

MASTER

A STUDY OF STRUCTURAL ATTACHMENTS OF A POOL TYPE
LMBR VESSEL THROUGH SEISMIC ANALYSIS OF A
SIMPLIFIED THREE DIMENSIONAL FINITE ELEMENT MODEL

by

H. Ahmed and D. Ma

Prepared for

5th SMIRT Conference

Berlin, Germany

August 13-17, 1979



U of C - AUA - USDOE

ARGONNE NATIONAL LABORATORY, ARGONNE, ILLINOIS

Operated under Contract W-31-109-Eng-38 for the

U. S. DEPARTMENT OF ENERGY

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

The facilities of Argonne National Laboratory are owned by the United States Government. Under the terms of a contract (W-31-109 Eng-38) made with the U. S. Department of Energy, Argonne University Association and The University of Chicago are authorized to employ, maintain and operate the Laboratory in accordance with policies and programs formulated and approved by the University of Chicago Association.

MEMBERS OF ARGONNE UNIVERSITY'S ASSOCIATION

The University of Arizona	The University of Kentucky	The Ohio State University
Carnegie Mellon University	Kansas State University	Oregon University
Case Western Reserve University	Lehigh University of Corvallis	The Pennsylvania State University
The University of Chicago	Marquette University	Purdue University
University of Cincinnati	The University of Michigan	Saint Louis University
Illinois Institute of Technology	Michigan State University	Southern Illinois University
University of Illinois	University of Minnesota	The University of Texas at Austin
Indiana University	University of Missouri	Washington University
The University of Iowa	Northwestern University	Wayne State University
Iowa State University	University of North Texas	The University of Wisconsin-Madison

NOTICE

This report was prepared for an account of work sponsored by an agency of the United States Government. Neither the United States nor any agency thereof, nor any of their employees, make any warranty, expressed or implied, or assumes any legal liability or responsibility for any third party's use of the results of or reliance of any information, apparatus, product or process disclosed in the report, or represents that its use by such third party would not infringe privately owned rights. Mention of commercial products, their manufacturers, or their suppliers in this publication does not imply or connote approval or disapproval of the product by Argonne National Laboratory or the United States Government.

MASTER

A STUDY OF STRUCTURAL ATTACHMENTS OF A POOL TYPE LMFBR VESSEL THROUGH SEISMIC ANALYSIS OF A SIMPLIFIED THREE DIMENSIONAL FINITE ELEMENT MODEL

BY

H. AHMED, D. MA

ARGONNE NATIONAL LABORATORY

ARGONNE, ILLINOIS

ABSTRACT

A SIMPLIFIED THREE DIMENSIONAL FINITE ELEMENT MODEL OF A POOL TYPE LMFBR IN CONJUNCTION WITH THE COMPUTER PROGRAM ANSYS IS DEVELOPED AND SCOPING RESULTS OF SEISMIC ANALYSIS ARE PRODUCED. THROUGH THIS STUDY VARIOUS STRUCTURAL ATTACHMENTS OF A POOL TYPE LMFBR LIKE THE REACTOR VESSEL SKIRT SUPPORT, THE PUMP SUPPORT AND REACTOR SHELL-SUPPORT STRUCTURE INTERFACES ARE STUDIED. THIS STUDY ALSO PROVIDES SOME USEFUL RESULTS ON EQUIVALENT VISCOUS DAMPING APPROACH AND SOME IMPROVEMENTS TO THE TREATMENT OF EQUIVALENT VISCOUS DAMPING ARE RECOMMENDED. THIS STUDY ALSO SETS FORTH PERTINENT GUIDELINES FOR DETAILED THREE DIMENSIONAL FINITE ELEMENT SEISMIC ANALYSIS OF POOL TYPE LMFBR (TO BE PUBLISHED IN A SEPARATE PAPER).

Three-dimensional finite element analysis of the structure of the bridge deck and the above-mentioned procedures for attaining damped modal properties. After the initial analysis, it was decided that such an analysis can only be accomplished by using a computer which has a disk of sufficient size to store all the data generated by the analysis. The analysis of fluid-structure interaction calculations is a very complex task and requires a large amount of computer resources. This study also concluded that a suitable model for the analysis of computer program such as the ABAQUS program is required. The analysis of such a problem such as the one described above can be handled with a model that can handle the problem of one and a half degrees of freedom. ABAQUS is a computer program that is designed to handle a problem of free vibration of a structure which is subject to a displacement of 10^{-3} m. The program is

1. the 10^{-3} m displacement of the structure is 10^{-3} m. The analysis of such a problem with the ABAQUS program is a very complex task and requires a large amount of computer resources. A simplified three-dimensional finite element model is used to handle the problem of this proposed equivalent viscous damping approach. The approach is based on the critical structural attachments in a post-type LMFBR which are shown in an application of the proposed approach to a post-type LMFBR.

This equivalent viscous damping approach was developed by the author in cooperation with Ref. (2) and (3).

II. Equivalent Viscous Damping Approach

The procedures used to determine the equivalent viscous damping for the structural analysis are consistent with the criteria established by the Nuclear Regulatory Commission's Standard Review Plan (SRP) Section 4.7. The equivalent damping values for structural components will be selected from Regulatory Guide 1.61, "Damping Values for Seismic Design of Reactor Buildings." The equivalent damping values for different components within each substructure of a post-type LMFBR. Composite modal damping values will be determined based on an energy proportional damping method.

A procedure using the ABAQUS computer program to obtain the response spectrum analysis of a substructured system which includes composite modal damping is outlined in

0

this page. The following information is for the user of the program. The user should read this information carefully before using the program. The program is designed to calculate the total energy and kinetic energy of a system of particles. The user should enter the number of particles, the mass of each particle, and the initial position and velocity of each particle. The program will then calculate the total energy and kinetic energy of the system.

The program is designed to calculate the total energy and kinetic energy of a system of particles. The user should enter the number of particles, the mass of each particle, and the initial position and velocity of each particle. The program will then calculate the total energy and kinetic energy of the system. There are two input files. The first input file is the input file for the program. The second input file is the input file for the program. The program will then calculate the total energy and kinetic energy of the system.

The program is designed to calculate the total energy and kinetic energy of a system of particles. The user should enter the number of particles, the mass of each particle, and the initial position and velocity of each particle. The program will then calculate the total energy and kinetic energy of the system. The detailed procedure for the program is as follows:

A. Input file

1. One recipe is required for the input file.
2. The user should enter and print the total energy and kinetic energy of each mode for all elements having the same material number. Although the same material will be used for more than one substructure, a different material number will be assigned for

The final response is obtained by modal superposition using PCST 7. A linear factor is applied to each modal response to account for its correct equivalent Viscous damping. The detailed procedure is shown as follows:

A. Assumptions

1. One response spectrum is used for ANSYS frequency analysis.
2. ANSYS calculates and prints the total strain energy and kinetic energy for each mode for all elements having the same material number. Although the same material will be used by more than one substructure, a different material number will be assigned for that material in each substructure to allow the software to compute the kinetic energy and the strain energy for each substructure.

B. Calculation of Equivalent Viscous Damping Factors

1. Equivalent viscous damping factors are calculated for each substructure using the strain energy proportion in eq. (11.1) for each mode considered in the analysis.

$$D_{ERR} = \frac{\sum_{k=1}^{nm} \sum_{i=1}^{ne} E_{ijR} d_j}{\sum_{j=1}^{nm} \sum_{i=1}^{ne} E_{ijR}} \quad (11.1)$$

where

D_{ERR} = equivalent viscous damping factor for R^{th} mode for the K^{th} substructure;

E_{ijR} = strain energy ($\frac{1}{2} U^T K U$) for i^{th} element of finite element mesh and j^{th} material of the K^{th} substructure;

d_j = fraction of critical damping for j^{th} material of the K^{th} substructure;

ne = number of elements;

nm = number of materials;

ξ = modal vector obtained from frequency analysis of the entire system.

ANSYS computes and prints D_{ERR} for each substructure for every mode. Note that $D_{ERR} = d_j$ for substructures consisting of one material.



and ω_{DR} is the resonance frequency of the drive, $\omega_{\text{DR}} = 2\pi f_{\text{DR}}$, f_{DR} is the frequency of the DR oscillations.

$$D_{\text{DR}} = \frac{1}{2} \sum_{i=1}^{N_{\text{DR}}} \frac{b_{\text{DR}}^2 \sin^2 \alpha_{\text{DR}}}{\omega_{\text{DR}}^2 - \omega_i^2 + j\omega_i \gamma_i} \quad (11)$$

$$D_{\text{R}}^i = \frac{1}{2} \sum_{j=1}^{N_{\text{R}}} \frac{b_{\text{R}}^2 \sin^2 \alpha_{\text{R}}}{\omega_{\text{R}}^2 - \omega_j^2 + j\omega_j \gamma_j} + \frac{1}{2} \sum_{j=1}^{N_{\text{DR}}} \frac{b_{\text{DR}}^2 \sin^2 \alpha_{\text{DR}}}{\omega_{\text{DR}}^2 - \omega_j^2 + j\omega_j \gamma_j} \quad (12)$$

where

$$b_{\text{DR}} = \frac{1}{2} \sqrt{\frac{2\pi}{\omega_{\text{DR}}}} \sqrt{\frac{1}{2} \sum_{i=1}^{N_{\text{DR}}} \frac{1}{\omega_{\text{DR}}^2 - \omega_i^2 + j\omega_i \gamma_i}} \quad (13)$$

$$D_{\text{DR}}^i = \frac{1}{2} \sum_{j=1}^{N_{\text{DR}}} \frac{b_{\text{DR}}^2 \sin^2 \alpha_{\text{DR}}}{\omega_{\text{DR}}^2 - \omega_j^2 + j\omega_j \gamma_j} \quad (14)$$

$$\alpha_{\text{DR}} = \arctan \frac{\omega_{\text{DR}}}{\omega_{\text{DR}}^2 - \omega_i^2 + j\omega_i \gamma_i} \quad (15)$$

$$F_{\text{DR}} = \frac{1}{2} \sum_{i=1}^{N_{\text{DR}}} \frac{b_{\text{DR}}^2 \sin^2 \alpha_{\text{DR}}}{\omega_{\text{DR}}^2 - \omega_i^2 + j\omega_i \gamma_i} \quad (16)$$

D_{R}^i is the spectral value corresponding to the R^{th} mode in the i th mode calculated by Eqs. (11)–(14);

α_{DR} is the phase of the drive.

G. Total Response Calculation

The total response is calculated in the method described in [10] as follows:

1) Calculate the spectral values for the R^{th} mode and the DR mode, D_{R}^i and D_{DR} . The linear factors are calculated which are used to calculate the spectral values corresponding in a given mode.

$$F_{\text{R}} = \frac{U_{\text{DR}}}{U_{\text{OR}}} \quad (17)$$

where

F_{R} is the linear multiplier for R^{th} mode;

U_{DR} is the spectral value corresponding to frequency of R^{th} mode and damping DR (or D_{R}^i);

U_{OR} is the spectral value corresponding to frequency of R^{th} mode and damping OR .

10. $\mathbf{D}_{OR}$ is symmetric and positive definite. $\mathbf{D}_{OR}$ is a $2N \times 2N$ matrix, N is number of nodes.

$\mathbf{D}_{OR} = \mathbf{D}_{OR}^T$ is a single factor obtained by equation 11.5 and 11.6, respectively. $\mathbf{D}_{OR}$ and $\mathbf{D}_{OR}^T$ may be obtained using the following steps: the formula for $\mathbf{D}_{OR}$ is given and values as shown in table 11.1.

D. Response Spectral Analysis for Ducts: A. K. Yeh [2] theory (non-elastic ducts)

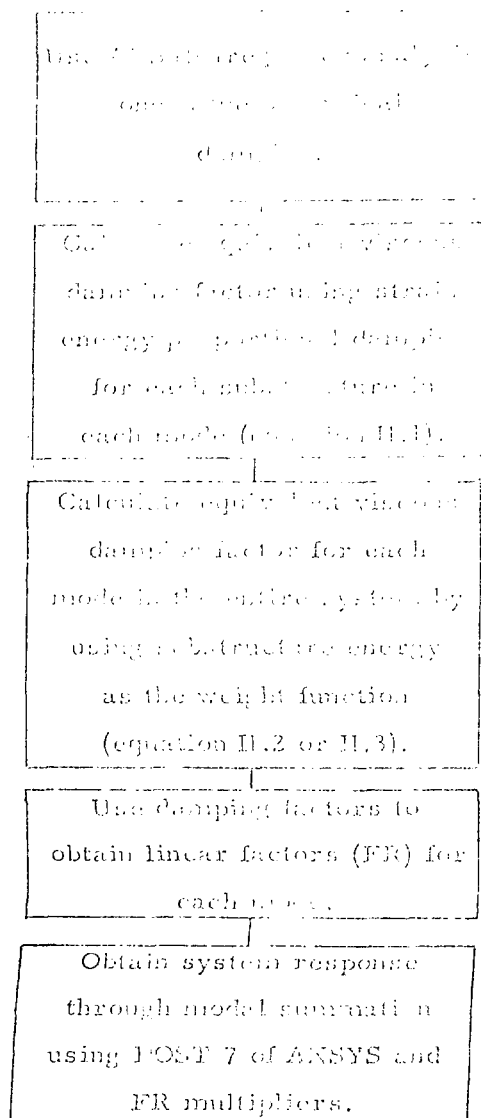
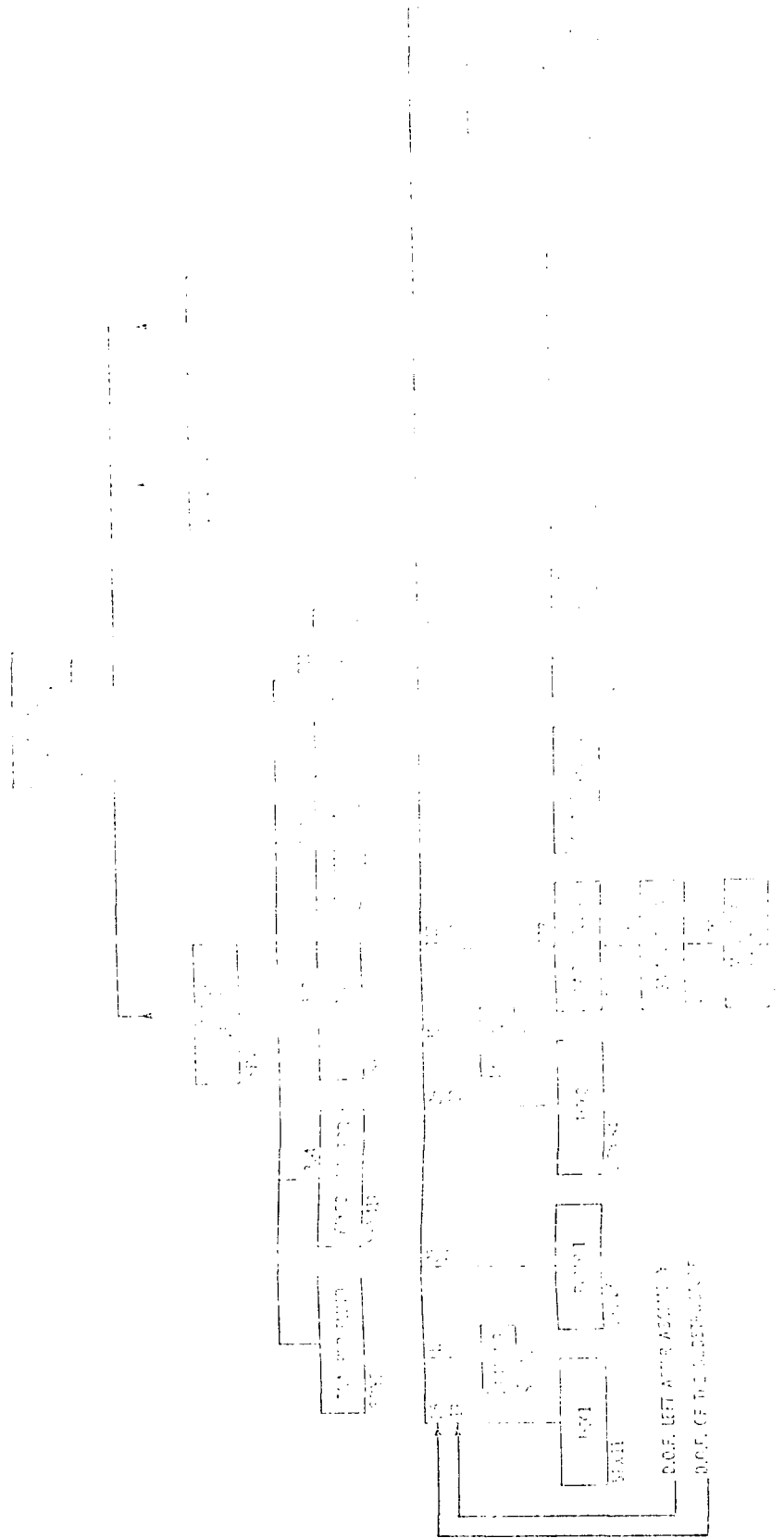
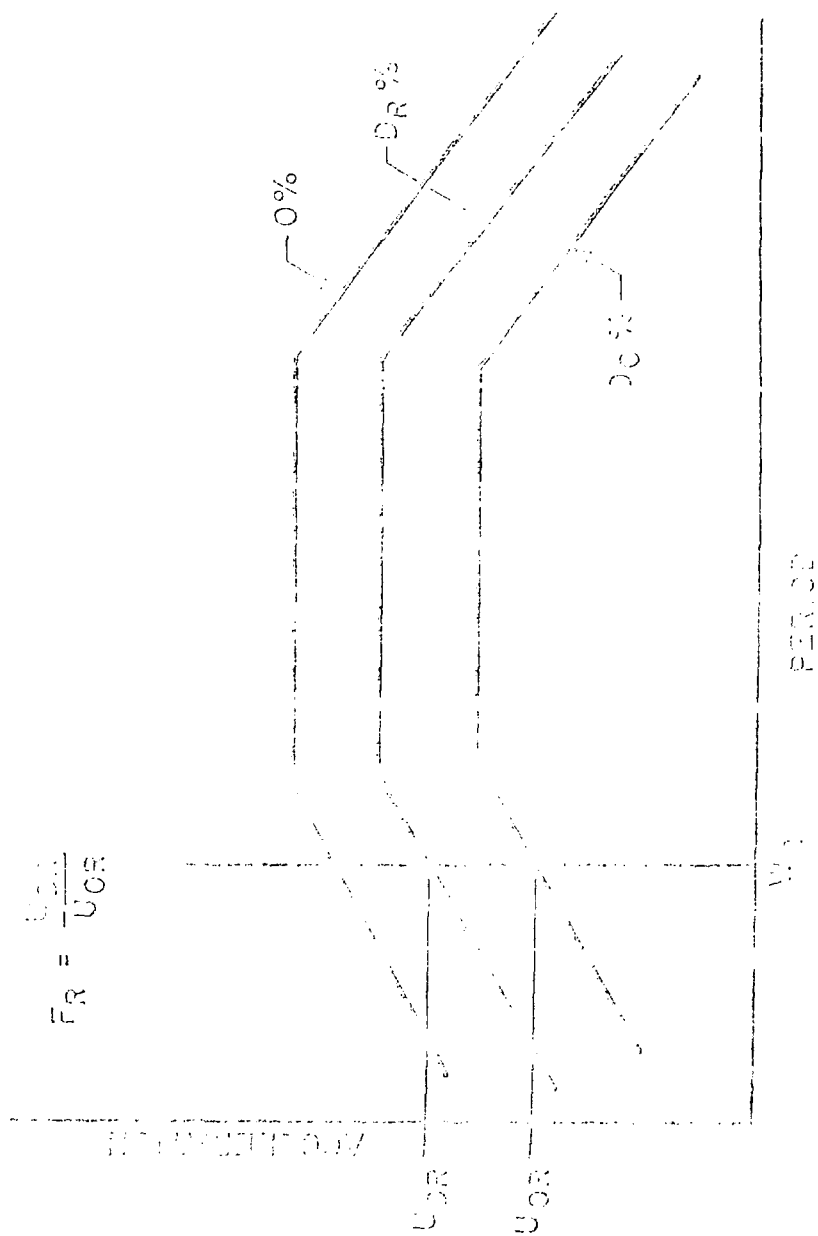
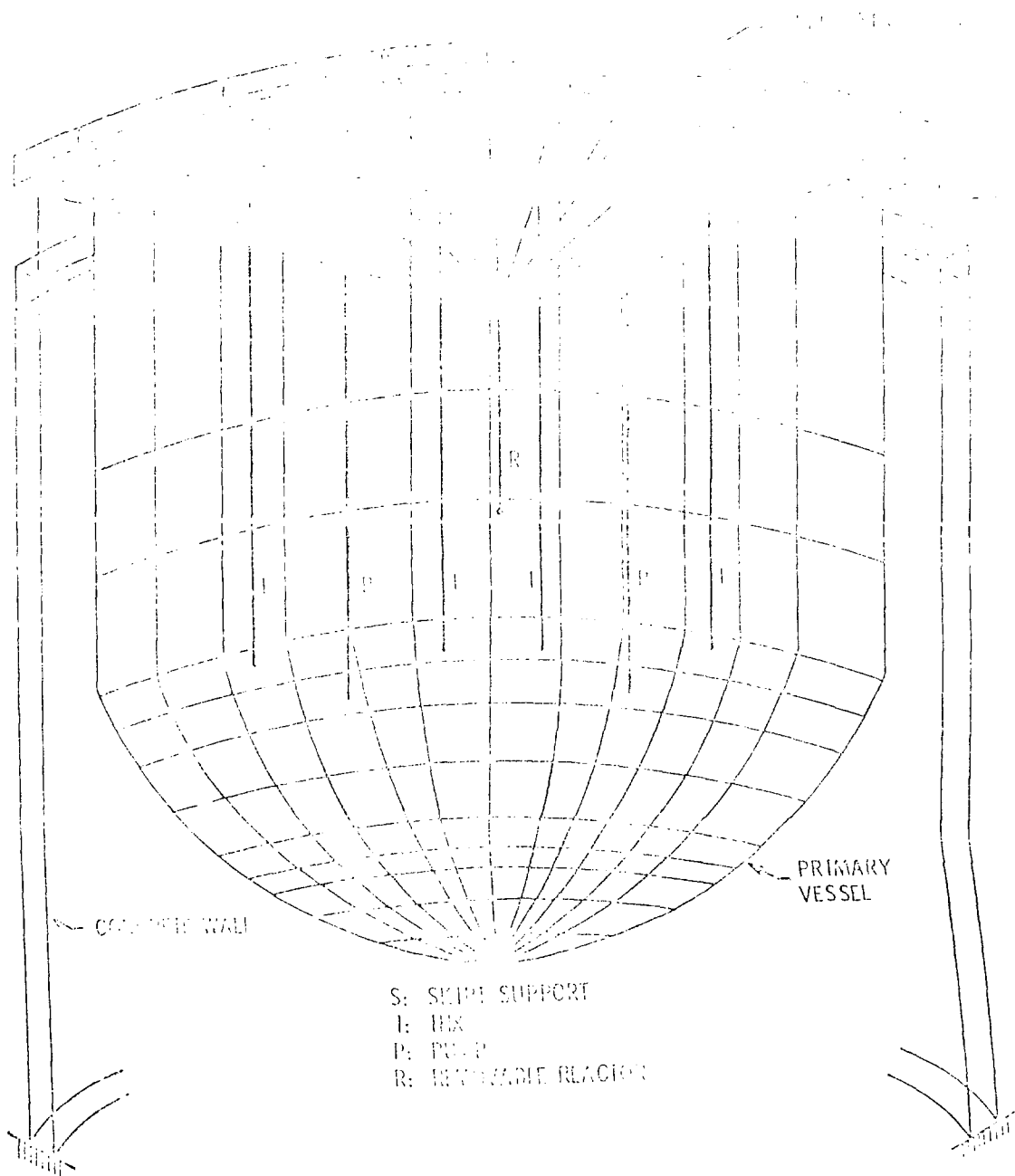


TABLE 4.1. Comparison of the two methods for the calculation of the effective viscosity

Device	Flow rate (l/min)	Device	Flow rate (l/min)
SPX10	1	Deaerated Fluid	4
SPX11	1	Fluid 2-Bolt Cone/Steel/Fluid	7/4/10
SPX12	2	Fluid 3-Bolt Cone/Steel/Fluid	2
SPX13	3	Fluid 4-Bolt Cone/Steel/Fluid	7/4/10
SPX14	4	Fluid 5-Bolt Cone/Steel/Fluid	7/4/10
SPX15	5	Piping of HX3	2
SPX16	6	Large Rotation Pump	4
SPX17	7	Small Rotation Pump	4
SPX18	8	Removable Reactor	4
SPX19	9	Guard Vessel	4
SPX20	10	Skirt Support/Reinforced Concrete	4/7
SPX711	11	HX3-Bolt Cone/Steel/Fluid	7/4/10
SPX712	12	Piping of HX3	2
SPX813	13	Pump 2-Bolt Cone/Steel/Fluid	7/4/10
SPX914	14	HX4-Bolt Cone/Steel/Fluid	7/4/10
SPX915	15	Piping of HX4	2
SPY116	16	Primary Vessel	4
SPY217	17	Thermal Duffle	4
SPY318	18	Redan	4
SPY419	19	Fixed Reactor	4
SPY520	20	Trapped Fluid	10
SPFL	21	Free Fluid	10







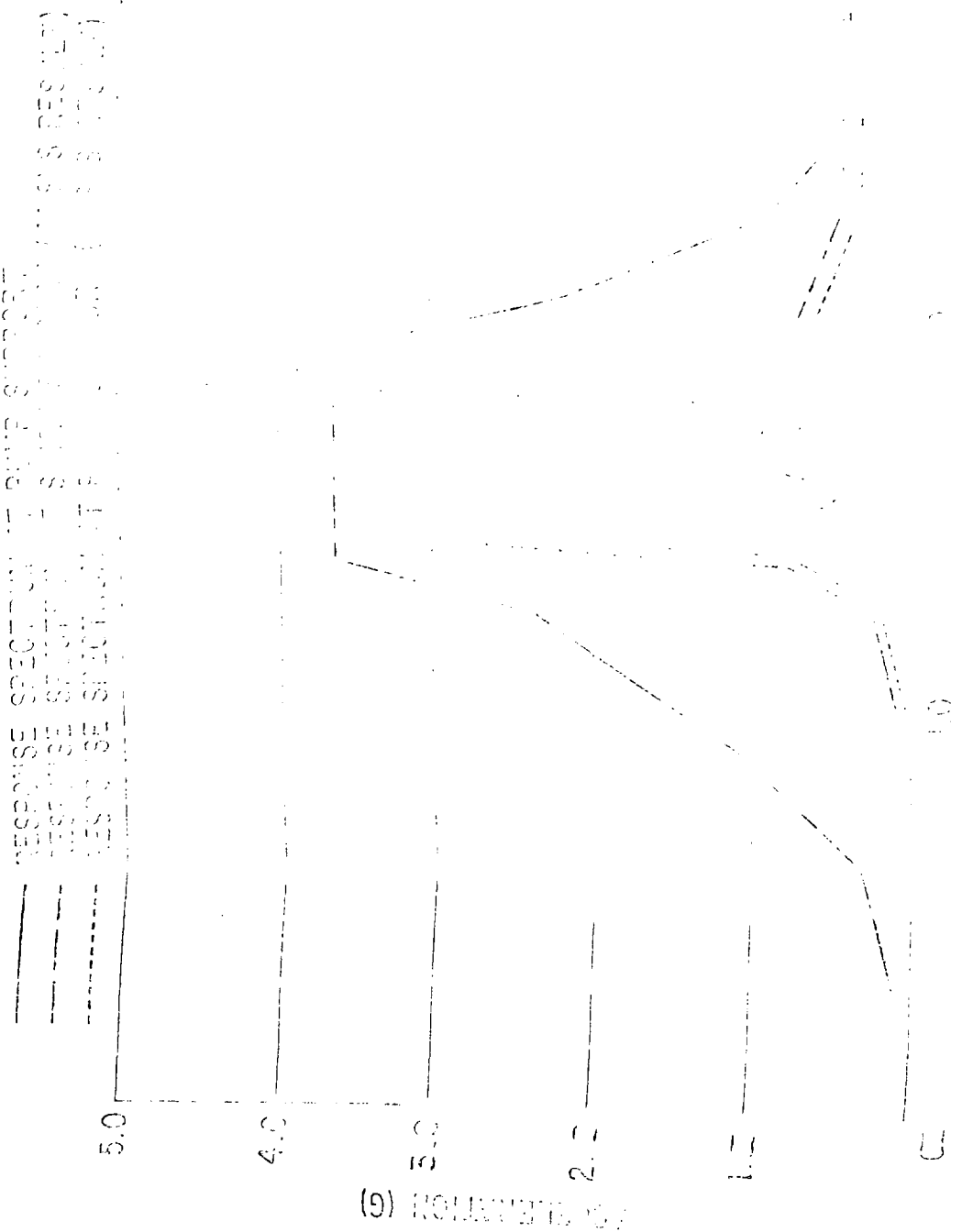


Figure 1 shows the results of the simulation. The results show that the system is stable and the output is close to the reference signal.

The results of the simulation are shown in Figure 1. The results show that the system is stable and the output is close to the reference signal.