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MD-portal Materials Database: Effective Materials Property Information Management in Nuclear Energy Systems

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1. Introduction

Nuclear structural materials are one of the important factors in manufacturing the components of nuclear power plants (NPP). The collective properties of the nuclear materials are defined as standard industrial codes such as ASME codes. While in service, the materials are aged and degraded, and the initial properties are changed according to the operating environments. These changes are a matter of substantial concern of the operators, regulators, and researchers in nuclear fields. Hence, the material property database considering the degradation is required, and the successful management and use of material property information must be responsive to the continuing changes and increasing complexity in nuclear engineering materials.

Recently, the nuclear materials division in the Korea Atomic Energy Research Institute (KAERI) launched a comprehensive portal website for nuclear material information, which is known as the MD-portal. The MD-portal contains various technical documents on the degradation and development of nuclear materials. Additionally, the nuclear materials database (MatDB) is incorporated in it. The MatDB covers the mechanical properties of various nuclear structural materials used as the components: a reactor pressure vessel, steam generator, and primary and secondary piping. In this study, we introduced the MD-portal MatDB briefly, and showed an application of the MatDB to the real case of material degradations in NPPs.

2. An Example Application

In this section, we focused on the relationship between the mechanical properties of the reactor pressure vessel materials, which were degraded by the neutron irradiation.

2.1 Database

The Charpy impact test data and tensile data from surveillance test reports of Korean LWRs are input into the MatDB system. Fig. 1 shows a screenshot of the MatDB displaying a navigation tree and a property tab, which are containing the material information of the selected heat/batch of the RPV material. The data were organized according to “pedigree” (equal to the heat/batch of the metals) information to ensure the traceability. Fig. 2 shows collective Charpy properties of the Kori-1 unit base metals [1-3].

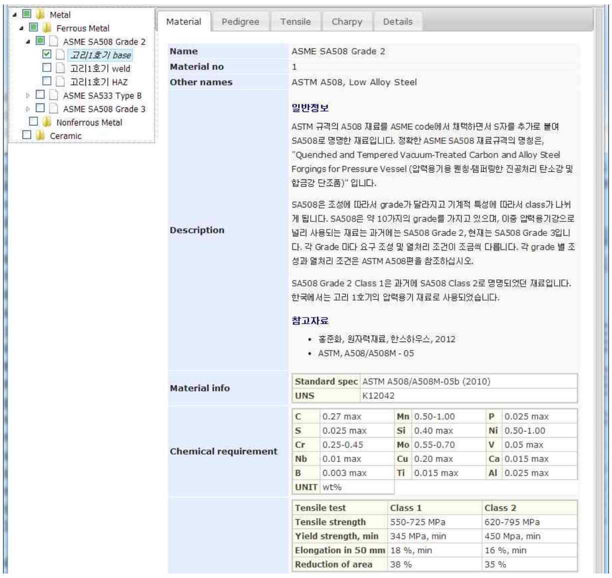

Fig. 1. Navigation tree and property tab of MD-portal MatDB. The basic material information is shown.

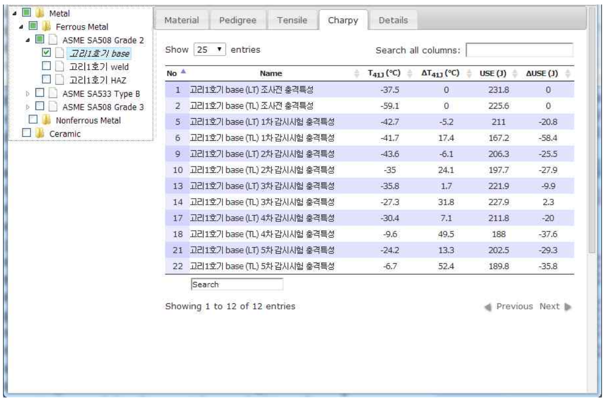

Fig. 2. Charpy impact test results of the Kori-1 unit base metals.

2.2 TTS vs. yield strength change

Fig. 3 shows the ΔYS with neutron fluence for the base metals and weld metals retrieved from MatDB. In the case of the base metals, ΔYS increase with neutron irradiation was clear. Some samples show a decrease in yield strength in a low neutron fluence region; however, it is believed to be a deviation of the test samples. In contrast, the weld data do not show a clear correlation between the neutron fluence and ΔYS. The variety of preparation process conditions seems to have caused a significant deviation in the weld data.

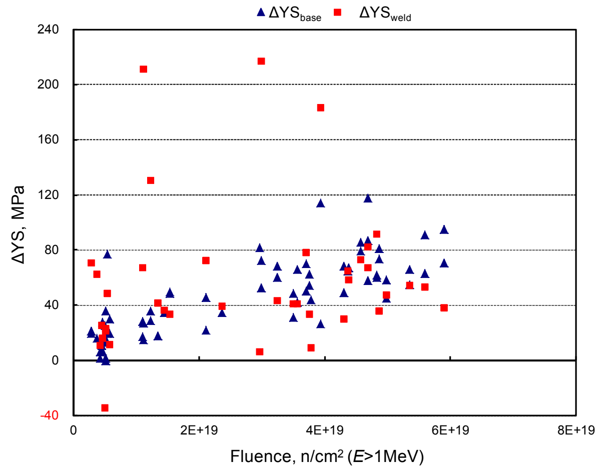

Fig. 3. Changes in yield strength of the base metal and weld metal of Korean surveillance data with neutron irradiation

Fig. 4 shows the relation plot between the ΔYS and TTS in the weld metals of the LWR data in Korea. As shown in figure, the points with large ΔYS over 100 MPa are originated from Kori-1 unit, which had a higher ΔYS and TTS because of the higher Cu content of about 0.22 wt% in Linde 80. We determined the proportional coefficients from the ΔYS for the data, which were 0.58, and it was rather higher than the proportional coefficient of the base metals of the same pedigrees, 0.49.

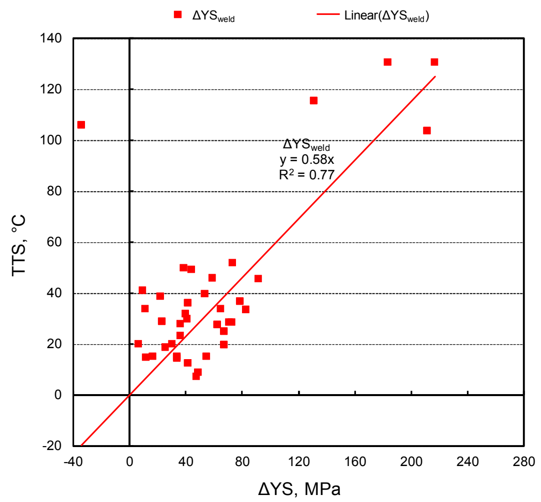

Fig. 4. Plots of ΔYS versus TTS: weld metal. Kori-1 data points are included (TTS > 100°C).

3. Summary

The data from MatDB were successfully applied to estimate the relevance of the Charpy-V notch impact test results and tensile strengths of Korean RPV steels in surveillance tests. The yield strength change caused by irradiation showed a rough linear relationship with the transition temperature shift change, and the proportional coefficient was determined. The MatDB includes the tensile and Charpy data at present, and the data and other properties such as fatigue, creep, fracture toughness, and SCC degradations are going to be added consistently. Such development will have a significant impact on the progress of nuclear materials and system engineering because of its usefulness of easy access.

REFERENCES

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