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"Excellence in Metallurgical Engineering"

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Case Study: How to Make a Better Ice Auger Blade

By

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Subject

Evaluation of a stainless steel ice auger blade to determine how to improve its performance. The blade was examined by chemical composition, hardness, and microstructure. The blade was specified as heat treated 420 stainless steel, with no hardness specified.

Chemical Analysis

The chemical analysis was done according to the following ASTM specifications: ASTM E1019 for carbon and sulfur, and ASTM E1086 for other elements. The results of the analysis are given in the table that follows.

Chemical Analysis of Blade
(Percent by Weight)

Element	Blade	420 SS
Carbon	0.31	0.15 Min
Manganese	0.33	1.00 Max
Phosphorous	0.016	0.040 Max
Sulfur	<0.005	0.030 Max
Silicon	0.42	1.00 Max.
Nickel	0.05	
Chromium	13.70	12.00 - 14.00
Molybdenum	0.05	

The chemical analysis shows that the material used for the blade was the specified 420 Stainless Steel.

Hardness Testing

The hardness testing was done according to ASTM E384 using a Knoop indenter and a 500 gram load. The results of the testing are given in the following table.

Hardness Test Data					
Location	KNOOP	STD DEV	MAX VALUE	MIN VALUE	HARDNESS
Core	528.00	2.59	531.00	526.00	49.12 RC

The hardness of 49 Rockwell C Scale indicated that the blade had been tempered between 700^{o} to 800^{o} F. A blade tempered in this range has good fracture toughness, but not optimal. Improved blade performance can be obtained by tempering between 500^{o} and 600^{o} F. for best fracture toughness. The resulting hardness would then be between 50.5 and 52 Rockwell C Scale.

Metallographic Examination

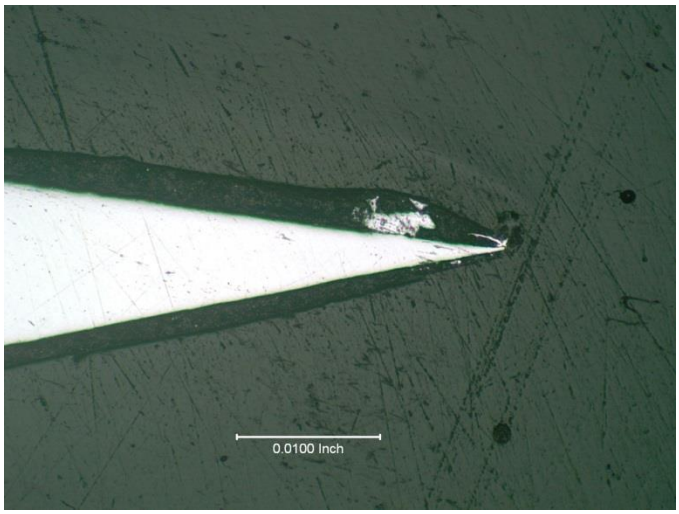

Figure 1 – 100X Sharpened Edge – As-Polished

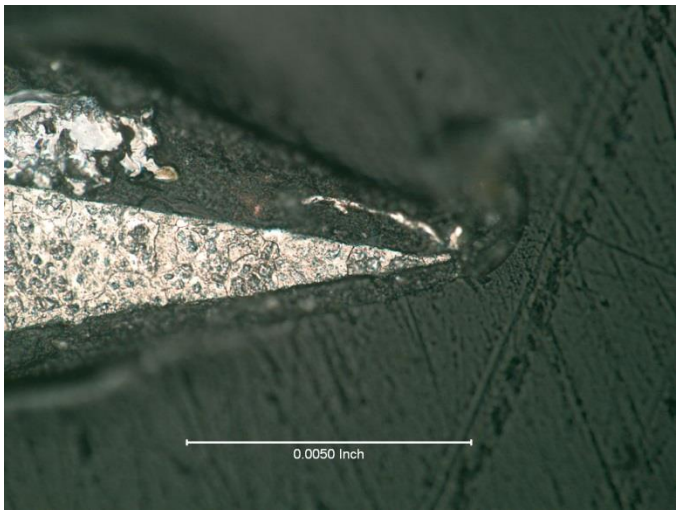

Figure 2 – 100X Sharpened Edge - Etched

Figure 1 shows the sharpened edge of the blade as-polished, and Figure 2 shows the same location after etching. The etched blade tip shows no indications of excess heating during sharpening, which would change the hardness.

Figure 3 shows the core microstructure of the ice auger blade. The microstructure is tempered martensite, which is consistent with tempering in the 700^{o} to 800^{o} F. range.

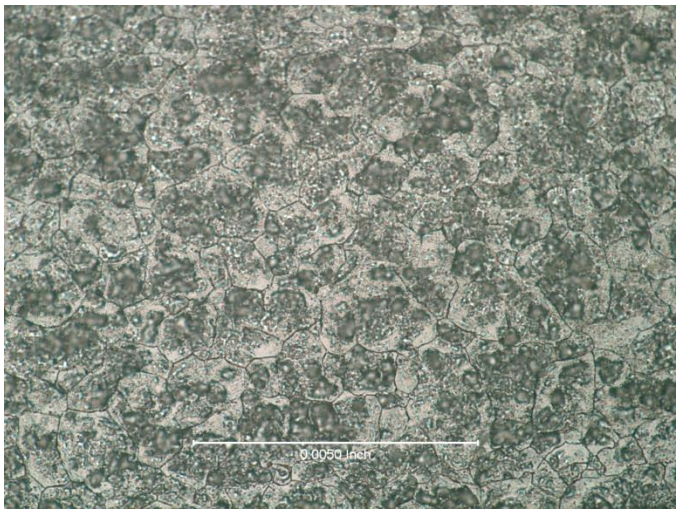

Figure 3 – 400X Core Microstructure of Ice Auger Blade

Conclusions

1. The blade was fabricated from specified 420 Stainless Steel.

2. The hardness of the blade of 49 on the Rockwell C scale indicates that the blade had been tempered at between 700^{o} and 800^{o} F.

3. The hardness of the blade does not reflect the optimum properties for a 420 Stainless Steel blade.

Recommendation

Optimum combination of fracture toughness and hardness results from tempering 420 stainless steel between 500^{o} and 600^{o} F. For the best performance, the blade needs to be tempered in that range. A specified hardness range of 50.5 to 52 Rockwell C scale is required to insure the best quality blade.

Note: It is important to have quantifiable materials specifications, such as hardness, for heat treatable alloys, that will reflect the desired end-use properties. It should also be noted that many high strength-low alloy steels can have similar hardness by cold finishing, or by heat treating, to the 25 to 35 Rockwell C scale range. The fatigue and fracture toughness characteristics are entirely different in cold worked materials and heat treated materials. It is important that the specifications are very clear as to how a specific hardness range is to be obtained in order to insure the proper performance of the end product.