TECH TIPS

CASE HARDENING

How often have you thought to yourself, or have been told, "If this component was to be heated red-hot then quenched in oil or water, it would be so much harder or stronger, as the case may be"?

Well, gentle reader, I have news for you, and most of it is bad. With most, though not all, steel components, you could heat it red hot and quench it out for 24 hours on and off over a week, and all that would happen is that it would become smaller through surface oxidation, but not a whit harder for all your efforts.

Now without delving into all the intricacies of metallurgy and the iron-carbon diagram, the "magical" component of steel is carbon (after all, this is a carbon world). All steel with less than 0.4% of carbon can be, and is, classified as "mild steel" and to which the foregoing heating comments apply.

This is not to say that 0.4% of carbon is a magical cut-off point, and that nothing happens with heating and quenching below this value. Rather, certain chemical changes take place in the structure of the metal, but they are minimal below this point. However, the changes become quite dramatic with more than 0.4% of carbon content, up to a maximum of 1.5%, and this material is classified as "high carbon steel". In other words, it can be heated and quenched and thus become hard and brittle, the hardness and brittleness increasing up to the 1.5% carbon point. After 1.5% carbon, the steel doesn't become any harder but it does become even more brittle. Files are a good example of 1.5% carbon steel. Hands up all those who have broken a file, inadvertantly of course! Though they are hard, files are also rather brittle.

At this point we had better define hardness and brittleness. "Hardness" can be defined as "resistence to mechanical abrasion", and is measured in units of Rockwell 'C' or Brinell. Brinell is now employed less than Rockwell 'C' which is more accurate on harder materials (the closer to 100, the harder the material). "Brittleness" is hardness coupled to a total resistence to bending e.g. a spring is hard but is tempered to become flexible. A sheet of glass is hard but brittle, and thus it shatters readily if bending is attempted.

How then is a spring, which has been heated red-hot and quenched so as to make it brittle, then made "springy"? This is achieved by the process of "tempering". The tempering process is simply re-heating the material to a specific temperature for the task required. This causes granular changes in the material, and when re-cooled, it is now not so hard and has become flexible i.e. in short, it has been "tempered".

So - mild steel has less than 0.4% carbon. High carbon steel (capable of being hardened by heating and quenching) has from 0.4% to 1.5% carbon content. Cast iron for example, has about 4.5% carbon content, and we all know how brittle cast iron is.

Mild steel objects can be hardened, but this is achieved by heating the object to be hardened in an atmosphere, either liquid or gaseous, having an excess of free carbon. This free carbon is promptly absorbed by the skin of the red-hot object, changing it to a layer of "high carbon steel" which when quenched becomes very hard, but still leaving a "soft" centre. This process is called "case hardening" and is employed extensively for gears.

Now you know what is amiss when gear teeth are "through the hardening". The hard skin of the teeth has worn away, leaving the softer metal underneath exposed.

Quenching is the process of cooling quickly and thus changing the molecular structure of the material. Water and oil are the most common media for quenching, but many other methods and additives are employed.

CASE HARDENING WITH LEATHER

The case hardening process can be carried out (with varying degrees of success) in most home workshops utilising one or the other of the proprietary case hardening compounds e.g. Casenite or Kardite. Both carry quite explicit instructions for use on the can. The real problem with them is having to warm the item to red-heat, covering it with the compound, heating it again, and the quenching. Normally this results in a quite poor surface finish. However, one of the oldest, and still very effective methods does leave a good surface, and requires the simplest of materials and equipment.*

All that is required is the object to be case hardened, a tin can complete with lid, into which the object will fit leaving space around it, and last but not least, an old pair of boots, or at least lots of leather scraps (or hide, hair or horn). Pack a layer of scraps into the bottom of the tin can, put in the object to be cased, and pack the remaining space with more carbon-rich scraps. Fit the lid tightly and wire it on. Put the whole thing into the back of an open fire, solid fuel space heater or fuel stove and let it come to red-heat. Keep it at red-heat for 4 - 6 hours, then fish it out, and quench it out in a bucket of water. This can be quite dramatic, so keep the admiring throng well back, and don't put your face over the bucket to observe what occurs. You may not enjoy it.

The tin can may end up rather "second hand" in the process, but the object should be unmarked with a fine grey finish, and a very hard skin about 0.20 - 0.30 inch (say 0.5 mm) deep.

I am still using odd cutters (made from mild steel only) which I case hardened with the aid of a space heater and a pair of old boots some years ago.

Note that the commercial method of casing is merely a [illegible] of molten and temperature-controlled carbon-rich salts in which the objects to be hardened are immersed. They thus absorb skin carbon and are protected from surface oxidation. A little beyond the average home workshop.

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*Possibly also known as "Kasenit".