performance steel plates for construction and industrial machinery use and the performance of the developed steels.

2. Development Details

2.1 Target Properties

The target properties for abrasion resistant steel plates and 780 MPa grade high strength steel plates for construction and industrial machinery use are shown in **Table 1** and **Table 2**, respectively. Considering actual use conditions, the plate thickness is set at a maximum of 32 mm for both abrasion resistant steel plates and high strength steel plates, and in consideration of weldability, the carbon equivalent (C_{eq}) is reduced corresponding to the standard and plate thickness. Moreover, in consideration of use in cold districts, Charpy absorbed energy at −40°C is guaranteed, depending on the standard.

2.2 Investigations for High Hardness and High Strength

In the abrasion resistant steel plates, first, improvement in the abrasion resistance of the plate, in other words, achieving high hardness in the plate, was studied. The hardness of steel plates is decisively determined by the C content and amount of martensite in the microstructure after quenching[2]. Accordingly, a composition design which simultaneously secures the C content for obtaining the target hardness and hardenability in order to achieve a full martensite structure after quenching is important.

The authors studied the effect of the C content on the hardness of the full martensite structure. As samples, steel plates with C contents of 0.10−0.32 mass% were used. Quenching was performed to these plates, and the surface Brinell hardness was measured after obtaining a full martensite structure (**Fig. 1**). It was found that the minimum C contents for obtaining HBW: 361 or higher or HBW: 477 or higher, which were the development targets for the hardness values of the abrasion resistant steel plates, were 0.14 mass% and 0.26 mass%, respectively.

Hardenability was studied with a maximum plate thickness of 32 mm, which was the development target, using the hardenability index D_I (defined in Eq.(1))[3,4] as an index of hardenability, considering a full martensite structure is obtained stably.

$$D_I = D_{IC} \times MF_{Si} \times MF_{Mn} \times MF_{Cr} \times MF_{Mo} \times MF_{Ni} \times MF_V \times MF_B \times MF_{Cu} \times 25.4\ (mm) \cdots (1)$$

$D_{IC} = (C/10)^{1/2} \times (1.70 - 0.09N)$
N: Austenite grain number
$MF_{Si} = 0.70Si + 1$
$MF_{Mn} = 3.33Mn + 1$
$MF_{Cr} = 2.16Cr + 1$
$MF_{Mo} = 3.00Mo + 1$
$MF_{Ni} = 0.36Ni + 1$
$MF_V = 1.75V + 1$
$MF_B = 1.3$ (With B addition)
$= 1.0$ (Without B addition)
$MF_{Cu} = 0.35Cu + 1$

Small cylindrical test pieces (3 mmϕ ×

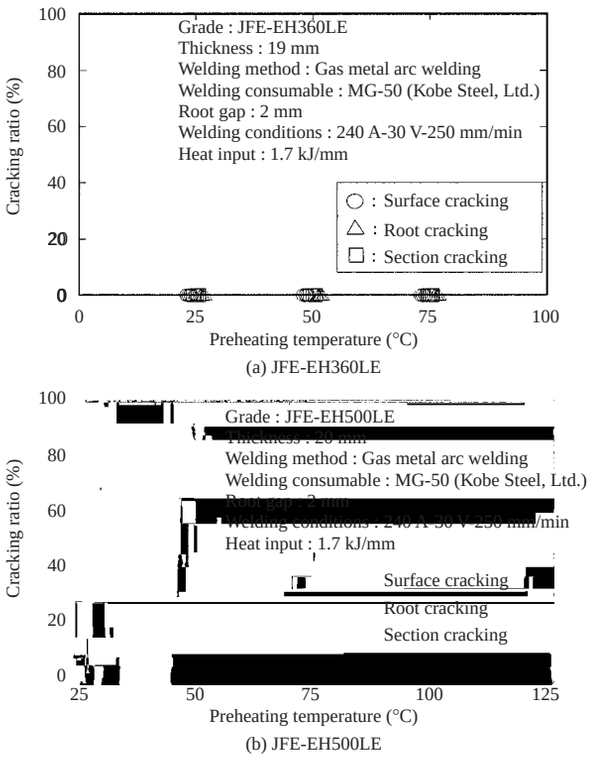

Fig. 5 y-groove cold cracking test results

perature toughness of 780 MPa grade high strength steel plate was markedly improved by applying microalloying technology and the thermo-mechanical control process, as represented by JFE Steel's *Super*-OLAC[5], and controlled heat treatment technology.

Figure 7 shows the strength and low temperature toughness of the developed steel. Is has an adequate strength as 780 MPa high tensile strength steel, combined with toughness signi f cantly exceeding that of conventional steel plates. Moreover, as shown in **Table 6**, this steel also provides excellent formability, showing no cracking at a bending radius of 1.5 times the plate thickness, in the more severe 200 mm width bending test. In the results of a y-groove cold cracking test, as shown in **Fig. 8**, the developed steel has excellent weldability, with no cracking at a preheating temperature of 25°C.

The developed steel is the f rst in the world to guarantee toughness at −40°C, in the f eld of steel plates for construction and industrial machinery use enabling use in cold districts, and also offers excellent performance

3.2 High Strength Steel Plate for Construction and Industrial Machinery Use, "JFE-HITEN780LE"

Table 5 shows the typical chemical composition of the developed high strength steel plate "JFE-HITEN780LE." In this developed steel, the low tem-