Development of Design & Safety Analysis Supporting System for Casks

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INTRODUCTION

Casks are containers for transporting and storing radioactive materials such as spent fuel, and they contain a great quantity of radioactive materials. So, they are subject to strict technical standards stipulated in laws and regulations. For this reason, when designing casks, various safety analyses are carried out to verify their safety. Each safety analysis is closely related with the others with an individual result of analysis being fed back as a given condition for another analysis. This results in a huge amount of analysis and design work. In order to cope with this situation, Mitsubishi Heavy Industries has developed a design and safety analysis supporting system 'CADDIE'(Cask Computer Aided Design, Drawing and Integrated Evaluation System), with the following objectives:

(1) Enhancement of efficiency of the design and safety analysis
(2) Further advancement of design quality
(3) Response to the diversification of design requirements

The system is presented below.

FEATURES OF THE SYSTEM

The features of this system are as follows:

(1) The analysis model data common to analyses is established, and it is prepared automatically from the model made by CAD.
(2) The input data for the analysis code is available by simple operation of conversation type from the analysis model data.
(3) The analysis results are drawn out in diagrams by output generator, so as to facilitate easy observation.
(4) The data of material properties, fuel asssembly data, etc. required for the analyses are made available as a data base.

SYSTEM CONFIGURATION

This system is a CAE(Computer Aided Engineering) system that integrates most of safety analysis codes, CAD system, and data base required for the safety analysis of casks. It is able to make a one-through-operation feasible from the planning of basic figure of the cask throughout the evaluation of analyses and results.

Fig. 1 shows the configuration of this system. Based on the IMAGE system(Interactive Modeling Aids for Graphics in Engineering) which has been developed by MHI as CAD/CAM/CAE system, this system is composed of an input and output generator to be used especially for shielding and criticality analyses, a data base required for the analysis, analysis codes, etc. Features of each element are described as follows:

(1) Modeler exclusive for casks(CASK-SURFACE)
This modeler is a modification of the module for creating an analysis model in the IMAGE system. It creates shape models and analysis models for casks by using graphic display. Fig. 2 shows an example of an analysis model created by this modeler.

(2) Design drawing compiling tool(IMAGE-DRAW)
This tool(IMAGE-DRAW) is the drawing preparing module in the IMAGE system. This tool enables design drawings to be prepared by adding detail shapes and dimension lines to analysis models.

(3) Design information data base
Data of the fuel assembly and material properties to be used for the safety analyses are summarized into the data base. The fuel assembly data base contains several items of information regarding the construction and material of fuel assemblies.
The material property data base contains the material properties such as density, specific heat, thermal conductivity, the ratio of elements in materials and the isotope composition of elements.

(4) Input generator(IG)
The input generator reads analysis model data created by the modeler exclusively for casks, creating input data for analysis codes associated with conversation type operation.
·Input generator for structural and thermal analysis
The IMAGE-FEM-IG, which is an input data creating module for the FEM analysis codes, is used to perform structural and thermal analysis. In addition, to address the thermal analysis codes TRUMP used in the system, an interface program converting FEM mesh data into node network models has been prepared. Fig. 3 shows an executing example of the IMAGE-FEM-IG.
·Input generator for shielding and criticality analysis
For shielding and criticality analysis, exclusive IGs(ANISN-IG, DOT-IG, and KENO-IG) have been developed. With the ANISN-IG and DOT-IG, it is possible to divide meshes and homogenize materials in the domain by conversation type operation. The KENO-IG allows input data to be created by recognizing three-dimensional shapes on the basis of a few two-dimensional models. In both cases, data required for analysis are read from the design information data base. Fig. 4 shows an executing example of the ANISN-IG.

(5) Analysis codes
The following codes are integrated in the system:

·Structural: MARC, ABAQUS, DYNA-2D
·Thermal: TRUMP, ABAQUS
·Shielding: ANISN, DOT-3.5
·Criticality: KENO(SCALE)
·Radiation source: ORIGEN-2

(6) Output generator(OG)
The output generator functions to trace the calculation result obtained by the analysis on the graphic display or the line printer for easy understanding. There are two types of output generators: the IMAGE-FEM-OG that graphically displays the output result in the FEM form and others exclusive for ANISN and DOT-3.5(ANISN-OG and DOT-OG). Furthermore, an interface program has been prepared to allow the output result from the analysis codes TRUMP and DOT-3.5 that are not in the FEM form to be processed by the IMAGE-FEM-OG. Fig. 5 shows an executing example of the IMAGE-FEM-OG.

Executing Examples of the System

Using the case of shielding analysis work as an example, system execution methods are presented below. The work procedure is as follows:

(1) Creating an analysis model by using the modeler exclusive for casks: Fig. 6
(2) Assigning materials data: Fig. 7
(3) Dividing meshes by DOT-IG: Fig. 8
DOT-IG automatically creates DOT-3.5 input data. When plural materials exist in the same domain to be analyzed, automatic homogenization by volume ratio is carried out.
(4) Executing analysis: Execution by batch job
(5) Outputting the result: Fig. 9

Effects Obtained by Introducing the System

The following effects have been obtained by introducing the system:

(1) Enhancement of efficiency of the design and safety analysis is obtained by developing various analysis supporting tools.
(2) The system enables more diversified and comprehensive investigation of casks contributing to the enhancement of design quality.
(3) It is possible to answer diversified requirements of contents quickly and attentively, and the system makes it possible to provide optimum designs and products based on highly reliable results of analysis.

SUMMARY

This system has come to be applied as of 1989 for the cask design and analysis affecting substantially onto the safety analyses and design improvement of the cask.

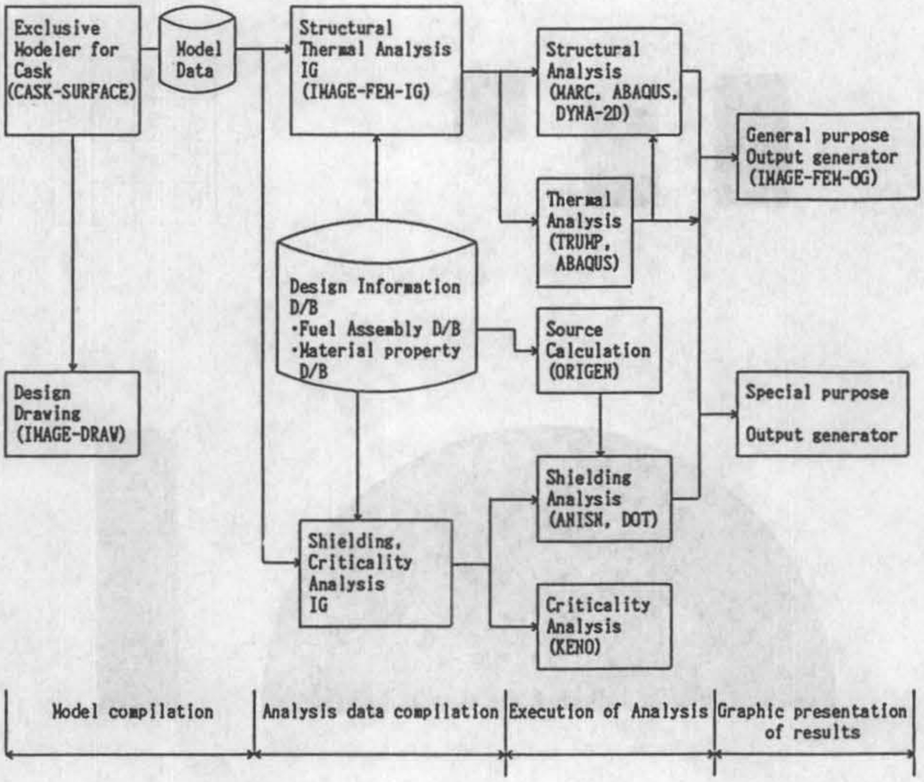

Fig. 1 System Configuration

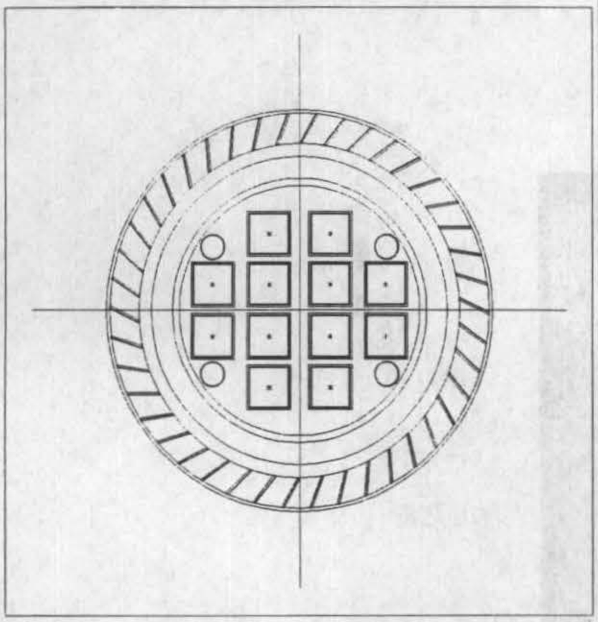

Fig. 2 An Example of Analysis Model

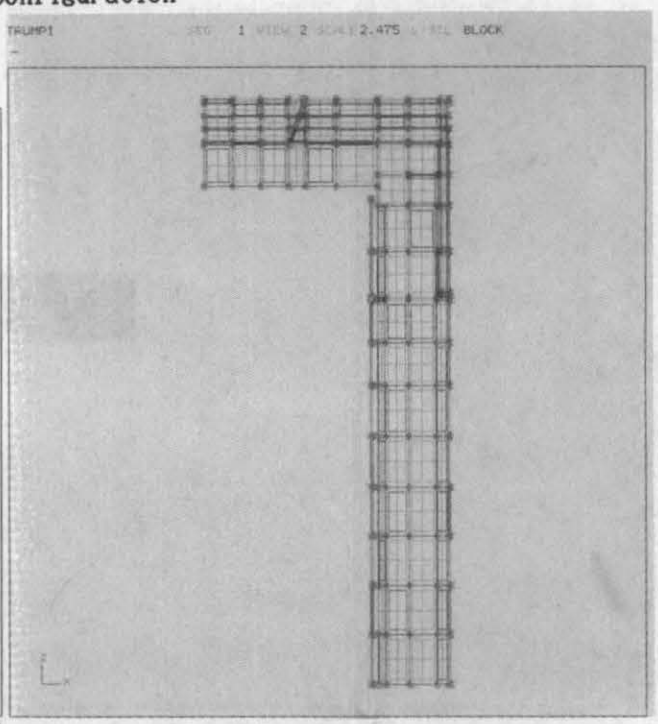

Fig. 3 An Executing Example of IMAGE-FEM-IG

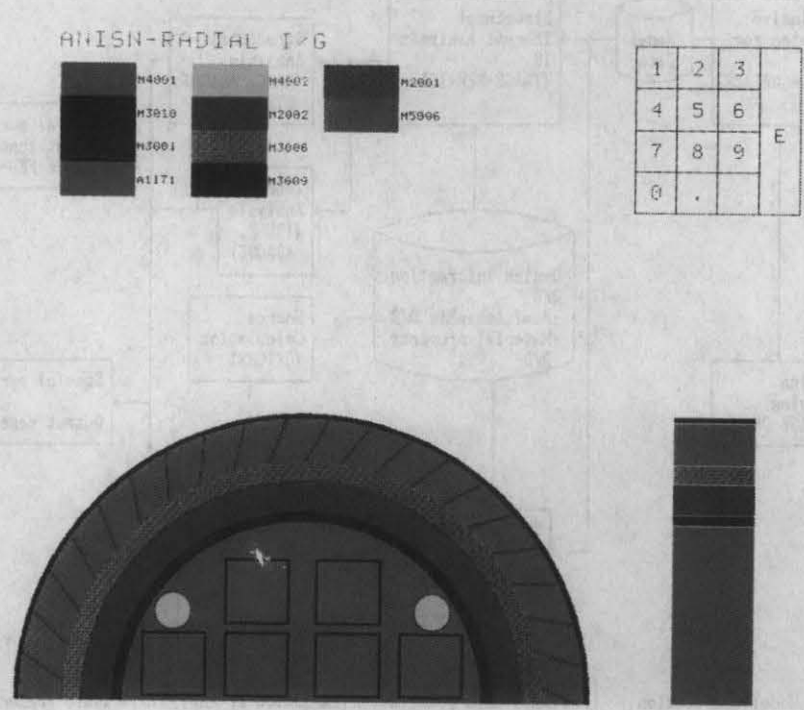

Fig. 4 An Executing Example of ANISN-IG

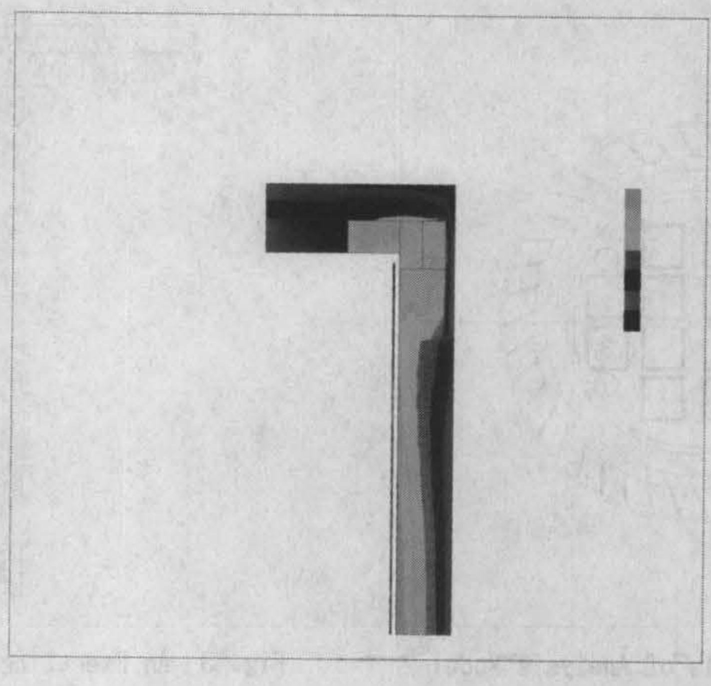

Fig. 5 An Executing Example of IMAGE-FEM-OG

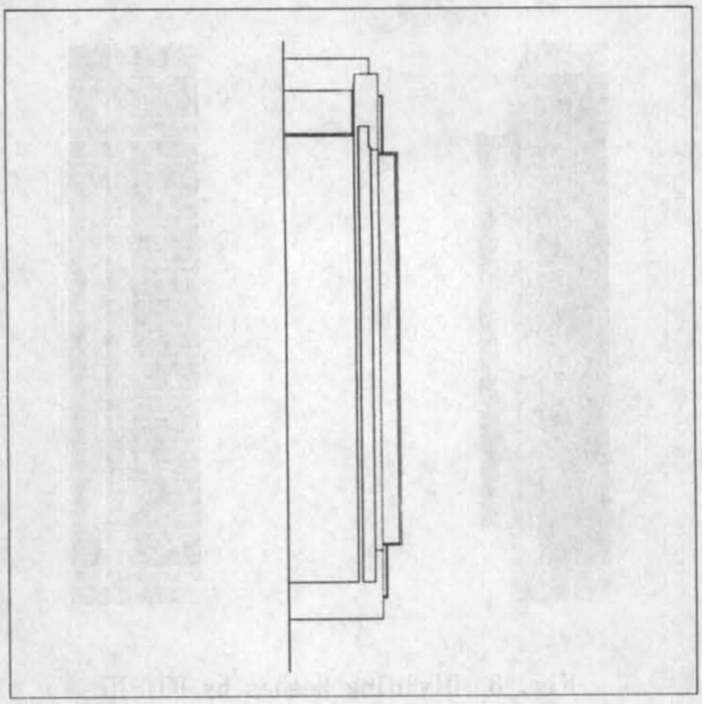

Fig. 6 Preparation of Analysis Model

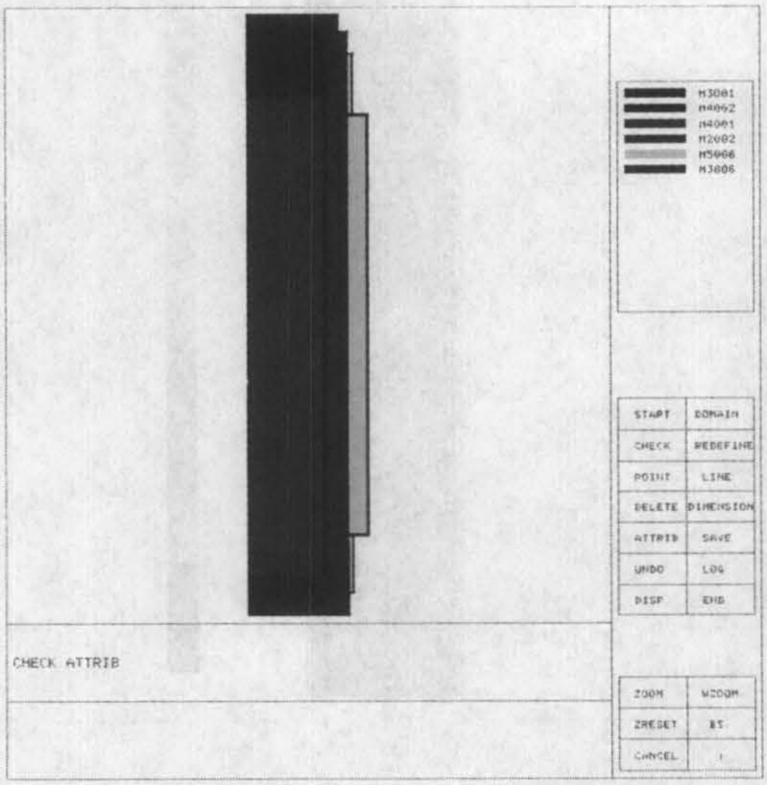

Fig. 7 Assigning Materials Data

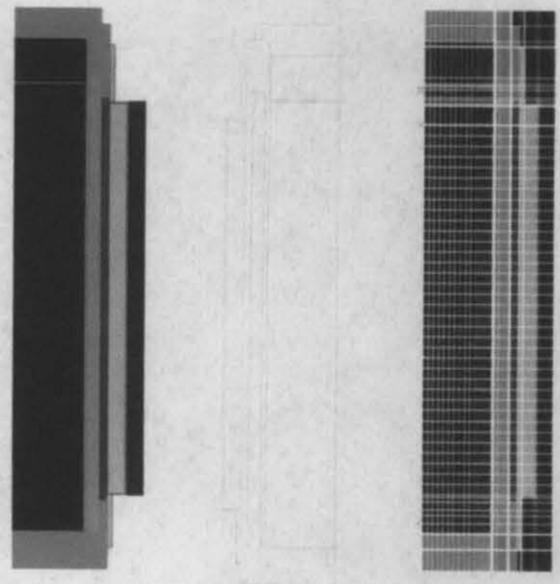

Fig. 8 Dividing Meshes by DOT-IG

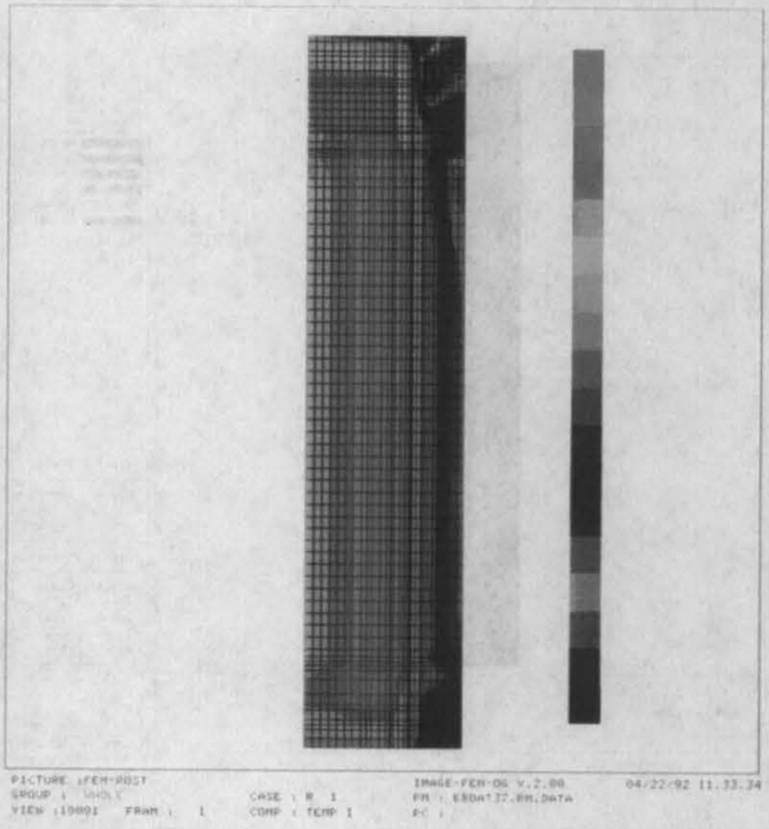

Fig. 9 Output Result