

(470) 耐サワーラインパイプ用電縫鋼管の水素誘起割れ発生限界に関する一検討

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1. はじめに 耐サワー電縫ラインパイプ APIX-60の連铸偏析部に関して、NECE試験条件下でのHIC発生限界を定量化することを目的として、連铸材で製造した電縫鋼管についてNACE試験後およびpH=1のHIC試験後の試験片を板厚中央部で脆性的に割ってHIC破面の観察・測定を実施した。SEMによるMnSの分布および偏析の寸法調査、EPMAによるP、Mnの濃度調査によりHIC発生限界を検討した結果を報告する。

Table 1. Chemical Composition of Tested Pipes.  
(Ladle analysis value:wt.%, Pipe size:12 3/4" × 0.375")

C	Si	Mn	P	S	Al	Nb	V	Ti	N	Ca	O
0.08	0.13	0.88	0.0040	0.0005	0.020	0.031	0.030	0.009	0.0035	0.0030	0.0020
0.09	0.20	1.05	0.0070	0.0015	0.035	0.045	0.040	0.015	0.0045	0.0045	0.0035

2. 供試材および試験方法

(1) 供試材。供試鋼管の化学組成範囲を表1に示す。連続铸造の後工場での一貫製造工程を経た電縫鋼管である。

(2) 試験方法。調査手順および試験方法を図1に示す。

3. 調査結果および検討

供試電縫鋼管はAPIX-70の規格をも十分満足する強度であり、組織は均一なアシキュラーフェライト組織である。写真1にHIC破面を、図2にP、Mnのピーク濃度を示す。

またMnSの分布測定結果をPピーク濃度とあわせて図3に示した。Pピーク濃度が高い程、MnSの発生頻度も高い傾向がみられる。これは偏析部の元素濃化が大きい程MnSの発生頻度が高いことを示すものと考える。

HIC発生限界をみると、MnSの発生頻度が10μ/mm程度で、限界Pピーク濃度は0.035~0.040%程度である。

4. まとめ

電縫鋼管段階でのHIC破面調査により、HIC発生限界に関し、有効な知見を得た。

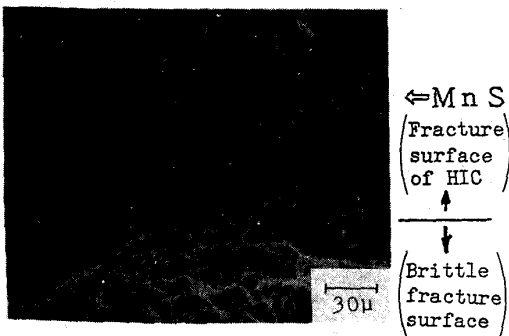


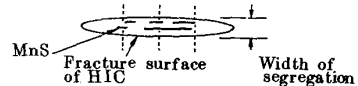
Photo 1. Fracture surface of HIC (Example)

Of the lengths of pipe produced from a hot coil, three lengths, each including a predetermined position in the longitudinal direction of the hot coil, were selected, and test specimens were taken two each from each of four positions in the circumferential direction of each length of pipe thus selected. These specimens were subjected to NACE test and the cracks developed were detected by three-dimensional UST equipment. The ratio of crack area was about 20%. These cracks were developed in the middle of the strip thickness. After that, the following two tests were conducted.

Random sampling of specimens from one group of specimens.  
→ Cooling with liquid N<sub>2</sub>.  
→ Cutting with a chisel at the middle of thickness.  
→ Observation of fracture surface of HIC

HIC test using a solution with pH=1 (pH adjust of NACE solution with HCl) → Three-dimensional UST → Random sampling of specimens → Cutting with a chisel → Examination of newly developed HIC

Measurement of total width of MnS under SEM.



Total width of MnS: Total width of MnS at the three positions of the fracture surface (on three cutting lines dividing the length of segregation into four equal parts as shown above) per 1mm of the width of segregation (μ/mm)

EPMA (Measurement of peak concentrations in the segregation zone):  
Peak concentrations of Mn and P: Peak concentrations determined by scanning the middle of the fracture surface of HIC in the direction at right angles to the rolling direction (Beam diameter: 2μφ)

Mark 'x' in Figs. 2 and 3 indicates the segregation zone where cracking occurred during NACE test.

Microscopic examination of cross section, structure, hardness.

Mark 'o' in Figs. 2 and 3 indicates the segregation zone where cracking did not occur during NACE test.

Fig.1. Testing procedure and method.

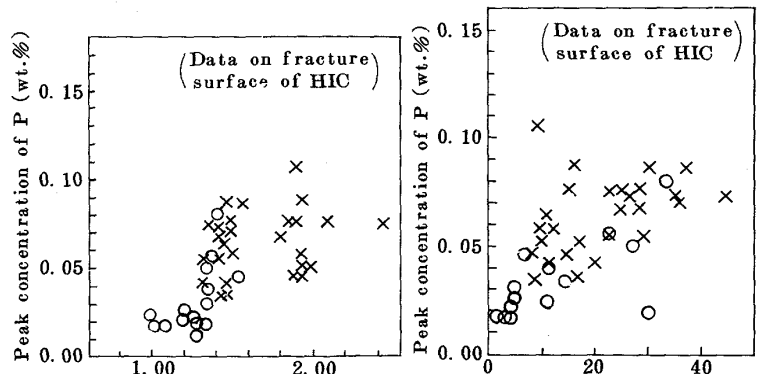


Fig.2. Peak concentration of Mn and P in segregation zone.

Fig.3. Total width of MnS per 1 mm of width of segregation and peak concentration of P.