International Journal of Engineering, Pure and Applied Sciences,
Vol. 1, No. 1, 2016

CHANGING BEHAVIOUR OF HYRDOGEN SUSPECATIBALITY ON IF STEELS DUE TO PRESENTATION OF NIOBIUM

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Abstract:-The influence of niobium in the hydrogen suspecatibality of IF steels change a new change for the industry the mechanical properties and permeation trapping of all these effects are studied with a cold working of if steels with deep drawabality and metallographic investigation concluded due to the absorption of niobium. In this paper these promoted transgranular fracture in cold rolled specimens. All these results of IF steel shows presence of niobium with cold rolled susceptible for niobium hydrogen embrittlement.

Key Words:- Interstitial free steel, Hydrogen embrittlement, Cold work, Hydrogen permeation, Fracture surface

1. INTRODUCTION

Ni-bearing interstitial free steel has an extra-deep drawing quality and is possible to obtain an excellent surface condition, thickness homogeneity and good flatness, allowing using in sheet metal industries [1, 3]. Many systematic experimental results of hydrogen permeation have been reported in well-annealed and cold worked iron [4–7]. Hydrogen is known to degrade numerous alloys; of particular interest are the detrimental effects of hydrogen on iron-base alloys since these alloys are often used in applications, where exposure to hydrogen is likely. Recently, the interstitial free steel has been developed and achieved extra-deep drawing quality with a yield stress (YS) of about 150 MPa. Generally, the interstitial free steel should be considered susceptible to hydrogen embrittlement due to the high diffusivity Ti-bearing interstitial free steel has an extra-deep drawing quality and is possible to obtain an excellent surface condition, thickness homogeneity and good flatness, allowing using in sheet metal industries [1, 4].Many systematic experimental results of hydrogen permeation have been reported in well-annealed and cold worked iron [3–7]. Hydrogen is known todegrade numerous alloys; of particular interest are the detrimental effects of hydrogen on iron-base alloys since these alloys are often used in applications, where exposure to hydrogen is likely [5-7]. Recently, the interstitial free steel has been developed and achieved extra-deep drawing quality with a yield stress (YS) of about 150 MPa. Generally, the interstitial free steel should be considered susceptible to hydrogen embrittlement due to the high diffusivity.

2. EXPERIMENTAL PROCEDURE

In this study, an electrochemical permeation technique was utilized to study the hydrogen transport in the annealed and cold worked interstitial free steel at 25^{o}C. Hydrogen precharged technique was also performed to study the degradation phenomena in the same specimens.

Table 1 Chemical Composition of Interstitial free steal

Element	C	Si	Mn	P	S	Ti	Cr	Al	Fe
Wt%	0.03	0.01	0.15	0.03	0.007	0.07	0,03	0.043	Bal

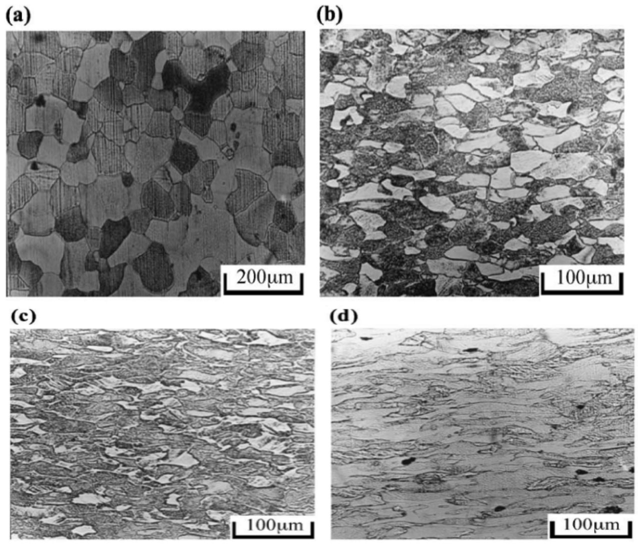

Fig. 1. Optical micrographs of (a) annealed (b) CW 20% (c) CW 40% (d) CW 60%

Table-B

Permeation rate, diffusivity for the interstitial free steel with a constant charging current density (10 mA/cm2 at25Jc

IF steel	J∞ L (mol(H)/ms	D eff ($^{m2/s)}$ 2/s)
Annealed	1.65 $x10^{-9}$	$7.81x10^{-12}$
CW 20%	$2.59x10^{-9}$	$1.77\ x10^{-12}$
CW 40%	$1.88x10^{-9}$	$1.18x10^{-12}$
CW 60%	$4.72x10^{-9}$	$1.18x10^{-12}$
CW 80%	$3.66x\ 10^{-9}$	$3.55x10^{-12}$

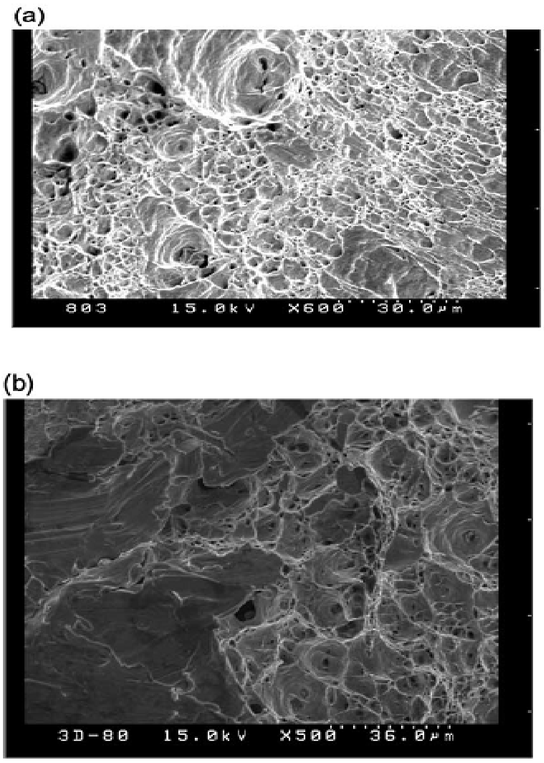

Fig.2 Fracture surface of CW 80% specimen: (a) uncharged and (b) 5-days cathodic charged.

The instrumentation and procedure were similar to those described elsewhere [8-10]. The cathodic site or hydrogen entry cell was galvano statically polarized at a constant charging current in 0. 1 N Na OH. The anodic side or hydroge n exit cell was potentiostated at 250 mV (SCE) in 0.1 N Noah. The potent iostatic curren t, i p , gives a direct measure of the hydrogen flow rate. The cell assembly was immersed at 25 F 0.5 j C. Both sides were deoxygen ated.The materials chosen for this study were an interstitial free steel and were provided by China Steel Corporation. Chemical compositions of the interstitial free steel are listed in Table 1. Specimens were cut from steel plate then heated at 850 j C for 1 hand furnace cooled. The preparation of these specimens involves cold rolled to different percent - age reduct ion and optical micrograp has are shown in Fig. 1. Then these specimens were ground with Carbimet- Sic grining paper down to 800 grit. Prior to the insertion in the test cell, each speci men was nickel plated (200 nm) on the anodic side to eliminate surface defects.

Table-4

IF-steel	Test Environment	UTS (Mpa)	Elongation %	Ductility change (%)
Annealed	uncharged	240	30	-
	Precharged	240	37	+22
CW20%	uncharged	270	7	-
	Precharged	*260*	*7*	*-29*
CW40%	uncharged	550	5	-
	Precharged	550	5	-40
CW60%	uncharged	610	4	-
	Precharged	600	3	20
CW8%	uncharged	720	5	-
	Precharged	720	4	-20

The instrumentation and procedure were similar to those described elsewhere [8-10]. The cathodic site or hydrogen entry cell was galvano statically polarized at a constant charging current in 0. 1 N Na OH. The anodic side or hydroge n exit cell was potentiostated at 250 mV (SCE) in 0.1 N Noah. The potent iostatic curren t, i p , gives a direct measure of the hydrogen flow rate. The cell assembly was immersed at 25 F 0.5 j C. Both sides were deoxygen ated.The materials chosen for this study were an interstitial free steel and were provided by China Steel Corporation. Chemical compositions of the interstitial free steel are listed in Table 1. Specimens were cut from steel plate then heated at 850 j C for 1 hand furnace cooled. The preparation of these specimens involves cold rolled to different percent - age reduct ion and optical micrograp has are shown in Fig. 1. Then these specimens were ground with Carbimet- Sic grining paper down to 800 grit. Prior to the insertion in the test cell, each speci men was nickel plated (200 nm) on the anodic side to eliminate surface defects.

Table-5

IF-steel	Test Environment	UTS (Mpa)	Elongation %	Ductility change (%)
Annealed	uncharged	240	30	-
	Precharged	240	37	+22
CW20%	uncharged	270	7	-
	Precharged	*260*	*7*	*-29*
CW40%	uncharged	550	5	-
	Precharged	550	5	-40
CW60%	uncharged	610	4	-
	Precharged	600	3	20
CW8%	uncharged	720	5	-
	Precharged	720	4	-20

The tensile specimens with gage section of 7x 25x 1 mm were fabricated by EDM. Tensile specimens were tested in air for the uncharged and cathodic charged conditions. The hydrogen charging was done by making the specimen as a cathode in 0.1 N NaOH solutions. For the precharging test, a specimen was charged with a constant current density (40 mA/cm 2) for 5 days, then it was removed from the electrolyte, rinsed with distilled water, acetone, and dried with pressurized air. The specimen was then immediately strained to failure using a Shimadzu AG- 300K NG testing machine. The strain rate adopte d in this study was 10^{5} . After completing the tensile test, the fracture surface was examined by scanning electron microscope.

3. DATA ANALYSIS

For this study, the flux of hydrogen through the specimen was measured in terms of the stead y-state current density, i Pl (mA/c m 2), and was converted tothe steady-state hydrogen permeation flux, J l (mol/m 2 s), according to

= /nf

where n is the number of electrons involved 1/mol and F is the Faraday's constant. The hydrogen permeation rate (mol/m 2 s) is defined by

= /nf L

where L is the specimen thickness in mm. For diffusion as the rate-limiting step, the effective diffusivity, Deff (m 2 /s) is related to the time lag, t L (s), by

= /6tl

4. RESULTS AND DISCCUSION

4.1. Permeation Test

The diffusivity and the permeation rate of the interstitial free steel at 30^{0} C with a constant charging current density (10 mA/c^{m2}) are listed in Table 2. The hydrogen diffusivity of annealed interstitial free steel is lower than those of pure iron [4 – 6]. It is due to the hydrogen trap and causing titanium hydride formation matrix. The data also clearly show a decreased in D_{eff} but an increased in J L as cold-rolled percentage increased for annealed specimens. The value of D_{eff} is decreased with increasing cold work, is due to the more hydrogen trapping site resulting from dislocations and deformation- induced microvoids [9-10] .Cold work increases the J L , this effect has been explained by short-circuit diffusion paths down dis- locations networks as well a s by low energy trapping of hydrogen to dislocation [7-8] .

4.2. Tensile Testing

Tensile proper ties of hydrogen charged and uncharged specimens are listed in Table 3. The tensitle data show a slight loss in mechanical proper ties with a 5-day hydrogen charging for all cold-rolled specimens, but slight improvement for annealed specimen.For the un charged specimen s, it is mainly simpleductile fracture, even the 80% cold- rolled specimen as show n in Fig. 2(a) , while the fractograph shows a trangronular cleavge effect with a partial ductile fracture surface for a 5-day hydrogen charged. This results can be explained as more hydrogn trapping site in cold worked specimen with higher dislocation density. The hydrogen precharged annealed speci- means show slight improvement in strength and elonogation can be explained as the tiny titanium hydride formation in the matrix, providing the easy glide of dislocation, and the precipitates also enhancing strength.

5. CONCLUSION

The work which is presented in this paper indicates that cold worked interstitial free steel is susceptible to hydrogen degradation .with the presence of niobium.

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