Some Thoughts on Knife Blade Steel Impact Toughness

The Charpy test is a measure of the impact toughness of a tool steel. This is measured in ft-lbs and represents the energy required to fracture a notched test piece under laboratory conditions. When you are talking about Charpy values you are talking about impact resistance and toughness. Brittle is the opposite of tough.

Typical Charpy values for some of the knife steels we use are:

154CM/ATS 34, D-2 and S90V, at RC 60 are in the 16 to 20 ft lbs.range.
A2 at RC 60 is about 40 ft-lbs
CPM 3V at RC58 is about 85 ft-lbs and drops to about 50 ft-lbs at RC 60

(see note below, 3V impact resistance may be somewhat lower than 50 at RC 60)

Note the above was written to answer an e mail I received on knife blade toughness and how tough my knives are. This reply is about 6 years old as I write this in 2006. The only caveat I would make at this time is on 3V. I made several chopping type knives from this steel at RC 60/61. Pushed very hard cutting oak I got some edge chipping. When the blades were re-tempered and the hardness was reduced to 58 the chipping was not a problem. The only conclusion I can draw from this is that 3V toughness falls off quickly over about 59/60 Rockwell. This is my experience and may not bear true with other makers. In addition this is based on just a couple of knives since I do not use much 3V. If a user wants a "non" stainless blade I usually recommend 10V.   Phil

Toughness is a particular concern with high alloy tool steels at high Rockwell hardness.

They have pretty good bending fracture strength but not so good impact resistance.

I primarily use high alloy steels at a relatively high hardness because I am striving for the maximum in cutting and edge holding performance.

To achieve that I am flat grinding blades to a very thin hard edge.

The harder a blade is the higher the tensile and compressive strength it has.

This is important on a thin edge because the stronger (high tensile and compressive strength) the steel is the more is resists edge rollover… a common reason a blade gets dull.

The problem is that--- the harder the blade is the less tough it is. So I am walking a fine line between hardness and toughness. A fine edge that is too brittle will get dull because it simply cracks away.

Some tool steel companies will give you data on Charpy tests of the steels that correlate to Rockwell hardness. Crucible is particularly good at this.

So if you know the Rockwell hardness then you have a pretty good idea of the impact resistance of the steel.

The best of all worlds is to be able to select the best steel for the knife use application. I would select a steel formulated for high toughness (high Charpy impact resistance) for a large camp knife or a sword. Good choices would be A-2 (40 ft-lbs at RC 60) or CPM 3V (85 ft-lbs ? at RC 58) On the other hand the best selection for a slicing type knife would be a steel with a very high vanadium carbide content hardened to a high value-- at least 60. It would have a relatively low Charpy value, but that’s ok since we are looking for maximum edge strength and wear resistance rather than toughness. A good choice would be CPM S90V (19 ft-lbs at RC 58)

I do my own heat treating and have a good Rockwell tester so can get very close to the line. In other words I make a very hard, thin blade that has enough toughness for a working blade. I make slicers (hunting and fishing scalpels) rather than choppers so it works out ok for me.

I think the tool steel companies are very conservative with their Charpy values. Especially on the CPM grades. For example I have been making a lot of hunting blades out of CPM 10V. The data sheet from Crucible on this steel indicates that it has about the same toughness as D-2 at the same hardness. I have found that I can heat treat 10V to about Rockwell 63 and it still has more than adequate toughness for a working knife. My experience with D-2 in the past indicates that it starts to get pretty brittle at about Rockwell 60.

I have also found with all the steels I am familiar with that toughness is very sensitive to heat treating. Good heat treating means a uniform crystal structure and as fine a grain structure as possible with any particular steel. Think about it. If you make a long bow out of a piece of wood that has a knot in it, that’s where it’s going to break-- and at a pretty low force. The same is true with steel. It’s going to fail where the imperfection is. I like to use a liquid nitrogen cryo quench right after the steel comes down to room temperature to insure the highest percentage of martensite possible and then to temper the blade a couple of times to develop adequate toughness but still retain a relatively high hardness.