Characterize CPM Rex 121 as a Blade Steel

This grade is intriguing for use for a very high wear resistant blade. Application would be for a hunting knife where resharpening during processing would be very inconvenient. An example would be on a large game animal in very inclement weather or on wild pigs that have abrasive bristles and hide. We are always balancing ductility with strength and wear resistance so the question is with so much alloy can it function with a very thin edge for use on various game or as a general use outdoors knife. Can it operate within the fracture toughness limits to take reasonable loads and have enough flexibility to resist significant edge chipping? Is the wear resistance and edge holding, significantly higher than other grades (A11 type) to warrant the lower fracture toughness properties and higher workability difficulty? We can conjecture and research what a few others have done to date on this grade but the only way to really find out is to make some test blades and wring them out and to later put them to actual use in the field.

Test Knife criteria

5. 4.5-inch trailing point blade with part tang construction, .125-inch-thick at spine, full flat ground down to .005-.007 behind the edge. Hardness to be determined based on how the heat treat comes out but shooting for the high to mid-60's range.

Taking a look at the chemistry indicates this material is rich in elements that form very hard primary carbides. Tungsten, Molybdenum, and Vanadium all form carbides. Cobalt does not form a carbide but assists in contributing to hot hardness. Altogether there is almost 25% carbide to start out with. The Hot hardness is not necessary in a knife blade but plays a role in the tool steel high speed cutting that this steel was designed for. 4% chromium is not enough to contribute to residual chromium in the matrix for corrosion resistance but allows this steel to be air hardening. I did not test for corrosion resistance, but a blade made with this grade is going to need attention to prevent rusting and pitting.

Carbon 3.4

Chrome 4.0

Tungsten 10

Molybdenum 5

Vanadium .5

Cobalt 9.9

Blade 1

I chose a mid-temperature austenizing for a first try to see how it comes out with my particular set up and also to check out the ductility.

Insert at 1550, Ramp to 2000, hold for ½ hr.

Plate quench

As quenched hardness was RC 70

Direct to LN2 and hold 40 hours

As quenched hardness out of the LN2 was RC 70/70.5

Temper 1 @ 1006 for 1 hr 30 min, RC 68

Temper 2 @ 1002 for 40 min RC 67

Temper 3 @1005 for 1 hr RC 65.5/66

Temper 4 @1045 for 1 hr RC 66

I did one more temper at 1000 to minimize residual stress due to final grinding and finish. The final hardness was RC66

Edge holding on this first effort was about 30% better than with my A11 grade reference blade. (see my standard cutting test procedure). Aggressive whittling and prying out of the cut on seasoned fir yielded a few chips with one measuring .005 deep. No evidence of rolling was observed, just chipping. The amount of force to precipitate the chipping was judged at more than one would use in a normal task in the field unless it was used for prying or light pressure chopping against bone.

To see if a lower austentizing temperature would improve the ductility I made another test blade with the high heat at 1950. With all else above the same it did drop the as quenched hardness by one point, but final tempered hardness came up to 67. Edge holding was not reduced at least on a couple of test runs slicing ¾ inch manila rope. I still got some chipping, on the pine no rolling but some finer chips rather than the one larger one. With only one test this would not be conclusive proof that the ductility was improved.

I think more testing is in order with possibly a blade done without a LN2 subzero and also a lower still austentizing temperature. I also will have an opportunity to get a blade in the hands of my friend who is planning some wild pig hunts this winter here in California.

I can conclude so far: As can be expected all the hard-primary carbides do make for high edge retention. The chipping observed is more than I have seen in my previous testing using the same method on K390 for example. Since there was no damage cutting on the rope I think there is enough tolerance to enable use on a large animal like a Bull Elk given reasonable normal use. As in the A11 grades chopping or twisting and prying has to be avoided. I did some sharpening with a Norton fine SC stone and was able to get it to the point of aggressive biting the rope however it was easier and more efficient to use a diamond plate for final sharpening and burr removal {very little burr due to the extreme hardness). A thin geometry (.005-.007) behind the edge enables easier sharpening and my cutting tests indicate longer cutting possible with a finish grit around 400 mesh. New sharp ceramic grinding belts are required for both roughing out before heat treating and also for finish work. A hand rubbed final finish would improve the corrosion resistance, but this is the most finish resistant grade I have ever worked with. More experiment needs to be done to find a belt that would leave a nice satin finish. Finally, this is the most expensive grade I have worked with, Final shipped cost is about $140 a pound. The requirement for fresh abrasive belts and additional finish labor also adds cost.

This is a steel that is pushing the upper edge of what is practical for a knife blade. At least with in my capabilities as a custom maker. This is the grade to use if absolute edge holding is the overriding criteria, but at the expense of ductility and low factor of safety against accidental edge damage It should be reserved for very experienced users who understand the limitations if its use. Lower hardness and the low end of the austenizing range did not seem to improve the ductility enough to show up in my tests. This is due to the very high carbide percentage and is to be expected from the chemistry. We are trying to adapt a high-speed steel designed to cut materials as hard and as abrasive as some of the steels grades we use for knife blades.

The best application here is a 3.5 to 4.5-inch trailing point or drop point ground thin and at RC 66 to 68 RC and light to medium use where edge holding is the overriding criteria. Users could carry a second knife more adept at work where higher fracture toughness is needed. As I get a few more knives in actual use in the field and a few more makers gain some experience using CPM Rex 121 we will be able to better evaluate its application in the wide range of knife blade steels available to us.

Phil