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Production of 9% Ni Steel Plates for Liquefied Natural Gas Tanks

Shigeharu Suzuki, Yoshifumi Nakano, Keisuke Hirose, Taketo Okumura, Hiroshi Nishikawa, Mineo Sato

Synopsis :

Along with the continuous increase in the size of LNG tanks, high toughness at low temperatures has been required of the main structural steels or 9% Ni steels in order to ensure the safety of tanks. Kawasaki Steel has successfully improved the products of 9% Ni steels with respect of fracture toughness at low temperatures and supplied 3000 tons of steel plates for the 80000 kl LNG tanks at Chita LNG Receiving Terminal. The present paper describes the properties of the 9% Ni steels produced recently and the main controlling items in the production. As a result of lowering phosphorus and sulfur contents and the strict control of the production line, the properties, especially the toughness at low temperatures, of the 9% Ni steel plates were much improved compared with those produced in the past. The properties of welded joints and fracture toughness showed that the 9% Ni steel plates are suited for the structural material of LNG tanks.

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The body can be viewed from the next page.

Production of 9% Ni Steel Plates for Liquefied Natural Gas Tanks*

Shigeharu SUZUKI **

Yoshifumi NAKANO **

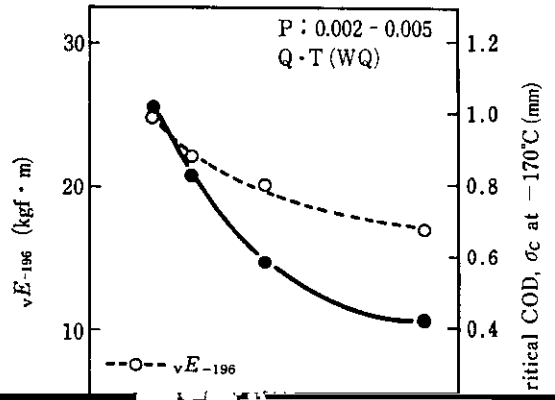
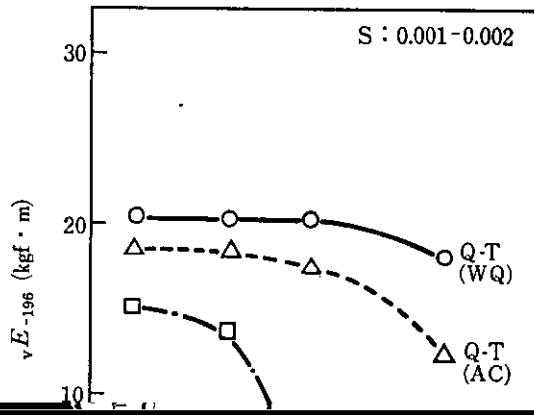
Keisuke HIROSE ***

Takao OKUMURA ***

Mitsuhiko MITSUKAWA ****

Table 1 Specifications of 9% Ni steel

Designation	Plate thickness(mm)	Chemical composition (%)					
		C	Si	Mn	P	S	Ni
ASTM A 553	≤50	≤0.13	0.15 - 0.30	≤0.90	≤0.035	≤0.040	8.50 - 9.50



2.2 Manufacturing Process

Composition of	C	Si	Mn	P	S	T(°C)
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As described in the preceding paragraph, the

low temperature treatment of 0.0% Ni and 1

Manufacturing process

Desulfurization of molten pig iron
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Dephosphorization pretreatment (Q-BOP)
↓
LD refining
↓

Major controlling items

Treating temperature and time, chemical composition

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Tapping temperature, chemical composition

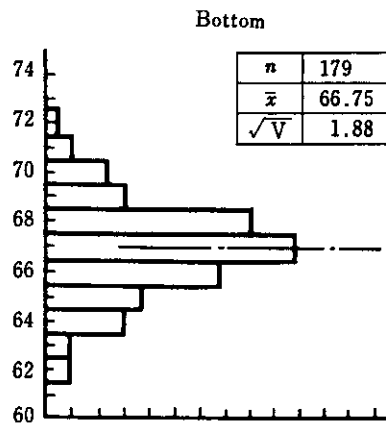
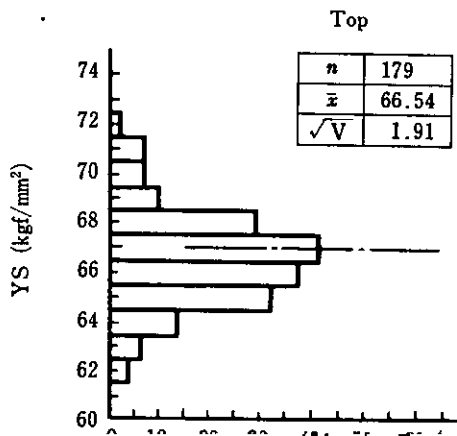
Treating temperature and time, chemical composition

30 Г

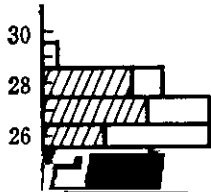
п	32
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15 Г

п	32
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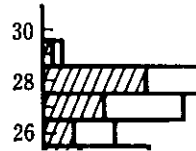


Longitudinal direction

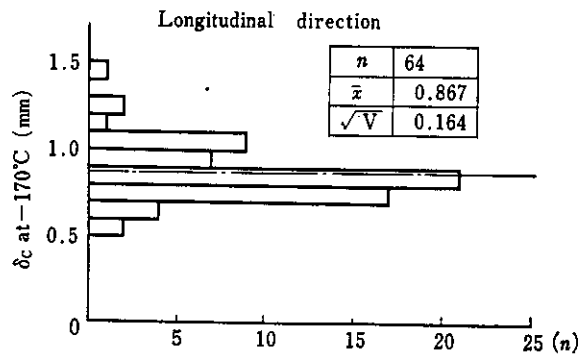


n	137
\bar{x}	25.31
\sqrt{V}	1.95

Transverse direction



n	179
\bar{x}	23.92
\sqrt{V}	2.92



4 Properties of Welded Joints and Fracture Toughness of 9% Ni Steel Plates

In order to secure the safety of LNG tanks, it is necessary to have adequate knowledge of the brittle crack initiation and arrest properties of welded joints. In Kawasaki Steel, these properties have been intensively studied, and some examples of testing with a 30 mm thick steel plate of relatively lower toughness in the direction perpendicular to the principal rolling direction are presented below, as taken from the previous manufacturing records.

Table 4 Chemical composition of weld metals

(wt %)

Table 7 COD test results at -170°C of welded joint of 30 mm thick plate

Welding method	Notch position	Fracture load	Plastic component of clip gage displacement	Critical COD
	mm from bend toward WM	9 450	1.967	0.528

Table 8 Wide plate tension test results

Test	Specimen dimensions(mm)			Prestrain (%)	Test temperature (°C)	Maximum load (t)	Maximum stress (kgf/mm ²)		K _c (kgf·√mm/mm ²)	Clip gage opening displacement V _g (mm)			Critical COD, δ _c (mm)		
	Thickness	Width	Notch length 2C				σ _{gross}	σ _{net}		1	2	Ave.	1	2	Ave.
Center notched wide plate tension test	30.83	1 000	400	0	-173	1 475	47.84	79.73	1 290	3.96	3.69	3.83	3.46	3.23	3.35

Table 9 Duplex ESSO test results

Specimen	Specimen dimensions(mm)	1) Prestrain	1) Test temperature	Impact energy	Load	σ_{gross}	2) Arrested	3) K_{Ic}	Go/No Go
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test, none of "pop-ins" was recognized on the load-clip gage opening displacement curve. Moreover,

by various welded joint strength tests and fracture toughness tests that the steel plates were adequately

cracks induced at the notch tip at the welded joint bond were all ductile cracks propagating in the interior of soft weld metal. It may be said, therefore, that the probability of initiation and propagation of brittle

applicable to the construction of LNG tanks. It is expected that the demands for 9% Ni steel plates will continue to increase, and the authors believe that their product with its excellent properties will fully meet

crack in the welded joints of steel plates tested is very small.

the users' requirements.

The welded joint strength tests and fracture tough-