

Commercially Pure (CP) Titanium Plate and Titanium Clad Steel Plate for Tube Sheet Use[†]

1. Introduction

Seen at the global scale, continuing grow in demand for electric power is expected in the future, accompanying population growth and economic growth in the emerging nations. The power generating equipment necessary to meet this power demand is also being expanded successively. One application of the commercially pure titanium plates and titanium clad steel plates introduced in this report is so-called tube sheet for condensers, which use sea water to cool steam after driving a steam turbine for power generation, and return the steam to water.

Figure 1 shows the structure of a condenser. Steam which has been used by a steam turbine is recirculated to the condenser, where it is cooled by passing sea water or other cooling water through the interior of titanium heat exchanger tubes and returned to water. This water is then heated again by the boiler to produce steam. The plate that supports these heat exchanger tubes is called a tube sheet, and is arranged at the boundary between the water box, where the cooling water is stored, and main body of the condenser. In cases where sea water is used as cooling water, aluminum brass was conventionally used in heat exchanger tubes from the viewpoint of cor-

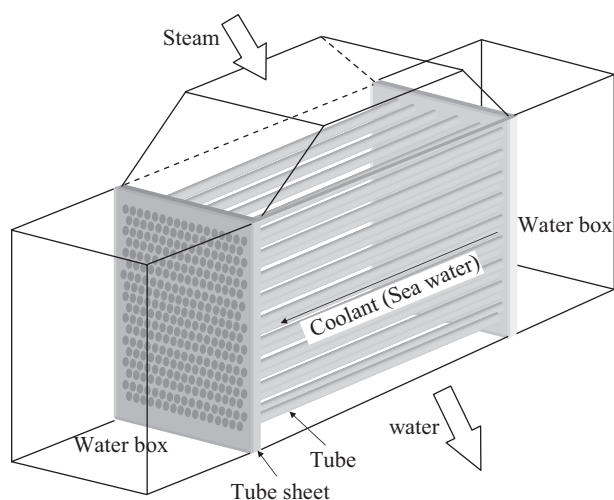


Fig. 1 Schematic of condenser

rosion resistance. However, since the 1970s, aluminum brass has been replaced rapidly by titanium in order to prevent erosion-corrosion by shellfish and corrosion by the trace amount of ammonium contained in steam. Commercially pure titanium plates or titanium clad steel plates are also used in the tube sheets that support the titanium heat exchanger tubes, as titanium cannot be welded with most other materials.

This report introduces commercially pure (CP) titanium plates and titanium clad steel plates manufactured by JFE Steel, mainly for tube sheet use.

2. Features of JFE Steel CP Titanium Plate and Titanium Clad Steel Plate for Tube Sheet Use

JFE Steel's titanium business began with sale of CP titanium plates in 1985 and titanium clad steel plates in

| Width (mm) | 1000-1600 | 1601-1800 | 1801-2000 | 2001-2200 | 2201-2400 | 2401-2600 | 2601-2800 | 2801-3000 | 3001-3200 | 3201-3400 | 3401-3600 | 3601-3800 | 3801-4000 |
|----------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|---------------|
| Thickness (mm) | | | | | | | | | | | | | |
| 6.0-6.9 | | | | | | | | | | | | | |
| 7.0-8.9 | 8 | | | | | | | | | | | | |
| 9.0-11.9 | 10 | | | | | | | | | | | | |
| 12.0-13.9 | | | | | | | | | | | | | |
| 14.0-14.9 | | | | | | | | | | | | | |
| 15.0-19.9 | 12 | | | | | | | | | | | | |
| 20.0-24.9 | | | | | | | | | | | | | |
| 25.0-39.9 | | | | | | | | | | | | | |
| 40.0-69.9 | | | | | | | | | | | | | |
| 70.0-100 | 10 | 9 | 8 | 7 | 6 | 5 | | | | | | | Not available |

■ : Please consult with JFE Steel.

Number in cell is maximum length (m). Minimum size is 1 m×3 m.

Fig. 2 Product size availability, titanium plate

| Width (mm) | 1000-2000 | 2001-2500 | 2501-3000 | 3001-3200 | 3201-3400 | 3401-3600 | 3601-3800 | 3801-3900 |
|----------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Thickness (mm) | | | | | | | | |
| Total | Cladding | | | | | | | |
| 6.0-8.0 | 1.5-2.5 | 10 | | | | | | |
| 8.1-10.0 | | | | | | | | |
| 10.1-12.0 | 2.0-3.0 | 11 | | | | | | |
| 12.1-16.0 | 2.0-4.0 | | | | | | | |
| 16.1-20.0 | | | | | | | | |
| 20.1-24.0 | 2.0-5.0 | | | | | | | |
| 24.1-28.0 | | | | | | | | |
| 28.1-30.0 | 2.0-6.0 | | | | | | | |
| 30.1-32.0 | | | | | | | | |
| 32.1-34.0 | | | | | | | | |
| 34.1-36.0 | 2.0-6.5 | | | | | | | |
| 36.1-38.0 | | | | | | | | |
| 38.1-40.0 | 2.5-7.0 | | | | | | | |

Number in cell is maximum length (m). Minimum size is 1 m×3 m.

*Please consult with JFE Steel.

Product size may vary according to its application.

Fig. 3 Product size availability, titanium clad steel plate

[†] Originally published in *JFE GIHO* No. 29 (Feb. 2012), p. 68-69

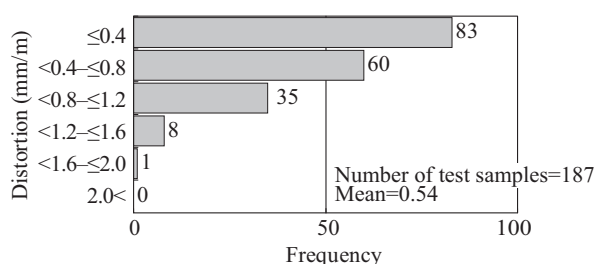


Fig. 4 Flatness: Commercially pure titanium plate

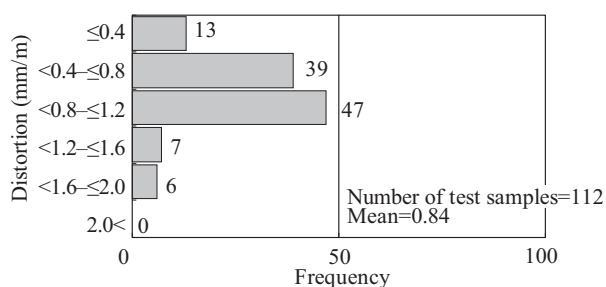


Fig. 5 Flatness: Titanium clad steel plate

Table 1 Thickness tolerance in a plate

| | Crown | Maximum deviation |
|----------------|-------------------------------|-------------------------------|
| Titanium plate | 0.10–0.25 mm ave.: 0.18 mm | 0.30–0.70 mm ave.: 0.48 mm |
| Clad plate | 0.75–1.15 mm ave.: 0.96 mm | 0.98–2.05 mm ave.: 1.54 mm |

Data taken from plates with following dimension;
 Ti Plate : (29–35) $T \times (2\,500\text{--}3\,500)W \times (4\,000\text{--}6\,800)L$ (mm)
 Clad : (28+5) $T\text{--}(35+5)T \times (2\,500\text{--}3\,500)W \times (4\,000\text{--}6\,800)L$ (mm)

1986, respectively, and now has a history of more than a quarter of a century. These products are manufactured at the Plate Rolling Plant at West Japan Works (Fukuyama District). It is possible to produce wide width products using the 4-high plate mill (Force: 9 000 t), which is one of the world's most powerful plate rolling mills.

The product size availability of CP titanium plates and titanium clad steel plates is shown in Figs. 2 and 3, respectively. Although it had not been considered possible to manufacture titanium clad steel plates without using the conventional explosion method to bond active titanium to steel, JFE Steel established a process which enables production of Ti-clad steel plates with stable quality by properly controlling the vacuum degree in the slab and optimizing the rolling process^{1,2)}.

The flatness of CP titanium plates and Ti-clad steel plates is shown in Figs. 4 and 5, respectively. In particular, when these products are used in tube sheet applications, good flatness is required from the viewpoint of

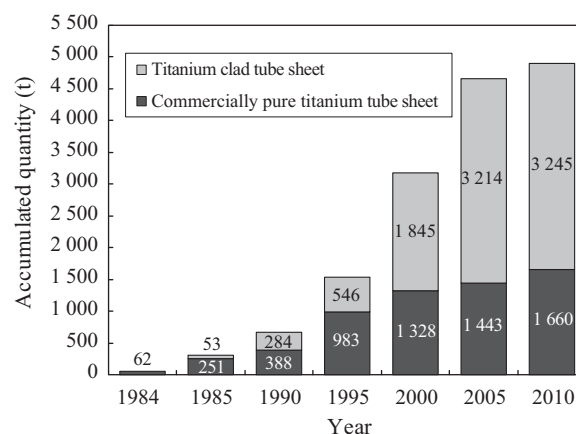


Fig. 6 Shipping record of titanium and Ti-clad tube sheet

water-tightness, as sealing with the side wall of the water box is performed using a gasket. With products manufactured by JFE Steel, it is possible to guarantee flatness of 3 mm/m or less, thus providing satisfactory flatness.

Table 1 shows the thickness tolerances of CP titanium plates and Ti-clad steel plates. JFE Steel's CP titanium plates and Ti-clad steel plates have small deviation and can meet strict plate thickness tolerances.

3. Conclusion

The shipping record of JFE Steel's commercially pure (CP) titanium plates and Ti-clad steel plates for tube sheet use is shown in Fig. 6. Cumulative shipments of these two products are now approaching 5 000 t.

In addition to use in tube sheets, JFE Steel also has a record of many sales of CP titanium plates and Ti-clad steel plates for other applications, such as various types of pressure vessels, special mechanical parts, etc., based on the advantages of wide width and excellent flatness and thickness accuracy.

In the future, JFE Steel will work to improve the quality and economy of its titanium products and actively produce and sell products that ensure customer satisfaction.

References

- 1) Hirabe, K. et al. Titanium & Zirconium. vol. 35, no. 1, 1987, p. 23.
- 2) Fukai, H. et al. Titanium '95 Science and Technology. 1995, p. 747.

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