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Effect of Stress Relief on the Amount of Retained Austenite After Cryogenic Treatment and on the Wear Resistance of a Tool Steel

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Abstract – The practice of tempering for stress relief before cryogenic thermal treatment in an AISI D2 tool steel has been shown to stabilize the retained austenite, nullifying the effect of cryogenic treatment The practice simultaneously enhances the wear resistance of the steel after complete thermal cycling (quench + stress relief + cryogenic treatment + double temper).

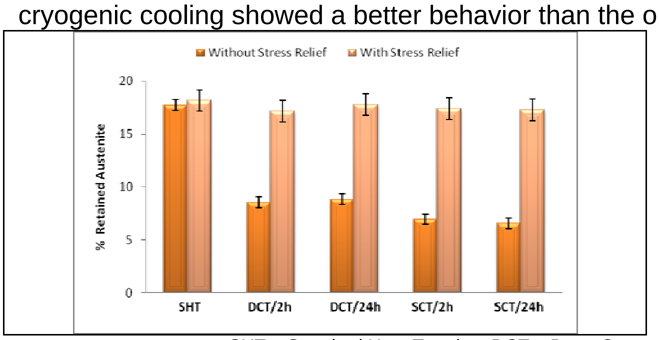
Cryogenic treatment has been shown to have a large effect on the properties of heat treated steels, especially tool steels. Nevertheless, due to the complexity of some parts it is necessary to do a prior stress relief heat treatment to avoid cracks and catastrophic failures. In previous work [1] it was verified that the stress relief treatment stabilizes the austenite even when the sample is submerged in liquid nitrogen. The literature [2] suggests that there is a C-curve kinetic behavior for the austenite to martensite transformation at temperatures lower than Ms.

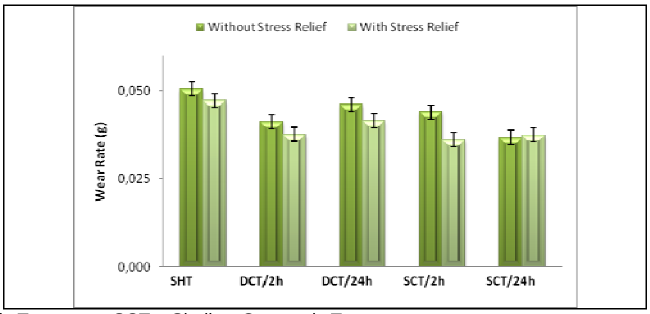
In order to confirm those previous work results[1] and test the hypothesis of a C-curve behavior, samples from an AISI D2 tool steel bar were austenitized at 1040°C for 40 minutes and then quenched in oil. Half of the samples were submitted to a stress relief treatment at 130°C for 90 minutes in order to enable comparison between samples with and without stress relief. Afterwards, some samples were submitted to a deep cryogenic treatment (DCT - immersion in liquid nitrogen) and others to a shallow cryogenic treatment (SCT -immersion in dry ice), for 2 and 24 hours.

After cryogenic treatment the volumetric fraction of retained austenite was determined using a magnetic saturation test, which was validated in a previous work [1]. This test consists of introducing the samples into a magnetic field (Hystergraf IS-300) of 1000kA/m and determining the maximum magnetic saturation. After that, the values obtained are compared to the value characteristic of an annealed sample, which is considered to have zero percent retained austenite.

Figure 1 shows that all the samples submitted to stress relief before the cryogenic treatment have the same volumetric fraction of austenite as the samples just quenched. These results confirm that the prior stress relief stabilizes the austenite, and even with a DCT for 24h no austenite is transformed into martensite. In addition it shows that the samples without stress relief submitted to SCT have less retained austenite than the ones submitted to DCT, and the amount of austenite diminishes with increasing time at SCT temperatures suggesting that the martensitic transformation show indeed a C-curve kinetic behavior.

The samples were double tempered and submitted to a wear test (described in detail in reference [3]). Figure 2 shows that, for this particular wear test, samples submitted to a stress relief heat treatment before cryogenic cooling showed a better behavior than the ones without this treatment.





SHT – Standard Heat Treating; DCT – Deep Cryogenic Treatment; SCT – Shallow Cryogenic Treatment.

Figure 1 – Percentage of retained austenite with and without stress relief previous to the cryogenic treatment.

Figure 2 – Wear rate of the samples with and without stress relief previous to the cryogenic treatment.

References

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