UDC 534.2:620.179.162:669.788

The changes in extensional wave propagation rate in carbon steel hydrogenated in electrolytic solution

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The effect of hydrogen absorbed by carbon steel on extensional wave propagation rate was studied using time-of-flight approach on a rod sample 212 cm long and 1,2 cm in diameter. A sample-cathode was placed in a tubular electrolyzer together with steel anode, both being connected to a stabilized current source. The amount of electric charge that passed through the electrolyte was 14 kC. Two piezoceramic transducers were placed on the edges of the sample and connected to the acoustic emission measuring system, one as a transmitter and the other as a receiver of the elastic waves. The acoustic signals were recorded before and after electrolytic hydrogen charging. A time window that exhibits the first five half-waves crossing the abscissa axis is shown in Fig. 1 for both cases – before and after hydrogenation. The parameters of the cell guaranteed the extensional mode of the longitudinal wave. Having the transmitting and the receiving part of the system synchronized with the same timer, we obtained very high reproducibility and accuracy in the values of times when signal was changing its polarity (0 and 180 phases). Table 1 contains linearly interpolated time data for all five half waves together with corresponding differential times.

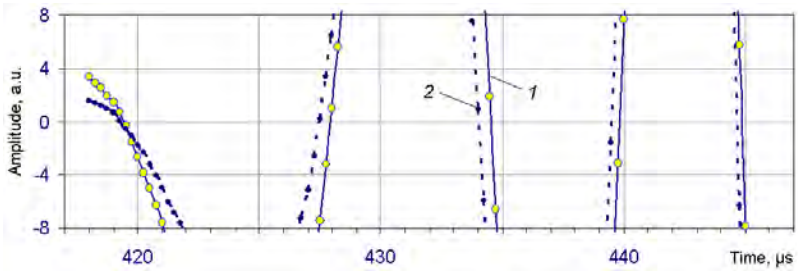

Fig. 1 Scaled time window exhibiting first five half-waves crossing the x-axis before (1) and after (2) electrolytic hydrogen charging

Table 1. The effect of the absorbed hydrogen on the moments of time when extensional wave changes its polarity (0 and 180 phases) and the corresponding differential times (all in μs)

Condition	Half wave number				
	1	2	3	4	5
Before H charging	419.43	427.94	434.55	439.82	444.89
After 14 kC of H charging	419.26	427.49	434.03	439.53	444.65
Propagation time change	–0.17	–0.46	–0.52	–0.29	–0.24

It is clear that electrolytic hydrogenation of steel resulted in an increase of the elastic wave speed. We evaluated the extensional wave propagation rate to be $c_E = (5{,}09 \pm 0{,}02) \times 10^3$ m/s before hydrogen charging. This is in good agreement with known data for steel and α-Fe. By averaging the obtained differential times we obtained an increase in extensional wave propagation rate $\Delta c_E = 4{,}1 \pm 1{,}8$ m/s as a result of hydrogen charging. High relative deviation is a result of the distorted shape of the extensional wave bell – a second major effect of hydrogen absorption.