Development of materials database and evaluation system is needed to establish risk-base engineering and technology for risk-acceptable and safe society. This paper shows the outline of “Materials risk information platform” under development as a system which indicates most suitable solution and information for selection and application of materials.

Keywords: Materials reliability, Risk, Life prediction, Materials risk information platform, Materials database

I. INTRODUCTION

20th century was a age when the quality of our life improved with development of technology. However, on the other hand, the environmental problem in a global scale has happened due to the increase of the waste accompanying mass production and mass consumption. It was also the time when the huge accidents by structures and machines which were built based on science and technology also occurred. The development of science and technology brought about improvement in the quality of a life but brought about a risk. For sustainable development, uncertainty must follow with a social advance and it must be ready for a risk. That is, 21st century will be risk society. Risk society is society in which man lives together with risk due to development of industry. The risk must be distributed fairly in society. Engineering and technology should contribute to this risk society. The development of engineering and technology for safety is needed about structures and materials, fully understanding a risk. However, risk and benefit have the relation of a trade-off. From the balance of benefit and risk, more than one solution exist and the selection of most suitable solution is needed for construction of the well-balanced society. Information and knowledge must be presented so that technical users may select the solution and know the situation of the risk.

In our country, there are many aging structures and plants which were built at the high-economic-growth era of 30 years ago. It is needed to predict the residual life and develop the maintenance technology for securing safety. On the other hand, for new structures and plants, high efficiency is required for saving energy resources. In this case of high efficiency, the service condition of the materials used in a structure becomes severe, and the development of new materials which are resistible to severe condition is needed. However, because the material property comes near the limit, unexpected behavior might appear during the service of these materials. The uncertainty of property prediction must be also clarified with improvement in the accuracy of property prediction.

Thus, when selecting the materials used in structures or plants, the system and database are needed from which the information on advantages and problems when using materials can be received and from which suitable solution can be obtained. Development of “a Material risk information platform” is proposed as this solution. This report shows the necessity for the development, the outline and the direction of development of this Materials risk information platform.
II. NEEDS OF RISK-BASE ENGINEERING AND TECHNOLOGY

In order to make a safe product and to use it safely, the rule for producing safely, for using safely and for maintaining safely must be prepared. For a product design, safety factor is decided based on experiences, and the product has been designed according to this rule and standard (Design by Rule). However, in order to decrease the overestimated safety factor, new design concept has been introduced (Design by Analysis). And from now, the design based on a risk will be established based on long-service actual experiences and trouble case database (Design by Risk Base).³

On the other hand, in order to use the structures and plants safely, development of maintenance management and equipment diagnostic technology is important. And the maintenance technology of equipments will shift also to risk base maintenance which selects the diagnostic procedure corresponding to the failure probability and damage mechanism.

Based on accumulation of actual experiences or failure cases, accumulation of knowledge of materials, product design and manufacturing, improvement of analysis technology and development of equipment diagnostic technology, the risk base design and risk base maintenance technologies are being tried based on risk assessment due to failure probability and accident effect. Thus, in engineering technical field, the trouble cases accumulated so far will be utilized positively for safe design or service. The development of safety analysis technology is expected to be useful for contributing to the risk society.

III. RISK ASSESSMENT

A risk is expressed as a combination of failure probability and accident effect (value of damage). Risk assessment is performed according to the general flow of Fig. 1. At first, the object to evaluate is selected and the failure and damage modes which are appeared in the system and parts of the selected plant are estimated. Then, failure probability is calculated corresponding to the damage mode estimated to happen in each components, and the value of damage by failure is evaluated. Based on these evaluation results, a risk matrix (relation between failure probability and value of damage) is created, and it judges whether it is the level which the evaluated risk can permit. If nonpermissible, a risk reduction measure is given and it reevaluates again. However, the risk cannot be lost at the end (residual risk).

IV. SUBJECTS OF MATERIALS RESEARCH IN RISK-BASE ENGINEERING AND TECHNOLOGY

The subjects of materials research which should be carried out were investigated in the flow of risk assessment as shown in Fig. 1. According to the procedure of the risk assessment shown in this figure, the following subjects of materials research are needed:

1. Selection of important components and systems, and estimation of failure and damage
   - database of the structural materials used for each component of plant
   - service cases (accident cases) database for estimating damage mechanism, knowledge of materials strength and fracture, metallic microstructural change / damage mode database

2. Evaluation of failure probability
   - material property database which includes data-scattering information for life prediction and
strength evaluation, life prediction method, and various material constants for carrying out the simulation of component behavior
- knowledge and database about equipment diagnostic technology
- simulation technology including load or environmental factor change
- allowable stress database of structural materials
(3) Evaluation of value of damage by failure
- knowledge for prediction of failure mode
- accident cases database
(4) Judgment of risk evaluation by using the risk matrix
- material property database for alternative materials
- knowledge and database of equipment diagnostic technology
- knowledge of life prediction method
(5) Display of residual risk
- evaluation of the uncertainty of analysis
- information about insufficiency of materials knowledge or database

The subjects requested from materials research for risk base engineering and technology is summarized as follows;
(1) knowledge and database about materials for estimating damage mechanism and failure mode
(2) knowledge and database for highly accurate life prediction
(3) development of calculation technology for carrying out the simulation of failure
(4) knowledge and database for the advancement of equipment diagnostic technology

V. DEVELOPMENT OF MATERIALS RISK INFORMATION PLATFORM

It is required for the technical user to be able to know the situation of risk and to select the technology, if the construction of the society which is safe but accepting risk is aimed. Then, the development of material information and knowledge base is needed, in order to select the materials corresponding to an acceptable risk value from the position of materials research. The research project "Development of Materials risk information platform" was started at National Institute for Materials Science from 2001 fiscal year. In this project, the materials for boiler of electric-power-generation plant are set as the target of research, because of the scale of a budget and the accumulation of information and knowledge for evaluation of materials and risk. The research period is five years, and since the research subjects include the broad field from the basis to application, this project is carried out under the cooperation of research organization, companies and academic societies with our institute.

The main structure and contents of this project are shown in Fig.2. The researches in the field relevant to materials and the researches in the field relevant to design and service of a plant are conducted. And the results of these researches are linked to the Materials risk information platform as a main system, and this project aims at construction of the synthetic material database and evaluation system for the materials selection and materials use based on risk assessment.

As research subjects relevant to materials, the following research and development are carried out; the construction of the service cases (accident cases) database which accumulates failure and damage examples of components or materials, the creation and collection of metallic microstructural change and damage photographs which are produced using the test specimens obtained in the laboratory, the evaluation of effecting factors on strength and life of components in a plant scale, and the development of accurate method of long-term creep life prediction.

As subjects relevant to design and service, the following researches are carried out; the examination about a rational safety factor for calculating design allowable stress, the comparison of various methods for strength evaluation and life prediction, the construction of a allowable stress database based on the knowledge and information obtained, the development of the equipment diagnostic system which takes in the risk, and the materials strength database under ultimate conditions that takes in the influence factors of machining process to the strength and life, such as surface condition.

Furthermore, since it is important to clarify the relation of technology and society concerning risk, the relations between materials or technology and society are investigated. Here, not only a electric-power-generation plant but other technical fields are took as the target of this investigation. And all of the results are put into the main system of the Materials risk information platform. The
platform will show the data and information for the selection of the optimal materials corresponding to risk target value (acceptable value).

VI. SYSTEM AND DATABASE FOR DECISION-MAKING

When making products, such as structures and plants, not all of technical subjects are clear and the uncertainty remains. For this reason, sufficient safety margin must be taken. However, this margin may be overestimated sometimes. Moreover, the improvement of performance, cost, safety and environmental load does not always have the same direction, and these factors have the relation of a trade-off.

Thus, in product design or manufacture, an engineer has to select the most suitable solution optimal based on information and knowledge. If risk can be indicated quantitatively for a certain solution selected, it is useful to take the measures under rational judgment.

For the product design concerning global environment and safety, a suitable solution must be looked for in consideration of many factors in a complicated system, and the development of guide and the construction of database for supporting the selection of optimal solution are desired. This research showed the outline of development of a Materials risk information platform for the boiler materials as the 1st step. The following researches in materials must be steadily continued in order to build such system and database for safety;

1. to understand the basic mechanism of materials properties and materials behaviors,
2. to produce, collect and arrange the data and the knowledge of materials,
3. to accumulate the actual accident information and damage information, and
4. to establish the method of materials development under the consideration of risk and total life.

From these total understandings, the materials application for safe and sustainable society should be decided. Risk-thinking and total-life-thinking are a key point of materials selection and development for 21st century.

VII. CONCLUSION

The structure and contents of development of a Materials risk information platform developed were introduced. In this project, the development of various kinds of databases and evaluation analysis methods and technology is aimed. Furthermore, the research from the viewpoint of social science is also done with the researches from the viewpoint of engineering and technology about risk. And the state of information offer in risk society and the contents of the information which should be offered will be considered through such various activities.

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