Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 7-8, 2015

Statistical Analysis of Charpy Transition Temperature Shift in Reactor Pressure Vessel Steels: Application of Nuclear Materials Database(MatDB)

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1. Introduction

Recently, a comprehensive portal website for nuclear material information, as known as MD-Portal was launched by the nuclear materials division in the Korea Atomic Energy Research Institute (KAERI). The MD-Portal contains various technical documents on the degradation and development of nuclear materials. Additionally, the nuclear materials database (MatDB) is also launched in KAERI recently. 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 MatDB briefly, and analyzed the Charpy transition temperature shift in reactor pressure vessel steels of Korean nuclear power plants retrieved from MatDB. It can show an application of the MatDB to the real case of material degradations in NPPs.

2. An Example Application

2.1 MatDB

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 Charpy impact test data and tensile data from surveillance test reports of Korean LWRs are input into the MatDB system. 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].

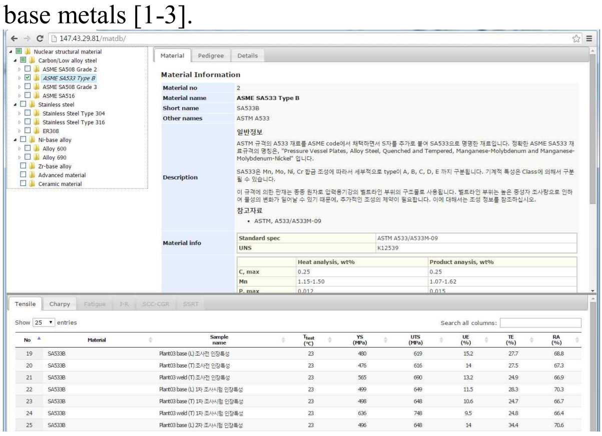

Fig. 1. Navigation tree and property tab of MD-portal MatDB. The basic material information is shown.

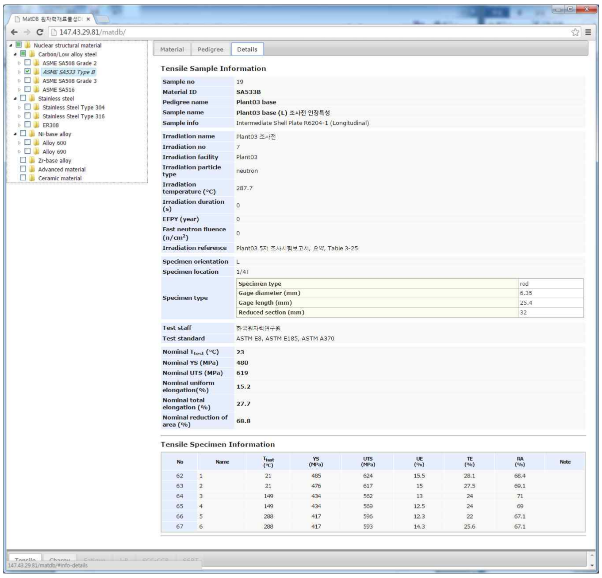

Fig. 2. Charpy impact test results of the Kori-1 unit base metals.

2.2 Statistical Analysis

Fig. 3 shows the TTS with irradiation time for the base metals retrieved from MatDB. In the case of the base metals, TTS increase with irradiation time, however the tendency was not clear. Some samples show a large deviation in the monotone increase tendency of TTS with irradiation.

Fig. 4 shows the relation plot between TTS and irradiation time in the weld metals of the LWR data in Korean nuclear power plant. As shown in figure, there is a gap between the high TTS points and low TTS points. It is because of the higher Cu content of about 0.22 wt% in Linde 80 of Kori 1 unit. We tried the simple modeling of REG1.99/2 onto the points. However, there are deviations in the results. Therefore, it is required to develop an elaborated model based on the statistics.

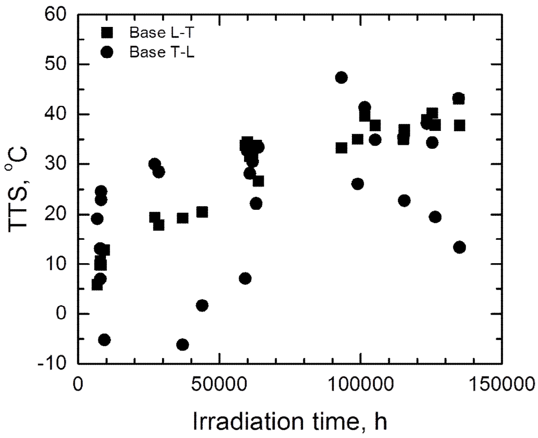

Fig. 3. TTS of base metal and weld metal of Korean surveillance data with neutron irradiation

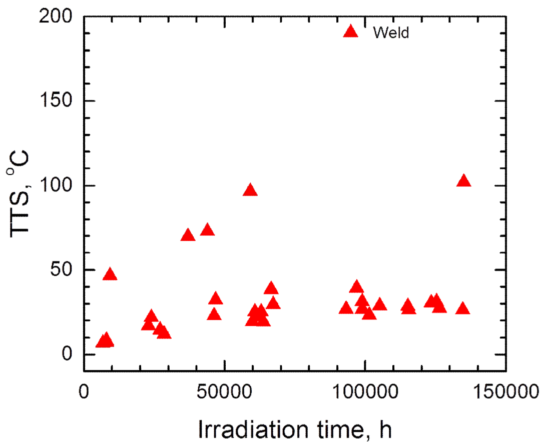

Fig. 3. TTS of weld metal and weld metal of Korean surveillance data with neutron irradiation

3. Summary

The MatDB includes the tensile results, Charpy results, fatigue results and J-R curve results at present. In the future other properties such as creep, fracture toughness, and SCC degradations are going to be added consistently. The data from MatDB were successfully applied to estimate the TTS analysis of Korean RPV steels in surveillance tests. The TTS behavior showed rather complex relationship with irradiation time, and an improved model is needed.

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