V is a very impressive steel. It's not the workhorse that 154CM/ATS34, 440C, D-2, 52100 are. It's tough to polish, tricky to heat treat, and expensive. It is a steel for a no compromise working knife where edge holding, cutting ability and corrosion resistance are the primary objectives. Crucible Materials has confirmed they will continue to make CPM440V available for knife stock into the foreseeable future. I know that's good news to all of us because we now have a choice of two excellent Particle Metallurgy knife steels.

The Custom knife movement has led the way to the new steels over the years and the commercial knife companies have just recently followed suit buy using ATS-34, and CPM440V (Spyderco). I'm betting it will take a while for this one to show up in production knives, so in the meantime if you want a blade out of this steel you'll have to convince your favorite maker to try it out. Let me know how you like it.