D2 Tool Steel

The tool steel known as D2 is considered to be a high carbon high chromium cold work tool steel.

The steel is high in both carbon and chromium for the purpose of forming large volumes of secondary chromium carbides as a result of the precipitation of the carbides during the tempering procedure. This gave rise to a high wear resistance steel.

The history behind the D series in general is, that the D series were original developed as a possible alternative group of steels to the High Speed Steels and for use as a less expensive source to manufacture cutting tools.

The alternative use as a cutting tool steel was not successful as the steel could not sustain its hardness at high cutting speeds, which developed friction and temperature. The cutting edge simply tempered itself back to the point of premature failure, thus the D group of steel was not successful as a cutting tool steel.

While they do not exhibit good corrosion resistance such as might be expected of say a martensitic stainless steel, they do offer good surface oxidation resistance.

The D series in general do not respond well to normalizing simply because there are some air hardening characteristics of the steel group.

D2 Steel Analysis

The nominal analysis of D2 Cold Work Tool steel is

Carbon = 1.40% to 1.60% (Nominal at 1.50%)

Silicon = 0.5il % to 0.60% (Nominal at 0.50%)

Manganese = 0.50% to 0.60% (Nominal at 0.50%)

Chromium = 11.00% to 13.00 % (Nominal at 12.00%)

Molybdenum = 0.70% to 1.20% (Nominal at 1.00%)

Nickel = 0.30% Max (Nominal at 0.30%)

Vanadium = 1.10% Max (Nominal at 1.10%)

D2 Thermal Treatment

Because of the high carbon content of the steel, there is a strong tendency for the steel to decarburize at the selected austenitizing temperature, unless the surface is protected against decarburization. The protection methods are:

- Wrap in Stainless steel foil with a smear of oil on the inside face of the foil so as to burn up oxygen that is entrapped inside of the foil. This will reduce the risk of surface oxidation and reduce the risk of decarburization
- Atmosphere heat treatment. Care must be given to create and maintain equilibrium conditions with the carbo potential of the furnace atmosphere and the carbon content of the steel.
- Salt bath heat treatment which (if neutral) will protect the work surface from both oxidation and decarburization.

In general, the D2 steel does have good oxidation resistance due to the high chromium content. The steel will polish very well after austenitizing.

Forging and Annealing

D2 is generally forged at a low temperature and is not allowed to exceed 2100˚F (870˚C). In addition to this, the steel should not be forged below 1600˚F (870˚C).

It is also necessary to slow cool after forging, followed by annealing. The steel should not be normalized. Care should be taken with the temperature selection for annealing, which should not be higher than 1650˚F (900˚C). In addition to the annealing temperature selection, care must be taken on the cooling rate of the steel. This is because of the high carbon and the high chrome. The steel has the potential to transform the austenite to martensite if the cooling rate is too fast.

Hardening

The steel MUST be very carefully preheated. This is because of the low heat conductivity and the steels poor ability to absorb heat. If the steel is heated too fast, then there is a strong likelihood that the steel may crack during the heat up phase. Therefore ramp and soak is very necessary for preheating. (This also applies to heat up for forging)

Ramp up to say 500˚ (260˚C), and hold for equalization. Ramp to 1200˚F (650˚C, equalize throughout the cross section. Then ramp to the austenitize temperature at 1790˚F (975˚C) to 1850˚F (1010˚C). Hold at the temperature and soak for 1 minute per 1 mm of maximum cross sectional area, and follow with the quench. Do not over soak at the austenitize temperature as grain coarsening will occur. Do not go to too low and austenitizing temperature, otherwise insufficient carbides will dissolve, and conversely, do not select too high an austenitizing temperature, otherwise there is a risk of too many carbides dissolving, which can lead to retained austenite.

The above is the most common practice of austenitizing D2 steel.

These steels (The D series) are very susceptible to retained austenite conditions. This is due to the high carbon and high chromium chemistry of the steel.

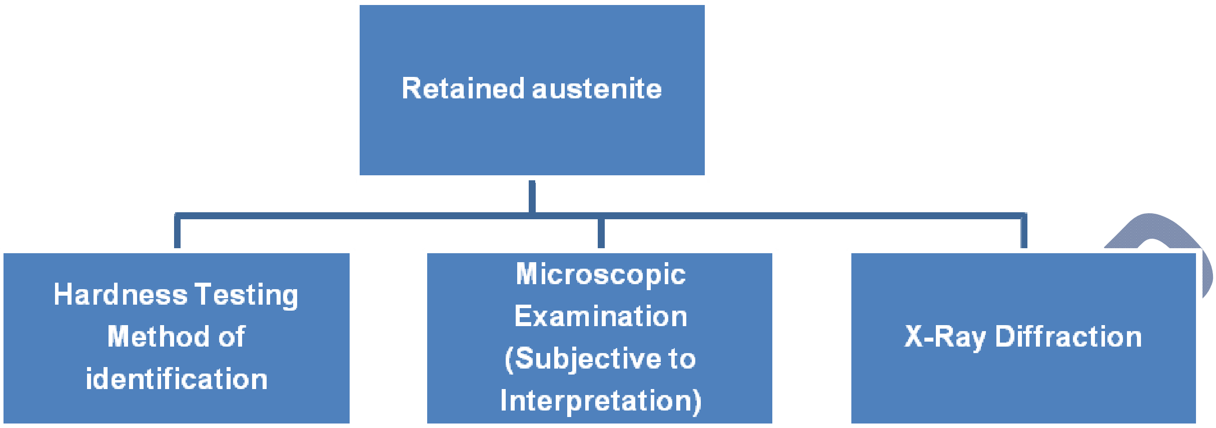
Tempering

It is necessary to temper the D2 steel as soon after the quench procedure as is practical. Do not let the steel grow cold after quenching, by delaying the tempering procedure. There will be a serious risk of cracking, particularly if retained austenite is present. The retained austenite will begin its decomposition and transformation to untempered fresh martensite. This will exhibit an increase in hardness, as well as a volumetric change (dimensional size change). In other words the steel will, most likely grow in size.

The tempering temperature selection will depend on what the austenitizing temperature was in relation to the as quenched hardness. The higher the austenitizing temperature selection and the longer the time, the more carbon, chromium and remaining alloys will have been taken into solution. This means that more carbides are available at elevated tempering temperatures. The tempering procedure must always be at least two times. The purpose of this is, that if there is any retained austenite, then at least 50% of that austenite will de decomposed at each subsequent temper. This also helps the steel for dimensional stability by the decomposition of the retained austenite.

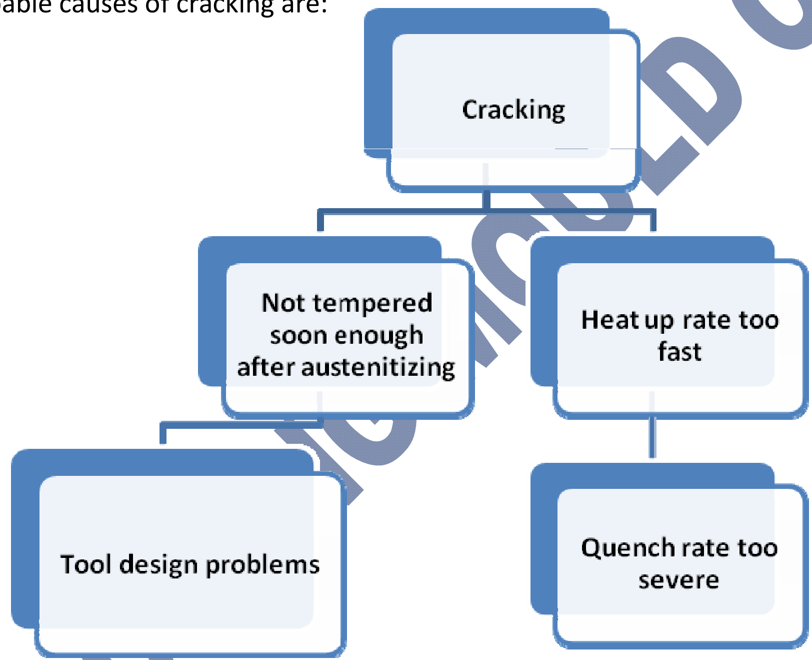
D2 trouble shooting

The problem of retained austenite will usually be ‘observed’ by the as quenched hardness test. However the following ‘tree’ shows alternatives methods of determination:



Cracking

The probable causes of cracking are:



Applications

The applications of D2 steel are numerous and the material can be used in many hostile environments, such as:

- Decorative knives
- Hunting knives
- Mill rolls
- Blanking dies
- Punches
- Spinning tools
- Shear blades