Opening Remarks

It is important for a better understanding of the mechanism of hydrogen embrittlement to mention the most accepted related theories. The influence of the hydrogen dissolved in the metallic lattice was emphasized for the first time by Professors Bastien and Azou in France in 1951 at the Ecole Centrale, then from 1958 to 1960 by Professor Troiano at the Case Western Institute in Cleveland.

They believe that under the influence of a stress gradient, the hydrogen atoms, or better, the hydrogen protons (being the electrons lost in the free electron cloud in the metallic lattice) diffuse to the regions with the highest tensile stresses, then reduce the cohesive force in the metal. Evidence was found that the hydrogen moves in the metal with a transport mechanism. When irreversible plastic deformations take place, the dislocations move, carrying along the protons, which pile up at obstacles as nonmetallic inclusions and form a microcrack at the head of the pileup. This explains the hydrogen embrittlement subsurface cracking. We then have to make a distinction between diffusible hydrogen that is free to diffuse out and trapped hydrogen that is attached to the dislocations, which is free to move only when the temperature is sufficiently high to increase the mobility of the dislocations. This temperature level corresponds to the recovery stage of annealing and has to be reached for hydrogen embrittlement relief.

LECO, and now a large contingency from Japan, have lead the way in separately measuring diffusible or mobile hydrogen and trapped or the total hydrogen concentration in steel. Their standards will be published separately by ASTM Committee E03 on Chemical Analysis of Metals, although in cooperation and in sanction with Subcommittee F07.04 on Hydrogen Embrittlement. Another recent approach is by David Berman, who addressed the use of the "barnacle" electrode to measure diffusible hydrogen in plated hardware. Similar concerns in welding are being addressed by the AWS. The use of gas chromatography and in-situ monitoring of hydrogen during welding were discussed in this symposium. Jean-Paul Fidelle, of France, updates the use of the disk pressure test for measurement of the relative susceptibility of steels to hydrogen embrittlement from a gaseous hydrogen environment. Numerous test techniques are constantly being devised and older techniques are being revised as more precise analytical tools become available.

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