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A STUDY ON THE APPLICATION OF STEEL MANUFACTURED TMCP WITH NB-MICROALLOYED ON COMMERCIAL SHIPS AND OFFSHORE PLATFORMS

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Abstract

DSME has applied Nb-steel made by thermo-mechanical control process (TMCP) on commercial ships and offshore structures widely. Especially, by adding the Nb to EH40, steel for thick plate applied on torsion box in container ship, E grade steel for LNGC and API 2W Gr50 for offshore structures required CTOD property, DSME could attain good weldability and the resistance for crack with Nb-microalloyed steel plates.

Introduction

Thick steel plate over 65 mm is applied on torsion boxes in large container ship. Also, high strength grade like EH36 is applied; therefore it needs to pave the way for welding of those steels. Meanwhile, API 2W Gr50 is used in the construction of offshore structures such as TLP, FPSO. However, the steel has been imported entirely to date. therefore, it has been difficult to supply and deliver domestically. DSME investigated application possibility of EH36, EH40 for the torsion box, and E-grade steel for LNGC and API 2W Gr.50 for offshore structures by adding the Nb to TMCP steel.

Weldability for EH40

In order to improve the weldability for thicknesses at a maximum of 80mm, it is necessary to apply tandem EGW. DSME performed application of Nb-microalloyed EH40 made at POSCO on EGW of tandem electrode. Table 1 shows the composition of E40 and Nb of 0.017% is included in the steel. We performed welding of the steel under heat input of 55 KJ/mm with Tandem EGW. Mechanical properties of welded specimens are displayed in Table 2. Although the tensile strength was lower than that of the base metal, it was qualified for the requirement. Also, all cases of impact toughness were qualified for the requirement. Therefore, EH40 was successfully welded by tandem EGW on Nb-bearing structural plate steel.

Table 1. Chemical composition of EH40.

C	Si	Mn	P	S	Ni	Cr	Mo	V	Cu	Ti	Nb	N	Ceq
0.062	0.17	1.58	0.004	0.001	0.20	0.10	0.004	0.002	0.10	0.018	0.017	0.004	0.367

Table 2. Mechanical properties of welded specimen for EH40.

Properties			Requirement	Base metal	Welded specimen
Tensile strength (MPa)		Root	510 ~ 650	569	511
		Face			517
Impact toughness at -20℃ (J)	Root	WM	≥ 41	436	42
		FL			299
		FL+1mm			387
		FL+3mm			280
		FL+5mm			400
	Middle	WM		413	70
		FL			79
		FL+1mm			48
		FL+3mm			167
		FL+5mm			405
	Face	WM		394	64
		FL			276
		FL+1mm			195
		FL+3mm			390
		FL+5mm			408

Weldability for E Grade

The size of LNGC has gotten larger and the steel plate applied on it also has gotten thicker. Therefore, steel plate should be possible to be welded with high heat input. DSME has evaluated the weldability of E grade TMCP steel. Table 3 shows the composition applied in this experiment.

Table 3. Chemical composition of E grade steel.

Symbol	C	Si	Mn	P	S	Al	Nb	Ti	N	Ceq
E1	0.082	0.245	1.35	0.015	0.002	0.028	-	-	0.0039	0.307
E2	0.079	0.250	1.45	0.015	0.002	0.036	-	-	0.0037	0.327
E3	0.080	0.249	1.44	0.015	0.002	0.035	0.01	0.01	0.0039	0.320

The thickness of the steels was 20 mm. In the case of the material symbolized as E3, Nb and Ti of 0.01% is included. With submerged arc welding process (SAW) of tandem electrode, we performed the welding of the steels with heat input of 4.6KJ/mm. Figure 1 shows hardness distribution with compositions. In the case of the weld zone of E3, hardness values were a little higher compared with the others. It was expected that the reason for higher weldability was due to the elements of Nb and/or Ti.

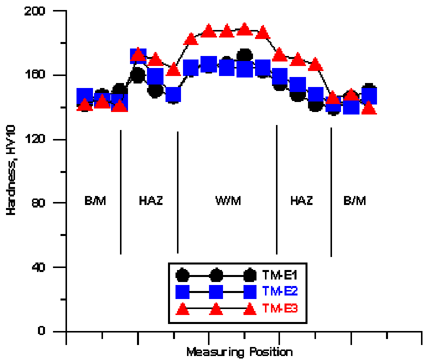

Figure 1. Hardness distribution with compositions of the base metal

Impact toughness of the weld zone and HAZ at -20°C is displayed in Figure 2. Toughness values of the weld zone of E1 were lower than the required value of 34J. On the other hand, in the case of E2 and E3, the values were higher than the required toughness value. The toughness value of the weld zone for the Nb-bearing steel sample E3 was the highest. Therefore, it was expected weldability of E3 was the most excellent.

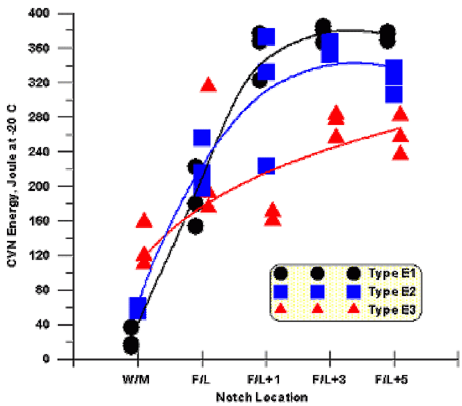

Figure 2. Impact toughness with compositions of the base metal

Weldability for API 2W Gr.50

Table 4 shows composition of the base metal used in this experiment.

Table 4. Chemical composition of API 2W Gr.50.

C	Si	Mn	P	S	Al	Cu	Ni	Cr	Mo	Nb	Ti	N	Ceq
0.07	0.27	1.46	0.003	0.002	0.033	0.27	0.25	0.014	0.002	0.012	0.015	0.0041	0.35

Nb of 0.012% is included in the material to improve properties. The thickness of the steel was 70mm. To confirm possible application of this steel grade, we performed the welding experiments with various heat inputs. Table 5 shows the mechanical properties for the welded specimen.

Table 5. Mechanical properties of welded specimen for API 2W Gr.50.

Process	Heat input (KJ/mm)	Tensile strength (MPa)		Impact toughness at -40℃ (J)				
		Req.	result	Req.	WM	FL	FL+2mm	FL+5mm
FCAW	0.7	≥ 490	584.8	≥ 27	76	72	298	332
SAW	4.5		540.9		228	342	355	355

Tensile properties and impact toughness were excellent compared with the requirements. API 2W Gr.50 for offshore structures is required to achieve the CTOD property, and excellent CTOD properties for the HAZ of the steel under a heat input of 0.7(FCAW), 3.0(SAW) and 4.5(SAW) which were already verified by POSCO. DSME performed CTOD tests for the weld metal of the steel. The results of the test are displayed in Table 6. CTOD values for weld metal were high. Therefore, from the result of tests, we concluded Nb-microalloyed API 2W Gr.50 could be applied on offshore structures due to excellent weldability of the steel.

Table 6. CTOD properties of weld specimen for API2WGr.50.

Process	Heat input (KJ/mm)	Notch location	Temperature (℃)	YS (MPa)	CTOD (mm)
FCAW	2.5	Weld metal	-10	563	0.70
SAW	4.0			475	1.89

Conclusions

From the above-mentioned investigation, we finally concluded as follows:

1) The weldability of E36 under condition of very large heat input was excellent by microalloying with Nb.

2) The weldability of E grade steel microalloyed Nb was excellent and especially, CVN energy at -20°C of the weld zone and HAZ by high heat input was remarkably excellent.

3) The result of the application of Nb-microalloyed API 2W Gr.50 on offshore structures was successful because of its excellent weldability and CTOD properties.