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Present status of Data-Free-Way (distributed database system for advanced nuclear materials)

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Abstract

The National Research Institute for Metals (NRIM), the Japan Atomic Energy Research Institute (JAERI), the Power Reactor and Nuclear Fuel Development Corporation (PNC), and the Japan Science and Technology Corporation are jointly developing a distributed database for advanced nuclear materials named Data-Free-Way. The main objective of the development is to share fresh and stimulating information as well as accumulated information for the development of advanced nuclear materials, for the design of structural components, etc. This paper describes the present status of the system and examples of utilization of the system. From such examples, it is demonstrated that the present distributed database system is attractive to evaluate materials performance in the fusion environment.

1. Introduction

Material behavior under the service conditions in the nuclear field can be little understood without practical examination. An easily accessible material information system with a huge material database using effective computers is, therefore, necessary for the design of nuclear materials and the analyses or the simulations of the phenomena occurring in the materials of the nuclear plants under the service conditions, especially neutron irradiation relevant phenomena.

Hence, the pilot system on the distributed database for advanced nuclear materials named 'Data-Free-Way' was constructed under the collaboration of the National Research Institute for Metals (NRIM), the Japan Atomic Energy Research Institute (JAERI) and the Power Reactor and Nuclear Fuel Development Corporation (PNC) [1–3] in order to share fresh and stimulating information as well as accumulated information for the development of advanced nuclear materials, for the design of structural components, etc. In the original pilot system, material information was mutually utilized through the local circuit. Now the system has been made more substantial through the advanced network with high data processing speed and multi-functions by taking advantage of current excellent data communication techniques like the Internet.

This paper will describe the present status of the new system, which is available through the Internet. Furthermore, some trials of attractive/sophisticated utilization of the system focused on the issues relating to fusion materials will be mentioned.

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2. System overview and present status

Development of the system has progressed and is scheduled as follows. Design of the pilot system was initiated in 1990. In 1991, the organizations, NRIM, JAERI and PNC, participating in the cooperation prepared their own computer programs and computers with their peripheral machines based on the same technical specifications. These computers were connected by a network through a 'digital data exchange packet (DDX-P)' line. In 1993, three other organizations, the Japan Information Center of Science and Technology (JICST), the National Research Laboratory of Metrology (NRLM) and the Ship Research Institute (SRI), joined the cooperations as observers and their computers were connected with the Data-Free-Way. Then JICST began to develop its own database. In order to make the system more substantial, the second stage collaborative research activity in which the main objective was to develop the utilization techniques for the Data-Free-Way was initiated in 1995 among NRIM, JAERI, PNC and JICST, whose name was changed to be the Japan Science and Technology Corporation (JST) after that.

Fig. 1 shows the present status of the system construction of the Data-Free-Way. The computer network consists of six organizations. These computer systems were introduced in each organization and connected to each other formerly through the DDX-P communication line and now through the Internet. Accordingly these databases and user interface can be mutually utilized through the computer network.

The conceptual user interface and related functions of the Data-Free-Way are shown in Fig. 2. The system

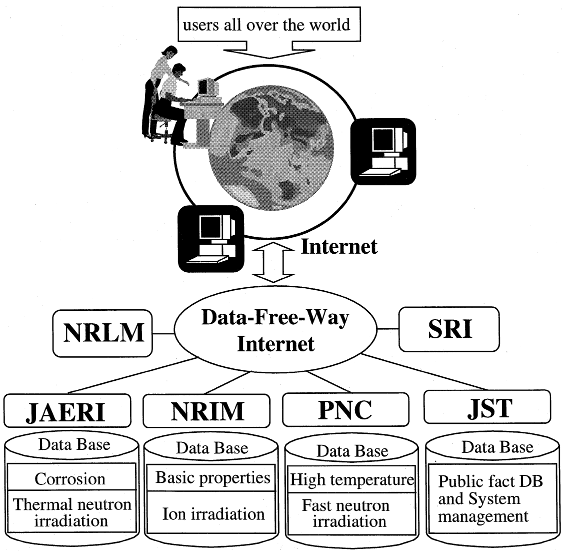

Fig. 1. Networking overview of Data-Free-Way system.

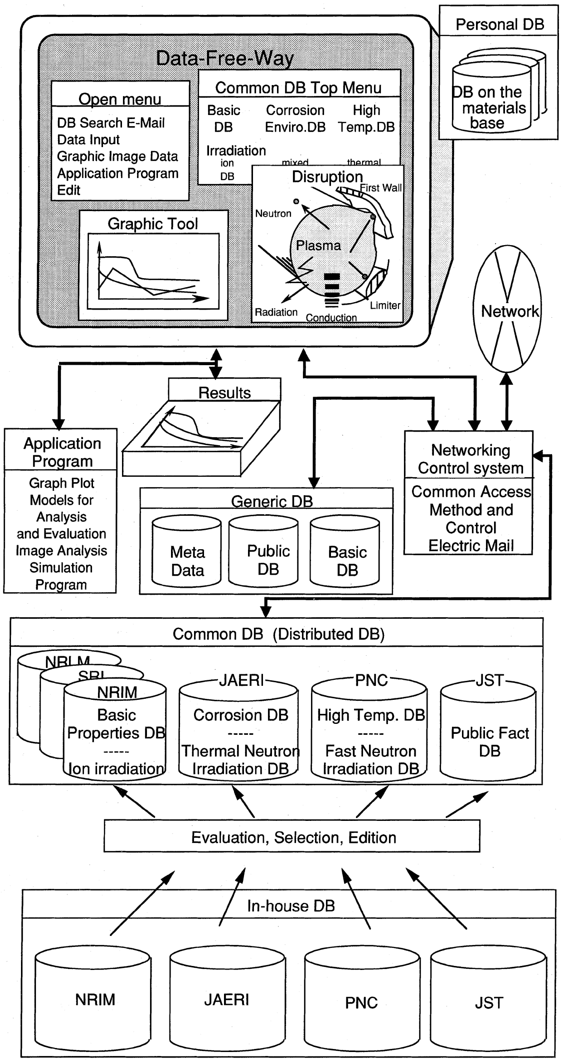

Fig. 2. Conceptual user interface and related functions of Data-Free-Way.

consists of a common database and a generic database as shown in Fig. 2. Evaluated, selected and edited data in each in-house database, which has been developed by each organization, are stored in the common database. For easy comparison of the relevant data sets from one organization with those of the others, a common data model is adopted.

Contents of the common database have already been shown in the previous reports [1,4–6]. NRIM prepares physical properties and ion irradiation data, JAERI prepares corrosion data, thermal neutron irradiation data and mixed spectrum neutron irradiation data, PNC prepares high temperature data and fast neutron irradiation data, and JST prepares public fact data. At present, the data of more than 17 000 specimens in various kinds of materials are stored in the common database. The generic database contains meta data, a data dictionary and sets of generic materials data for smooth communication. Both the common database and the generic database can be exchanged mutually among the participating organizations through the network. The user interface of the system plays an important role in developing a useful system, especially to extract information from the complex mixture of material data. Concepts of the user interface including a graphic analytical model and application programs for analysis and evaluation of data are adopted to the system. The system can be easily accessed by engineers and scientists in the nuclear field.

The world wide web (WWW) home page and the WWW server have been prepared. The URLs of NRIM, JAERI and JST sites are 'http://inaba.nrim.go.jp/', 'http://jmpdsun.tokai.jaeri.go.jp/dfw-e/dfw-e.html' and 'http://dfw.jst.go.jp/', respectively. As the data input-output supporting system, the additional functions have been prepared to reinforce the linkage function between the database and the WWW, such as the retrieval-layout function of image data, the simple graph preparation function, the linkage function between numerical data and image data, the preparation function of a fixed retrieval screen, the saving-reproducing function of retrieval conditions, etc. The dictionary on data items and unit conversion function have been prepared as a users' supporting system. Fig. 3 shows examples of the WWW home page screens using the linkage function between numerical data and image data.

3. Examples of data handling for application to fusion reactor materials

Neutron irradiation properties for austenitic stainless steels, which are important for the International Ther-

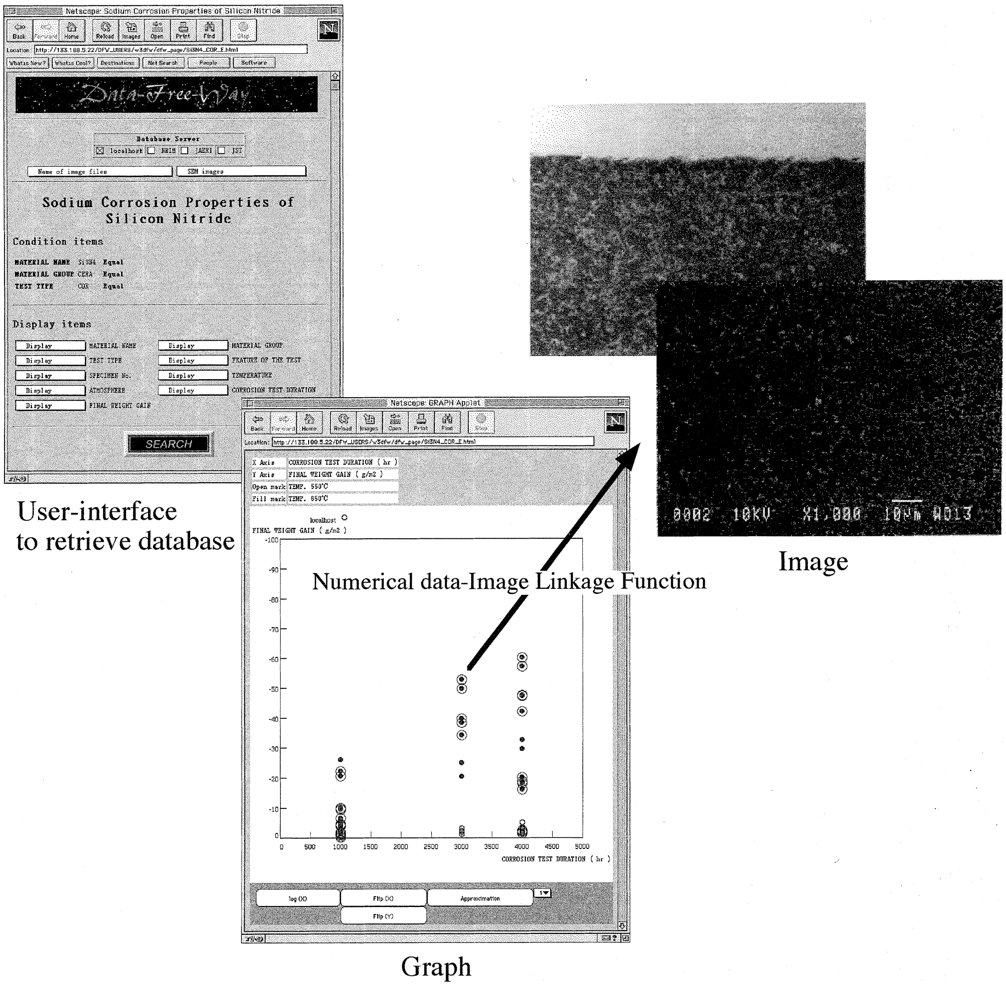

Fig. 3. Examples of WWW home page screens using the linkage function between numerical data and image data.

monuclear Experimental Reactor engineering design, have been widely studied. Data from such research activities have been collected and stored in the Data-Free-Way. Two examples of data handling for type 316 stainless steels are described in this section.

Fig. 4 shows the relation between the total elongation (TE) and the uniform elongation (UE) under the various tension test conditions for type 316 stainless steels [7–12]. Approximately 290 points are indicated in this figure. The displacement damage ranges from 0.3 to 121 dpa.

Interesting trend is recognized that the data points are divided into three groups of A, B and C. In the group A, the values of TE and UE are almost equivalent. The values of UE are almost constant despite increase of UE in the groups B and C. The values of UE in the group B are larger than those in the group C. Both of unirradiated and irradiated data are included in the group A. On the other hand, almost all the data in the group B are unirradiated ones and those in the group C are irradiated ones. Paying attention to the test temperature, the data obtained at lower than 600°C belong to the group A and those at higher than 600°C belong to the group B or C.

Fig. 5 shows the relation between the total strain range and the number of cycles to failure under the various fatigue test conditions for type 316 stainless steels [12–15]. Eighty points are indicated in this figure. The displacement damage ranges from 0.3 to 15 dpa.

Fatigue life reduction due to irradiation is observed in only one case where the 20% cold-worked type 316 stainless steel is tested at 430°C. In the other cases no significant fatigue life reduction due to irradiation is

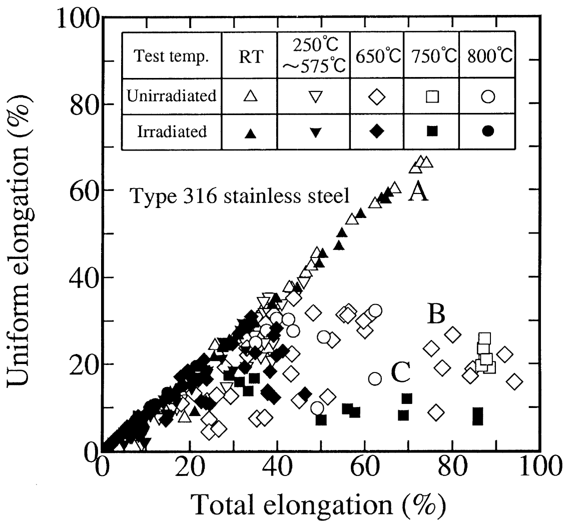

Fig. 4. Relation between total elongation and uniform elongation under various tension test conditions for type 316 stainless steels [7–12]. Displacement damage ranges from 0.3 to 121 dpa.

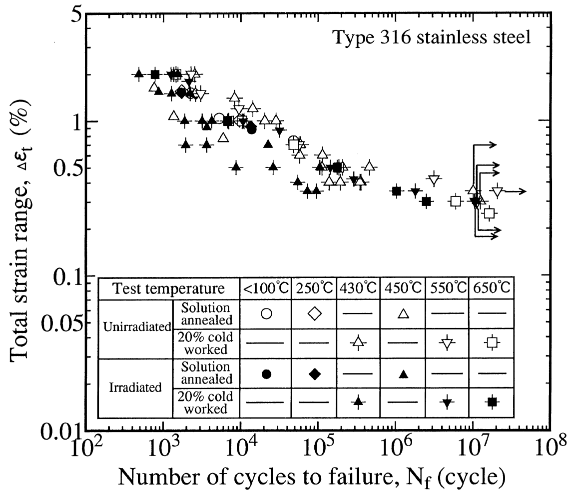

Fig. 5. Relation between total strain range and number of cycles to failure under various fatigue test conditions for type 316 stainless steels [12–15]. Displacement damage ranges from 0.3 to 15 dpa.

observed, even in the case where the solution-annealed material is tested at 450°C which is close to 430°C. The observed difference between them might derive from the difference in the heat treatment condition, the carbon level of the tested materials because the carbon levels of them are 0.02 for the solution-annealed material and 0.06 for the 20% cold-worked one in mass%, respectively, the irradiation level etc. Anyway the lowest fatigue strength is observed in the case where the 20% cold-worked and irradiated material is tested at 430°C in Fig. 5. It is also noticed that the fatigue strength of unirradiated 20% cold-worked material is higher than that of the solution-annealed one and that the material tested at 650°C exhibits no endurance limit (10^7 cycles) for strain ranges as low as 0.25% unlike the material tested at 430°C or 550°C.

4. Summary

NRIM, JAERI, PNC and JST are jointly developing a distributed database for advanced nuclear materials named Data-Free-Way. The main objective of the development is to share fresh and stimulating information as well as accumulated information for the development of advanced nuclear materials, for the design of structural components, etc. This paper describes the present status of the system. As examples of utilization of the system, results of analyses of tensile and fatigue properties of irradiated and unirradiated type 316 stainless steel. From such examples, it is demonstrated that the present distributed database system is attractive to evaluate materials performance in the fusion environment.

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