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TMCP Type KSUS329J3L Clad Steel Plates for Chemical Tankers

1. Introduction

Chemical tankers are ships that carry liquid chemicals. Stainless steel plates and stainless clad steel plates with excellent corrosion resistance and high strength are mainly used in these ships because the cargo tank is a very severe corrosion environment and must also withstand severe loading conditions such as a high specific gravity cargo and the effects of ocean waves. JFE Steel produces high corrosion resistant clad steel plates [1] and has developed "TMCP Type KSUS329J3L Clad Steel Plates" which are applicable to the cargo tanks of chemical tankers. The cladding material is a duplex stainless steel, "KSUS329J3L," and the manufacturing method has been approved by Nippon Kaiji Kyokai (ClassNK).

2. Concept of TMCP Type KSUS329J3L Clad Steel Plate

Figure 1 is a schematic illustration of the cross section of a cargo tank of a chemical tanker. KSUS316 L, which is a type of austenitic stainless steel, is mainly used in the cargo tanks of chemical tankers built in Japan [2]. The mainstream material for cargo tanks in Europe is duplex stainless steel [3], and use of duplex stainless steel (KSUS329J3L) in cargo tank partition walls to achieve higher corrosion resistance is also increasing in Japan. Although KSUS329J3L shows excellent corrosion resistance as a result of solution heat treatment, harmful precipitates such as intermetallic compounds which deteriorate corrosion resistance easily form in the temperature range around 900°C [4]. Thus, as problems in the manufacture of KSUS329J3L clad steel plates, corrosion resistance is degraded by precipitates in the hot rolling state, and the mechanical properties of the base metal deteriorate in the solution treatment state. Therefore, generation of harmful precipitates and the accompanying degradation of corrosion resistance was suppressed, while also satisfying mechanical property requirements, by applying TMCP (thermo-mechanical control process) technology in the rolling process. **Figure 2** shows a schematic diagram of the suppression of precipitates by TMCP technology.

3. Characteristics of TMCP Type KSUS329J3L Clad Steel Plate

The microstructure of the cladding material of the newly-developed TMCP type KSUS329J3L clad steel plate is shown in **Photo 1**. The ratio of the ferrite phase and austenite phase in this microstructure is approximately 1:1, and precipitates which are harmful for corrosion resistance, such as intermetallic compounds, are not formed. The pitting corrosion resistance and phosphoric acid corrosion resistance of the TMCP type

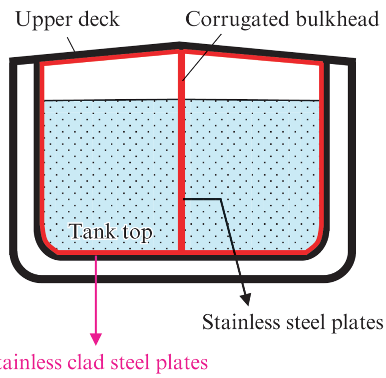

Fig. 1 Schematic illustration of cross-sectional cargo tank of chemical tanker

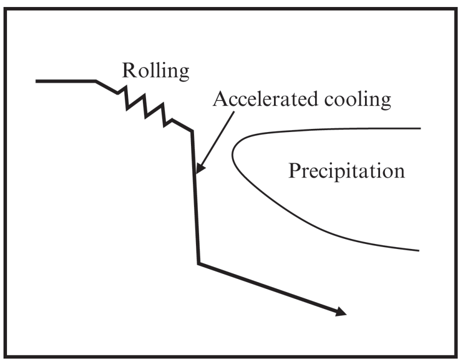

Fig. 2 Schematic illustration of preventing precipitation with accelerated cooling

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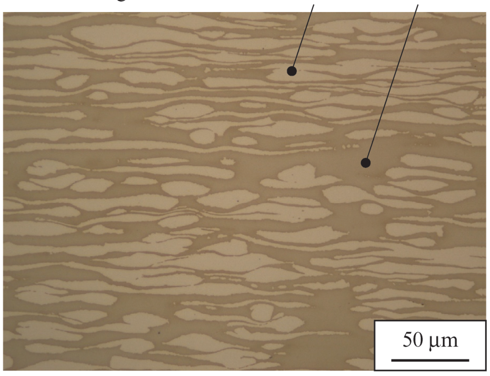

(Position: 1/4t of cladding material)

Photo 1 Microstructure of cladding material part of TMCP type KSUS329J3L clad steel

Table 1 Corrosion resistance of TMCP type KSUS329J3L clad steel plates

	CPT (°C)	Corrosion rate*1(mm/y)
KSUS329J3L clad (TMCP)	50	0.0
KSUS329J3L plate (ST)	50	0.0

CPT: Critical pitting temperature (JIS G 0578 B)
ST: Solution treatment
*1 Immersion test in phosphoric acid for 120 h at 50°C
50%P_2O_5 + 3%H_2SO_4 + 0.5%Fe^{3+} + 0.5%F^- + 0.03%Cl^-

Table 2 Mechanical properties of TMCP type KSUS329J3L clad steel plates

Thickness (mm)		Tensile test*1			Charpy impact test*2
Base metal	KSUS329J3L	YS (N/mm^2)	TS (N/mm^2)	El (%)	vE_{-20} (J)
13	3	450	557	22	387
KD36 Specification		≧373	≧515	≧17	≧34

YS: Yield strength, TS: Tensile strength, El: Elongation, vE_{-20}: Absorbed energy at −20°C
*1 Full thickness tensile test
*2 Base metal Charpy impact test

KSUS329J3L clad steel plate are shown in **Table 1**. Pitting corrosion resistance was evaluated by a ferric chloride corrosion test based on the JIS G0578B method. Since the critical temperature for pitting corrosion (Critical Pitting Temperature: CPT) is 50°C, which is the same as that of solution treated KSUS329J3L (Solution Treatment: ST), the developed plate has excellent pitting corrosion resistance. Phosphoric acid corrosion resistance was evaluated by the corrosion rate calculated from the weight change before and after the test, in which the corrosion test piece was immersed continuously for 120 h at 50°C in the test solution (50% P_2O_5 + 3% H_2SO_4 + 0.5% Fe^{3+} + 0.5% F^- + 0.03% Cl^-), which simulated crude phosphoric acid as a cargo. The corrosion rate was 0.0 mm/y, which is equivalent to that of solution treated KSUS329J3L, confirming stable corrosion resistance in phosphoric acid.

Table 2 shows the results of the tensile test of the KSUS329J3L clad steel plate and the impact absorbed energy of the base metal at −20°C. The tensile test pieces were taken from the total thickness of the base metal and the cladding material of the clad steel, and the Charpy impact test pieces were taken from the base metal part. Both tensile properties and impact absorbed energy satisfied the specification of KD36.

4. Conclusion

As described above, TMCP type KSUS329J3L clad steel plate has excellent corrosion resistance, and KA, KB, KD, KA32 to 36, and KD32 to 36 have received approval from Nippon Kaiji Kyokai for thicknesses up to 16 mm. It has also been confirmed that the characteristics of this plate have no problems in terms of weldability and fatigue properties [5], and application to the cargo tanks of actual chemical tankers is advancing.

Application of TMCP type KSUS329J3L clad steel plate is expected to lead to further improvement of the safety and reliability of chemical tankers.

References

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