PIPING AND ANALYSIS OF NITROGEN COOLING SYSTEM OF PFBR

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ABSTRACT

This paper focuses on the piping design of the nitrogen cooling system of the cold trap in PFBR. The stresses acting on the pipe were discussed and the displacement on the pipe during the nitrogen flow is also considered. The design as well as analysis is carried out in the system software called CAESAR II.

Key words: PFBR-Prototype fast breeder reactor, CAESAR II, Nitrogen cooling.

INTRODUCTION

This work is carried-out in the nitrogen piping of the cold trap in the Prototype Fast Breeder Reactor (PFBR). The PFBR is the sodium cooled pool type fast breeder reactor that can generate power of 500Mwe, which is located at BHAVINI, Kalpakkam. It is the Stage II fast breeder reactor envisaged as part of the country's three stage nuclear power programme.

PFBR

PFBR is a 500 MWe, sodium cooled, pool type, mixed oxide (MOX) fuelled reactor with two secondary loops. MOX fuel is selected on account of its proven capability of safe operation to high burn up, ease of fabrication and proven reprocessing. Pool type concept is adopted due to its inherently high thermal inertia of the large mass of sodium in the pool which eases the removal of decay heat, use of a simple vessel with no penetrations leading to high structural integrity of the vessel and no radiation damage. Two loop design has been adopted which is economical and also meets the safety requirements.

A. Operation

During the operation of the PFBR, heat from the core region is transferred to the

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primary sodium inside the reactor core. Then the primary sodium gives its heat to the secondary sodium through the Intermediate Heat Exchanger (IHX). The secondary sodium passes through the steam generator and transfers its heat to the water.

B. Cold trap

The cold trap (CT) is used to maintain the concentration of impurities in sodium below the stipulated value so as to reduce the corrosion of structural material and the risk of plugging in narrow flow passage in the cold region. Pressurised nitrogen at 700KPa (g) in the closed circuit is used to cool sodium in CT/s. Nitrogen in-turn rejects heat to the service water in the N_2/water heat exchangers. Two nos CTs (1 working + 1 standby) are connected in parallel. Normally one cold trap is operated. However provisions are made such that both the CTs are operated in parallel.

Design of piping

The design of the piping circuit used in the cold trap is designed using the system software CAESAR II. This software is an engineering tool used in the mechanical design and analysis of piping systems. Use CAESAR II to create a model of the piping system represented by simple 3D beam elements and to define the loading conditions imposed on the system. With this input, CAESAR II produces results in the form of displacements, loads, and stresses throughout the system. Additionally, CAESAR II compares these results to limits specified by recognized codes and standards.

A. Piping input generation

Once the desired job name has been specified, the user can invoke the interactive model builder by selecting the Input-Piping entry of the Main Menu. The input generation of the model consists of describing the piping elements, as well as any external influences (boundary conditions or loads) acting on those elements. Each pipe element is identified by two node numbers, and requires the specification of geometric, cross sectional, and material data.

Each pipe element is described on its own spreadsheet. Data which are likely to be carried forward are automatically duplicated by the program to subsequent spreadsheets. This means that for many elements, the user must only confirm the numbers and enter the delta dimensions. When necessary, point specific data can easily be entered on the appropriate element,,s spreadsheet. The menus, toolbars, and accelerators offer a number of additional commands that the user can invoke to enter auxiliary processors or use special modelers or databases.

B. Input graphics screen

CAESAR II makes it easy to input and display all the data needed to accurately define a piping system analysis model. Input can be accessed or modified on an element-by-element basis, or datasets can be selected to make global changes. The inputted data can be viewed on the graphics screen. It shows the developed pipe layout and the user has the option of viewing the node numbers, length of elements, insulation thickness, thermal data, restraints etc. Necessary changes may be made to the design by viewing and conforming through the input graphics screen.

Error checking of the model

The CAESAR II program includes an integrated error checker. This error checker analyzes the user input and checks for consistency from both a "finite element" and "piping" point of view. Reports are clear, accurate concise and fully user definable. The Piping Error Checker is started automatically by the input module. There are two main functions of this error checker; first to verify the user's input data, and second to build the execution data files utilized by the remainder of the CAESAR II program. The verification of the user's input data consists of checking each individual piping element for consistency. Errors discovered which would prevent CAESAR II from running (such as a corrosion allowance greater than the wall thickness) are flagged as fatal errors to the user.
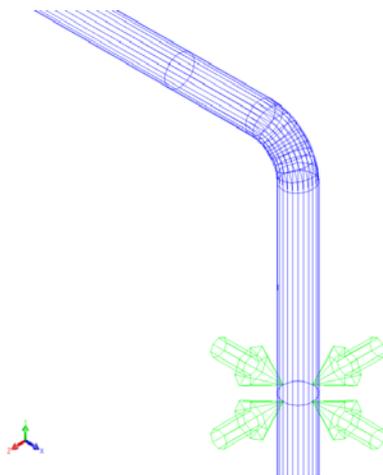
Fig. 1: Input graphical screen

Unusual items (such as a change of direction without a bend or intersection) are flagged as warnings to the user. Other messages, of an informational type, may show intermediate calculations or general notes. If the error check process completes without fatal

errors, a center of gravity report is presented and the analysis data files can be generated and the solution phase can commence. Upon successful completion of the error checking routines, the user is, by default, returned to the main CAESAR II menu. If fatal errors do exist, the analysis data files are not generated and the solution phase cannot be started. The user is then, by default, returned to the piping input module for corrections

Load case builders

CAESAR II begins with a standard set of load cases based upon the piping code selected and the loads defined in input. A static analysis can be started from the Main Menu once the analysis data files have been generated by the error checker. The first stage of a static analysis is the setup of the load cases.

Output graphical screen

The user can also use the View-Plot menu command or the Plot toolbar to review the analytic results in graphics mode, which can produce displaced shapes, stress distributions, and restraint actions.This screen is similar to input screen with additional options for display of results like deflections, forces, moments, stresses and their distribution in both pictorial and animated forms.
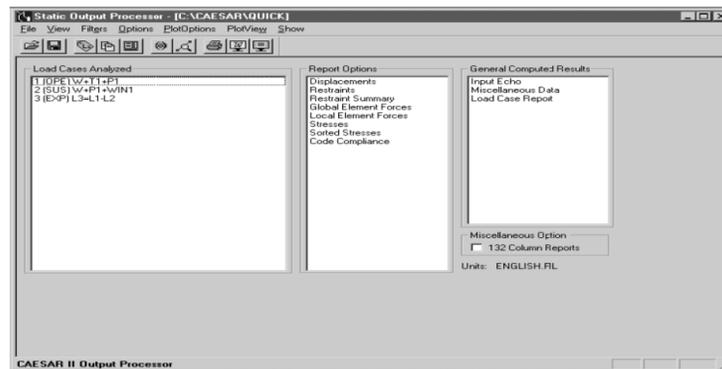
Fig. 2: Static output processor

Once all the input parameters are provided, the CAESAR II analyses the input data with the standards and the output will be displayed.

RESULTS AND DISCUSSION

The operation load displacement and the sustained displacement are displayed graphically as well as the table for displacement on each node will also be available.
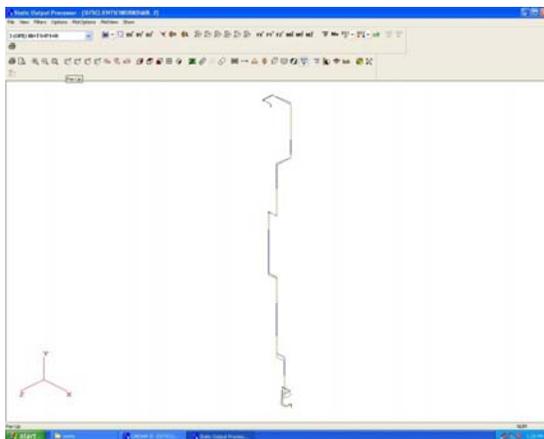
Fig. 3: Displacement chart

Stress summary report

(1) Operation loads: The stresses acting on the pipe during operating condition i.e. when the working fluid is flowing in the pipe

Table 1: Operation load

Type of stress	Node	σ (Kpa)
Bending stress	58	150067.0
Torsional stress	59	33777.8
Axial stress	164	1227.9
Hoop stress	8	670.8

(2) Sustained loads: The stresses acting on the pipe during sustained condition i.e. when the working fluid is not flowing in the pipe

Table 2: **Sustained load**

Type of stress	Node	σ(Kpa)
Bending stress	205	47668.4
Torsional stress	60	8563.5
Axial stress	120	1632.6
Hoop stress	8	670.8

CONCLUSION

The Requirement of the nitrogen pipe of PFBR (prototype fast breeder reactor), BHAVINI is studied and analysis to the reference given by the BHAVINI as per ASME Standard Piping Design Standard Using CEASAR II software.

The Detailed analysis was done with Hanger load, resistance, valves, supports and it is found that the pipe design is satisfies the ASME upper limits standards

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