Retrieval Transmutation and Decay Process of Nuclides Using Nuclear Reaction Database on Internet

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Abstract

In the data system for alloy design and selection of materials used in various nuclear reactors, huge material databases and several kinds of tools for data analysis or simulation code of the phenomena under neutron irradiation are required. A nuclear reaction database system based on the data of FENDL-II on the Internet has been developed in NRIM site of "Data-Free-Way". The user interface in this database was made for the retrieval of the necessary data and for the expression of the graph of the relation between the nuclear energy spectrum of neutron and neutron capture cross section. It is indicated that using the database, the possibility of chemical compositional change and radioactivity in a material caused by nuclear reactions can be easily retrieved, though the evaluation is qualitatively.

1. Introduction

The computer aided data systems are required in order to the alloy design and selection of materials used in various nuclear reactors. The system should consist of huge material databases and several kinds of tools for data analysis or simulation code of the phenomena under irradiation. The huge martial database has several small databases stored the special data such as nuclear data and decay data. Thus, a database on transmutation for nuclear materials had constructed on PC [1,2]. The database converted to a system used on Internet. As a database for nuclear material design and selection used in various reactors are developed in NRIM site in "Data-Free-Way"[3-5].

The database storing the data on nuclear reaction needs to calculate of the simulation for chemical compositional change and radio-activation in transmutation. Using the database, we can retrieve the data of nuclear reaction for material design on the Internet and understand qualitatively the behavior of nuclear reaction such as the transmutation or decay. The database is required for the friend user-interface for the retrieval of necessary data.

In the paper, features and functions of the developed system are described and especially, examples of the easy accessible search of nuclear reactions are introduced.

2. Outline of the database on transmutation for nuclear materials

2.1 Database system

In the database of transmutation for nuclear materials, the data of nuclear reaction for material design is stored and we can understand qualitatively the behavior of nuclear reaction such as the transmutation or decay. The database is managed by ORACLE where RDBMS (relational database management system) is supported on work station with unix OS.
As the RDBMS and WWW were connected, user are able to retrieve necessary data using Netscape or Explorer as a user-interface through the Internet.

Fig. 1 shows the home page in the WWW of NRIM site on "Data-Free-Way". Users be able to access the database by selecting the term of "transmutation of material" in the home page. Then. the opening screen of the database as shown Fig. 2 is appeared. Users are able to select various interfaces for retrieval and obtain the necessary data. The interfaces are used in the periodic table or the chart of nuclides.

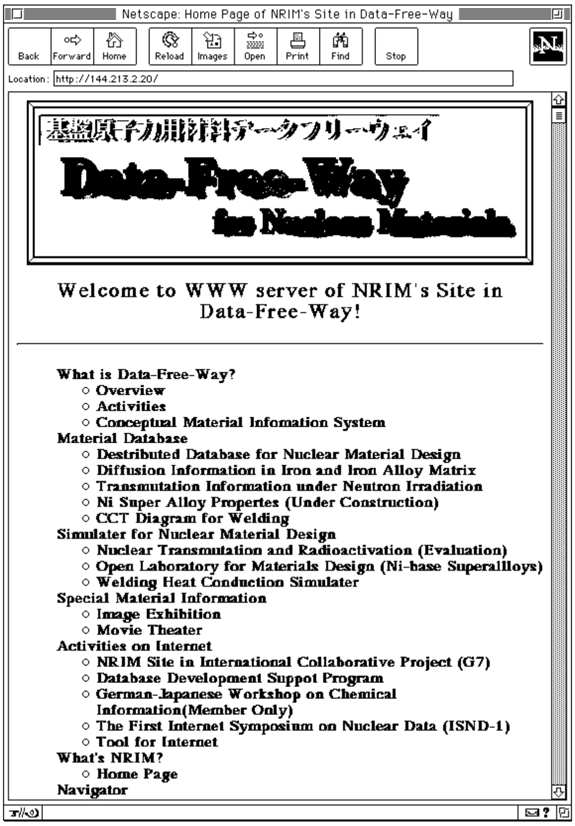

Fig. 1 Home page in the WWW of NRIM site on "Data-Free-Way"

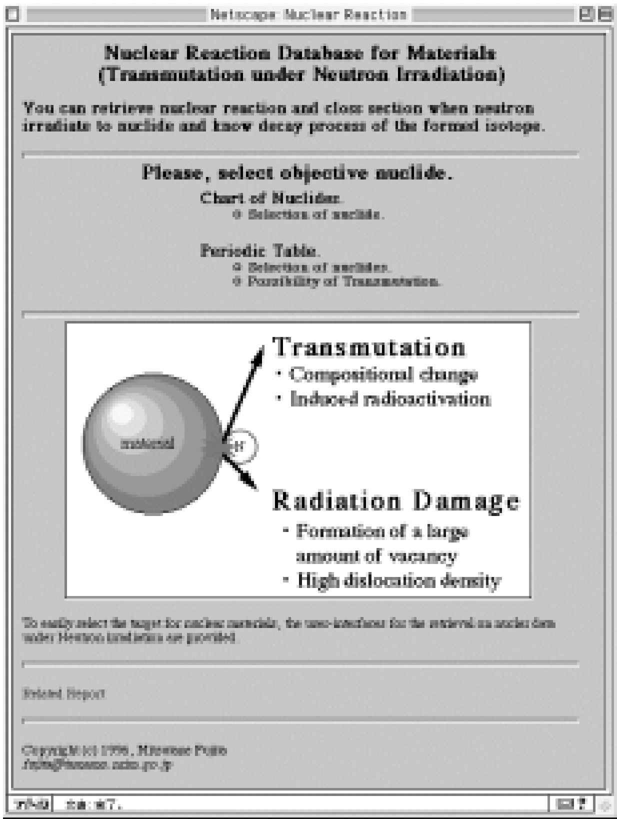

Fig. 2 Opening screen of the for transmutation under neutron irradiation..

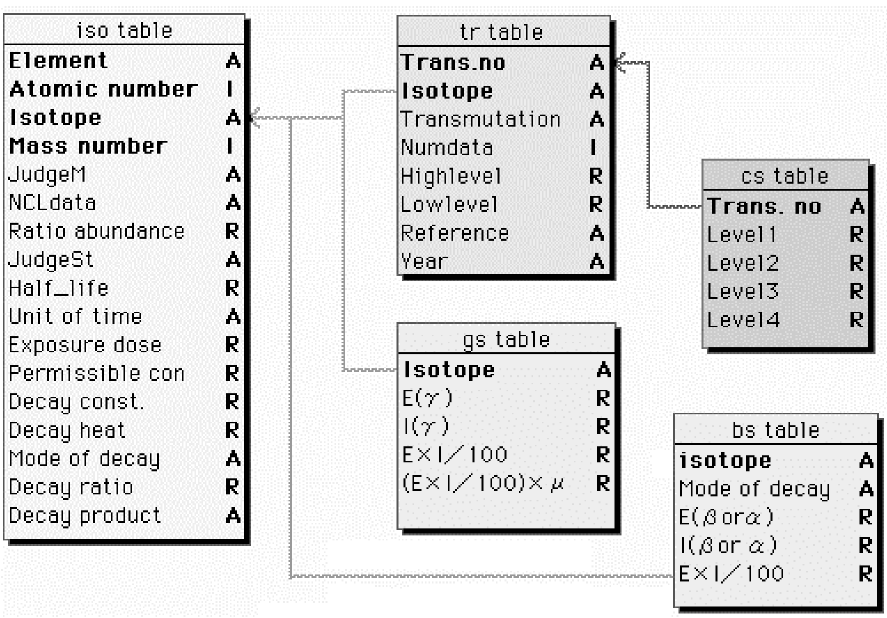

Fig. 3 The data structures of the database on transmutation for nuclear materials.

2.2 Data structure

The database consists of five main tables, as shown Fig. 3. The main tables are isotope (iso table), decay (gs table and bs table), transmutation (tr table) and cross section (cs table). The isotope table consists of the data such as element name, atomic number, isotope name, mass number, the natural abundance ratio, half-life data, gamma-ray or beta-ray energy and maximum permissible concentration in air (MPC), which are taken from isotope table. The energies of gamma- ray and bata-ray on decay are stored in two tables of gs and bs. The decay heat are calculated from the data of these tables. The transmutation table has the data of transmutation process, produced nuclide and etc.. The neutron capture cross-section table has the data with 42-energy group covering from thermal neutron energy to 15MeV.

2.3 Stored data

Various data, which are required for simulation on nuclear reaction, have been collected from reports as follows;

I. Nuclear data such as neutron cross-section are mainly collected from FENDL II. The number of cross section for nuclear reactions which was stored in the database is 3213 in stable nuclides and 5484 in unstable ones.

II. The data on Decay process, gamma ray, isotope and element are collected respectively from

  a. "Table of Radioactive Isotopes" E. Browne and R. B. Firestone, 1986, LBLU of C, John Wiley & Sons,
  b. "Radiation Data Book", edited by Y. Murakami, H. Danno and A. Kobayashi, 1982, Chijin-Shokan.
  c. "Chart of the Nuclides" compiled by Y. Yoshizaw and T. Horiguchi and M. Yamada, 1996, JNDC and NDC in JAERI.
  d. "Elsevier's Periodic Table of the Elements", compiled by P. Lof, 1987, Elsevier.

3. Functions and user-interface

3.1 Functions

Fig. 2 shows opening main menu screen of the database. This database has four retrieval functions of nuclear reaction process, properties of radioactive isotope, spontaneous decay
of each isotope and decay of produced nuclides after nuclear reaction. We can understand qualitatively the behavior of nuclear reaction such as the transmutation or decay. Fig. 4 shows screen of the selection of the isotope or the nuclide from the cart of nuclides. Fig. 5 shows a example of the screen of properties for retrieved ^{93}Zr nuclide. User is able to know mass number, the natural abundance ratio, half-life data, gamma-ray or beta-ray energy on retrieved nuclide. Fig. 6 shows screen that by selecting the desired nuclear reaction in right folder, user is able to know records on a given transmutation and spontaneous decay in the reaction process. If user clicks the graph button in the screen shown Fig. 5 or Fig. 6, the graph as shown in Fig 7 appears. The graphs are shown the relation between transmutation cross section and neutron energy spectrum on various reactions. The high value of the cross section means qualitatively that the neutron reaction easily occurs.

The user-interface (i.e. folder) of the database performs an important role either useful system or not. Using this user-interface, end-user can easily obtain the necessary information by the easy operation for retrieving, because a screen provided with pop-up and pull down menu, is employed to be mainly operated by micro-mouse in addition to keyboard.

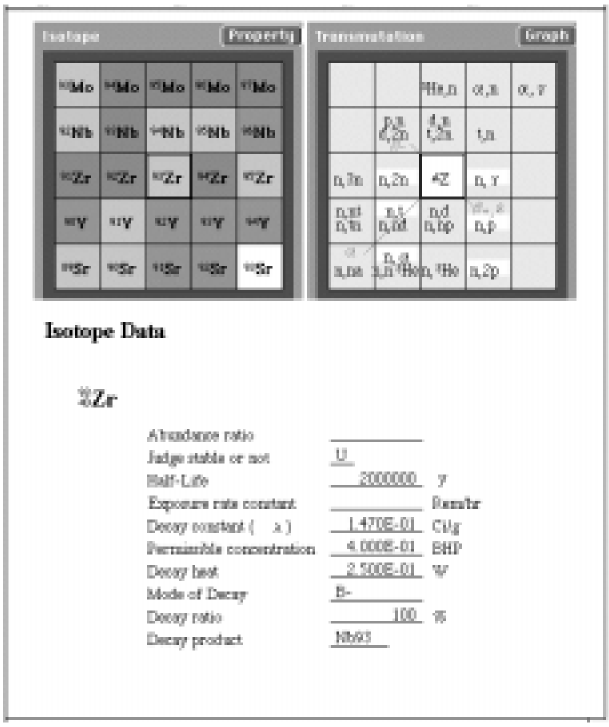

Fig. 4 Selection of isotope or nuclide by the chart of the nuclides

Fig. 5 Screen of properties for retrieved ^{93}Zr nuclide

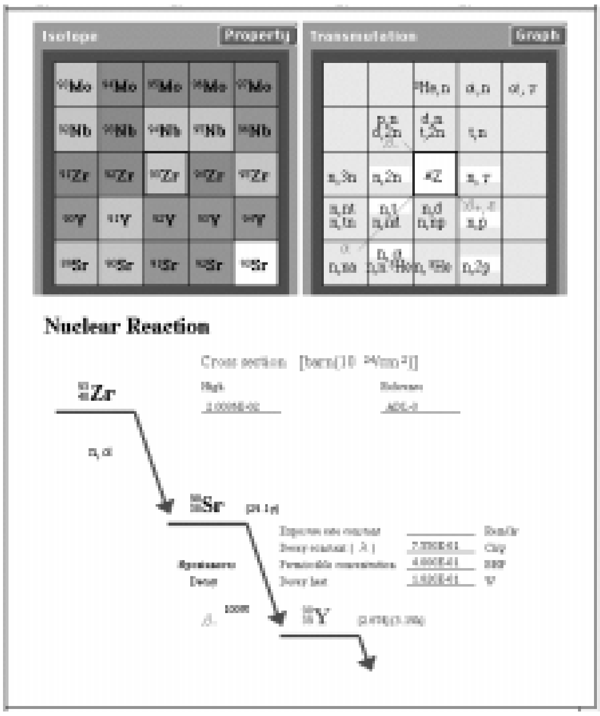

Fig. 6 Screen to retrieve data on nuclear transmutation and decay process of ^{93}Zr nuclide and the results.

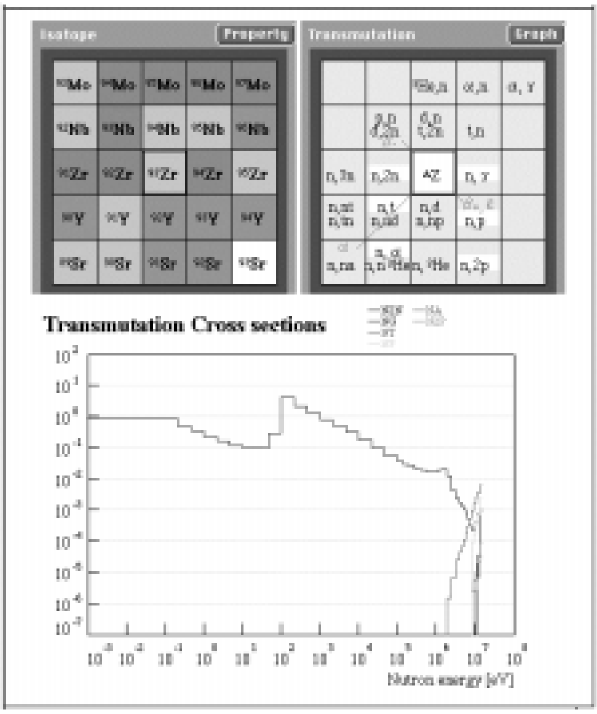

Fig. 7 A example of graph of relation between neutron capture cross section for various reactions and neutron energy spectrum.

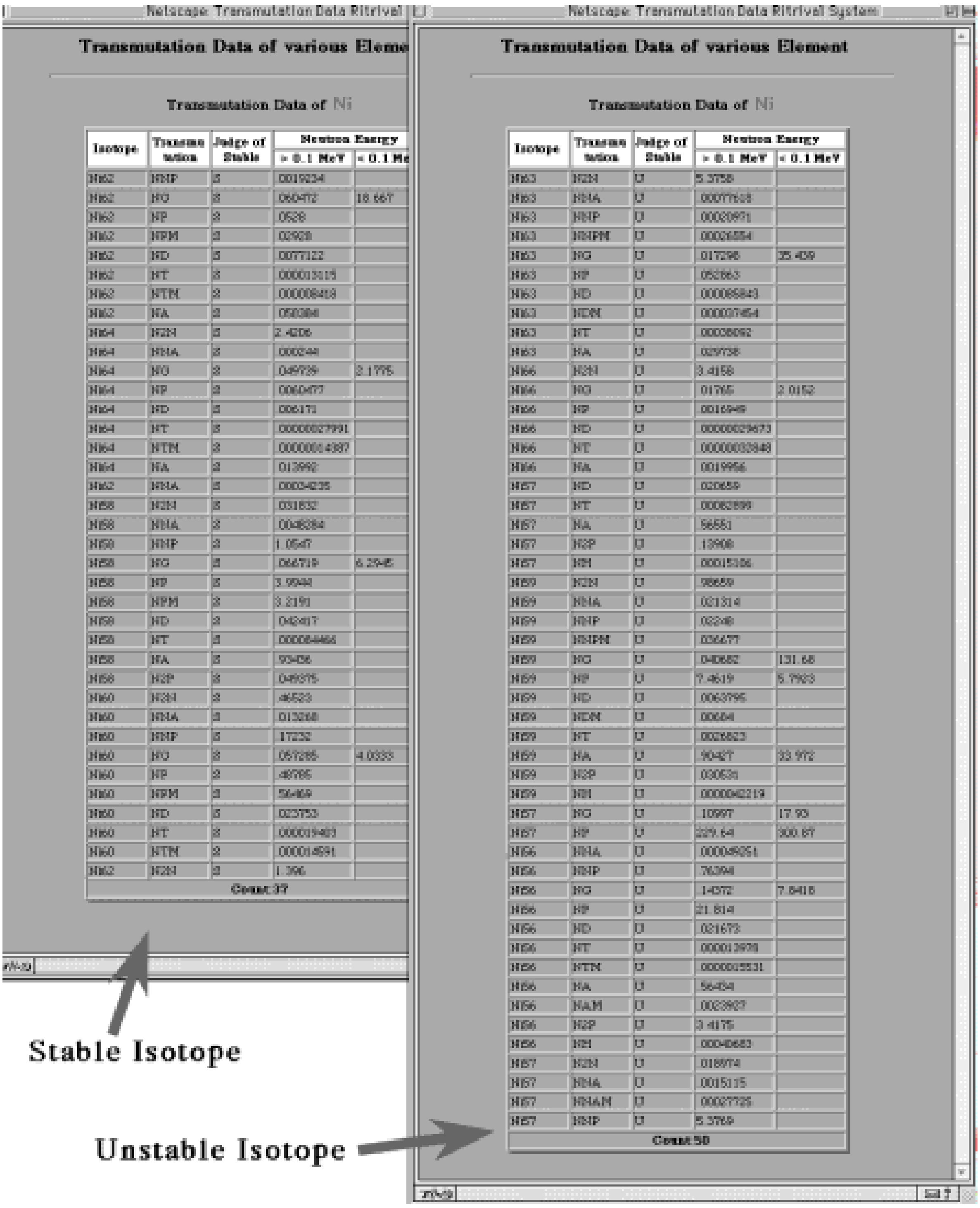

Fig. 8 Screen to retrieve data on formed nuclides and cross section under high neutron energy (>0.1eV) or low that (<0.1eV)on various transmutations in Ni.

4. Example of system operation

Fig. 8 shows the screen to retrieve data on formed nuclides and cross section under high neutron energy or low that on various transmutations in Ni. It is able to know that the reaction in nutron transmutation in Ni easily occurs qualitatively.

Type 316 stainless steel is used as the structural material of the fuel sub-assemblies in the sodium cooled fast breeder reactors. This steel is regarded as a candidate material for blanket structures of the fusion reactors. However it is required that materials should have a high resistance against swelling and low radioactivation under the high-energy neutron irradiation environment such as in fusion reactors. Ferritic 9Cr1WVTa steel is also being considered as an alternate candidate structural material to type 316 stainless steel [3]. An amount of He formation and radioactivity under neutron irradiation of both steels will be evaluated as an example of application of the present simulation system.

Using the database, the possibility of large amount of He formation and radioactivity in the candidate materials can be easily evaluated qualitatively. The possibility of He formation is known by retrieving cross section size of (n, alpha;) reaction on compositional atoms of materials. The radioactivity is known by retrieving half-life of transmuted products of compositional atoms of material. Transmuted products with half-life of more than one year in type 316 and ferritic steel can be easily know qualitatively. These result suggest that type 316 stainless steel has more radioactive nuclides and is radioactivated more easily than ferritic 9Cr-1WVTa steel under neutron irradiation. It is found that this system will be frequently used by nuclear material scientists as a material information tool, if this system is jointed to networking system such as "Data-Free-Way"[3-5].

5. Summary

1) A database on transmutation for nuclear materials with user friendly interface was constructed in WWW server on the Internet. (http://inaba.nrim.go.jp//Irra/).
2) The database consists of mainly five tables stored the information of isotope, two decay tables of gamma-ray and beta-ray, transmutation and cross section for 42 neutron energy group converted from FENDL-II.
3) The compositional change and radioactivity in materials can be easily evaluated qualitatively.
4) The radioactivity is known by retrieving half-life of transmuted products of compositional atoms of material. Transmuted products with half-life of longer than one year in type 316 and ferritic steel. These result suggest that type 316 stainless steel has more radioactive nuclides and radioactivated more easily than ferritic 9Cr-1WVTa steel for reduced activation under neutron irradiation .

References

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