Progress in Welding Consumables for High Tensile Strength Steels in Japan

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ABSTRACT

The history and progress of development and improvement involving the latest techniques in Japan are introduced and reviewed in welding consumables for high strength steels (over 500MPa yield strength) for low temperature service which has been mainly applied in offshore industries where stringent requirements of impact toughness and CTOD are demanded. This paper also points up some issues on these welding consumables for future.

KEY WORDS: welding consumable; high strength steel; toughness; CTOD

INTRODUCTION

The application of high strength steels have been expanding in conjunction with the need for larger structures, due to advantages of this types of steel such as decreasing plate thickness, reducing components weight and increasing allowable stress. Most of the structures need welding to assemble; therefore it can be said that the advancement in welding technology as well as in steel production technology has contributed to the development in high strength steels and extensive applications. In Japan, it was in the early 1950’s when high strength steels were applied to actual structures. After that, a lot of studies on welding consumables for high strength steels have been done especially in improvement of crack resistance and toughness as the keywords.

APPLICATION OF HIGH-STRENGTH STEEL IN STEEL STRUCTURES

Figure 1 shows annually the applications of high-strength steels (HT590 or higher classes) in large-size steel structures in Japan. It is found that the year of employing higher-strength steels differs markedly depending on the type of structure. The applications of high-strength steels in spherical tanks, bridges and penstocks were begun comparatively early from around the end of the 1950s. In contrast to this, steel buildings and ships (commercial ships) were fabricated with high-strength steels after the 1980s when TMCP steel was developed.

Recently, though the domestic construction of oil/gas drilling offshore structures is not much, the application of higher strength steels in the overseas offshore structures is progressed; hence, there are increasing demands for higher strength and toughness according to the marine conditions or the trend of exploring colder seas.

Fig. 1 Application era of high-strength steels in Japan (HT590 class or higher) [Figure: made from actual key projects in Japan by author]

The yield strength levels and typical design temperatures in various steel structures that use high-strength steels are shown in Fig. 2. The strength level ranges from 390-830MPa by yield strength (YS), and the design temperature falls in a range of 0--60ºC according to the strength level; i.e., the strength and toughness requirements vary depending on the type of structure and application. There was a case where welded structure was seriously damaged by brittle fracture in the past; hence, safer design has been employed to resist brittle fracture by means of applying the elasto-plastic fracture mechanics. According to this trend, weldments have also been required to possess higher toughness values such as high Charpy absorbed energy and, in some cases, CTOD for welded joints.