87E128121

Fast breeder reactor primary pump discharge sphere support device

Ph.Terny & J.C.Blaix
Novatome, Lyon, France

E.D.F. - S
DI
GESTION
TECH
12, 14, avenue
69628 VILLEU
Téléphone : (7)
Enregistré le 08 SEP. 1987

1 INTRODUCTION

In their lower part, the fast breeder reactor primary pump are connected to a sphere-shaped discharge capacity from which the diagrid feedpipes emerge.

This discharge capacity is rigidly set on the strongback by means of a device that bears the forces resulting from the bottom effect. This last being generated by the pressure of the sodium discharged from primary pump. When the reactor operating conditions undergo some rapid changes combined to temperature changes, the structures differential expansions result in high stresses in the sphere support as well as in the feedpipes.

This paper aims at describing a sphere support which is provided with flexibility under horizontal forces and a higher stiffness under vertical forces for a better adaptation to the various loading conditions.

2 DESCRIPTION OF THE PROBLEM

In a pool-type reactor, the primary pumps are located inside the reactor vessel itself and circulate the sodium.

In the case we are dealing with, the primary pumps are fastened to the reactor slab by means of a flange.

This is the only level where they are hung and embedded. The hydraulical part is immersed in the cold plenum. The primary sodium originating from the intermediate heat exchangers, is radially sucked in by this hydraulical part before being discharged axially through a sleeve hanging to the pump bulb and articulated on to the sphere (figure 1).

At the bulb and sphere level, tightness of the sodium discharged is provided for by a sealing device. Forces resulting from the bottom effect and those due to the differential expansions between the strongback and the diagrid connecting pipes occurring under incident transient conditions (figure 3) are carried by the discharge sphere which is rigidly set on the strongback supporting the diagrid and the core assemblies.

In the RNR 1500 preliminary design, the strongback has been designed as a disk structure, at the difference of SPX where a ring-type structure has been implemented (figure 2).

During thermal transients, such a design leads to some radial expansions and large deflections of the strongback which must be combined to those of the diagrid and the connecting pipes. These deformations difference must be accommodated by the sphere support.

It is not possible to use a radially free sliding system in sodium. On the one hand, there are high friction coefficients and on the other hand, the friction surfaces resistance cannot be guaranteed during the whole reactor lifetime, which implies seizure risks inducing unallowable loadings for the primary coolant pipes (buckling risks).

3 THE PROPOSED DESIGN

The proposed design consists in welding a conical shell at the sphere level.

In its small base, this shell is welded on a connecting plate. The sphere -conical shell- connecting plate assembly is provided with a high rigidity.

A plane thin sheet metal is welded between the connection plate and a strongback protuberance called "bracket".

This sheet metal which is under than the conical shell, crosses the shell from one side to the other through two slots providing clearance for the sheet metal deformation.

The sheet metal has been designed with a thinned portion in its center, allowing its flexibility in bending. The sphere -conical shell- connecting plate assembly can be then hung to the strongback through of the sheet metal (figures 3, 4).

Stiffeners have been provided for so as to allow load concentration in the sheet thinner portion.

4 MECHANICAL BEHAVIOR

Under thermal transient conditions, the sphere is radially displaced by the expansion of primary pipes. Owing to the conical shell slots, this simply results in a bending of the sheet at the level of its thinned portion.

The wide sheet metal carries tensile stresses and can easily bears the vertical loads as well as the sphere weight avoiding any buckling risk.

At last, the sheet upper part provides for the sphere support redundancy in case of failure of the bending section.

5 PRELIMINARY DESIGN

The preliminary design of these structures has been carried out on the basis of rather small thicknesses as regards the sphere, the conical shell and the sheet bending portion. Thicker plates have been selected for the stiffeners.

Structures are made up of Z 2 CND 17 12 steel, with a controlled nitrogen content, provided with mechanical properties similar to those of steel 316 (Reference 1).

Computations have been performed according to the finite elements method, by means of the NOVNL program (Reference 2) with the use of the eigth-nodes shell elements. They have been achieved in the elastic range on a mesh representing half of the support (figures 5 and 6).

The following loadings have been taken into account :

- the distributed load corresponding to the bottom effect (around 52 tons per pump)

- the horizontal differential displacements, resulting from expansion differences between the strongback brackets and the diagrid, at the time of their major significance (figure 7)

- the deflection resulting from the bending difference between the strongback and the pipes.

The analyses are carried out in accordance with the RCC-MR code (Reference 3) in order to avoid any damages due to buckling, progressive deformation and fatigue.

Results can be summarized as follows :

- As regards buckling, the only critical area of the structure is the upper part of the bending sheet which behaves as a three-edge embedded plate. Yet, even while taking account of a possible plastification, a 2,5 safety factor is provided with respect to the critical load.

- As far as progressive deformation risks are concerned, the hot shock does not give rise to any problem. On the contrary, with a cold shock, the membrane stress intensity, combined to bending stress, is close to the allowable limits.

- Concerning fatigue, the hot shock-cold shock cumulative usage factor is very low.

A part from these limits, what should be noted is a heterogeneous distribution of the primary stresses in the sheet upper part. Therefore, its height or its thickness must be increased.

The upper stiffener and the side plates of the bracket are submitted to stress concentrations at the level of their connection to the bracket upper plate.

Some improvements have been made : in the sheet upper part, the stiffener height has been increased, and the side plate shape has been changed.

In the same way, the changing of thickness in the sheet metal is located close to the sheet/plate welding, thus leading to high concentrated loads.

In acceptable solution consisted in lenghtening the thick portion of the sheet.

Figure 8, shows the proposed modification and the new drawing.

6 CONCLUSION

Providing the above-mentionned improvements are implemented, the proposed solution opens the way to a satisfactory preminiminary design.

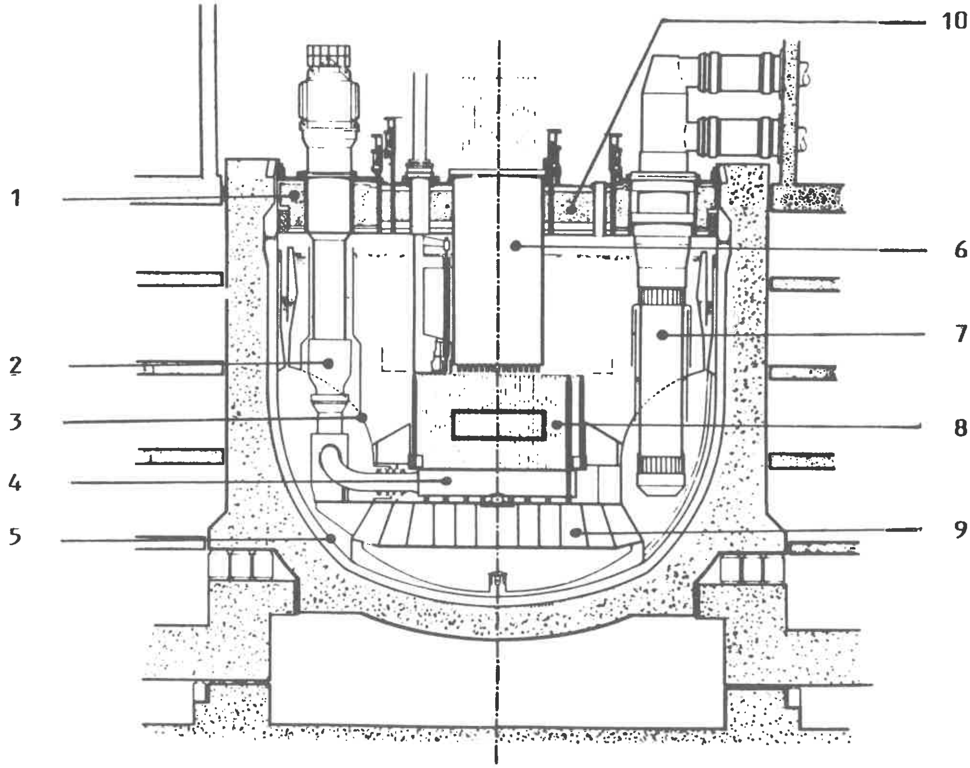
On the basis of these results, more complete analyses will be carried out, taking account of the vibration risk and of the influence of thermal stresses due to sodium stratifications in the cold plenum.

REFERENCES

(1) : RCC-MR Règles de conception et de construction des matériels mécaniques des ilôts nucléaires RNR. Volume Z. Annexe technique A3. TOME 1. Ensemble de caractéristiques 1 S.

(2) : Programme NOVNL, programme d'analyse linéaire et non linéaire en statique et dynamique. Notice d'exploitation NOVATOME TAD 85.004 Indice 3.

(3) : RCC-MR. Tome I. Volume B. Matériels de niveau 1 (Edité par l'AFCEN).



1 - Roof Slab

2 - Primary Pump

3 - Inner Vessel

4 - Diagrid

5 - Primary Vessel

6 - Abore Core Structure

7 - Intermediate Heat Exchanger

8 - Core

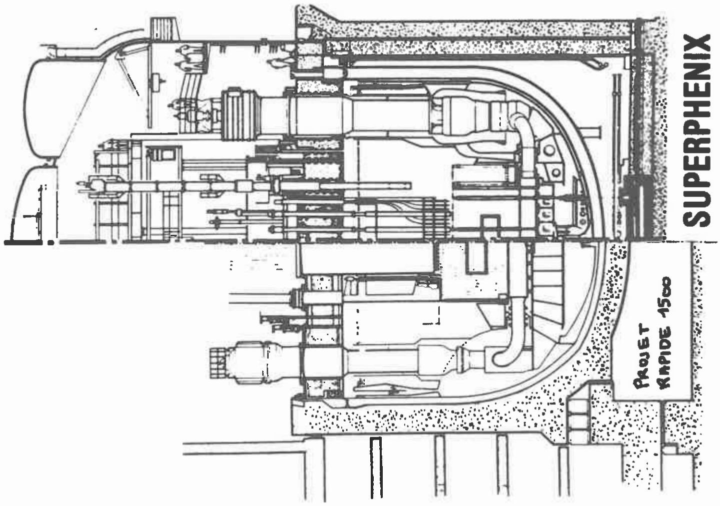
9 - Strongback

10 - Rotating Plugs

L M F B R - Reactor Block

FIGURE 1

REACTOR BLOCK



CROSS - SECTION THROUGH THE PRIMARY PUMPS

FIGURE 2

SPHERE SUPPORT DEVICE

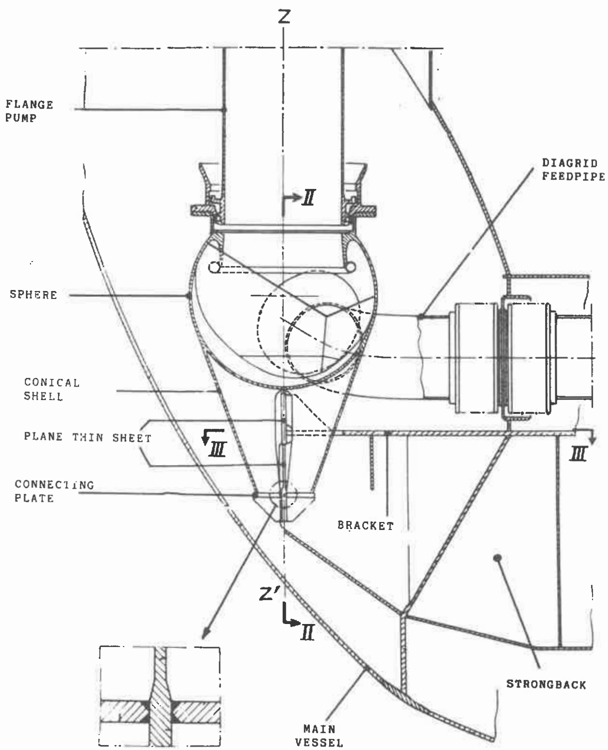


FIGURE 3

SPHERE SUPPORT DEVICE

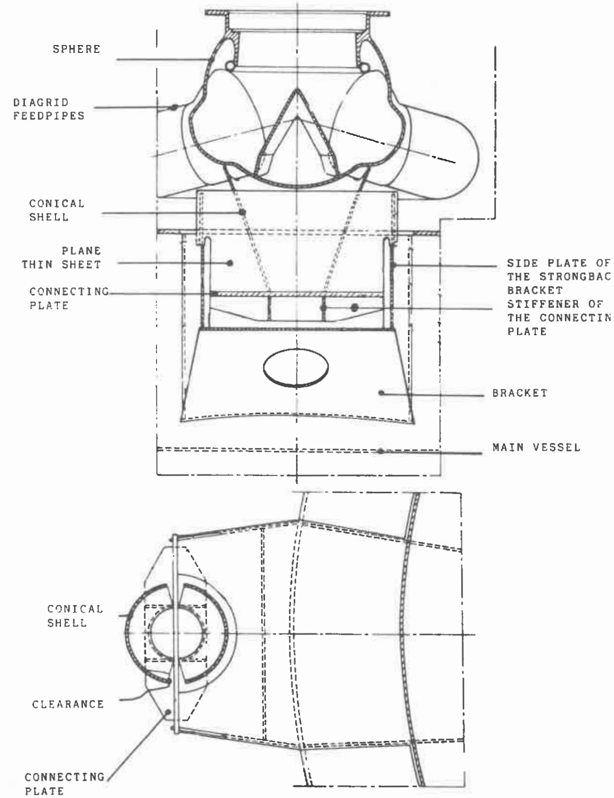


FIGURE 4

FIGURE 5

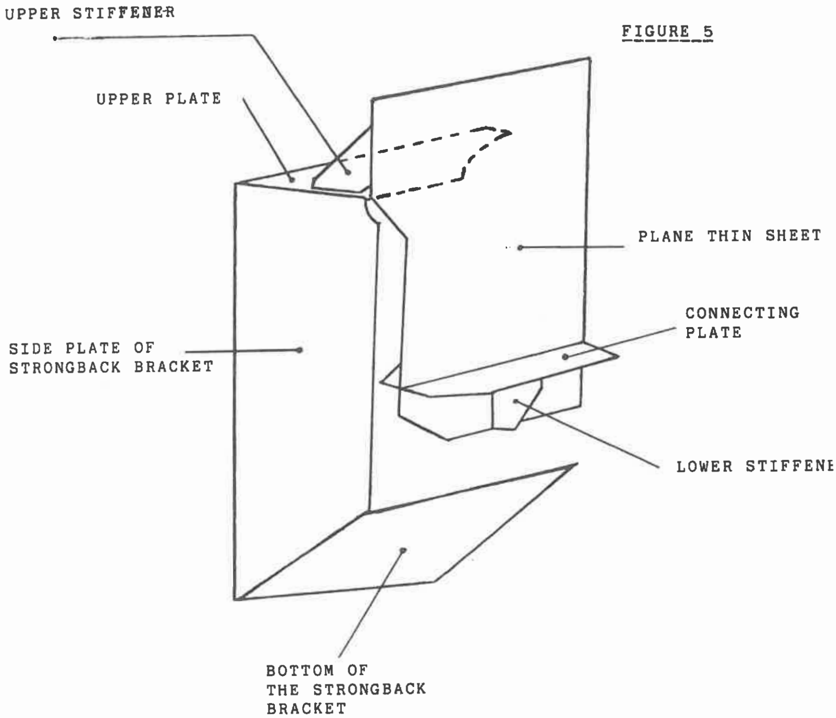
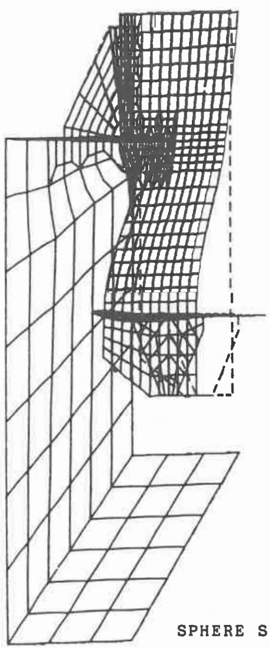
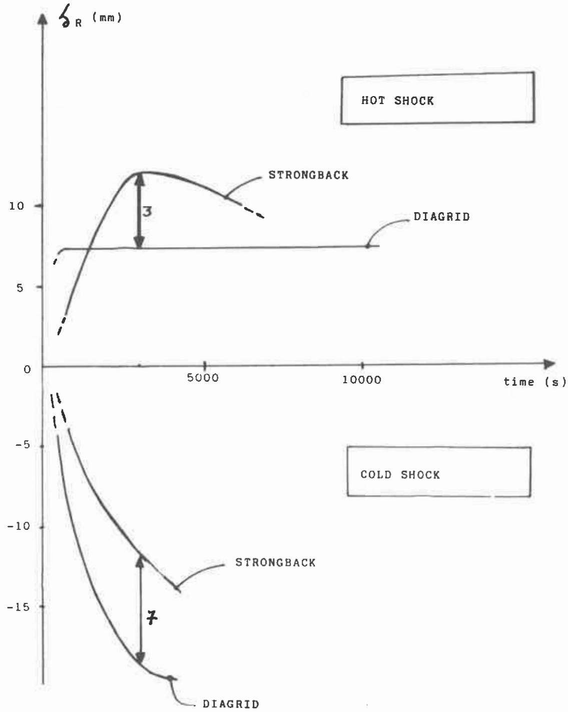


FIGURE DRAWN FROM THE FINITE ELEMENT MODEL

FIGURE 6

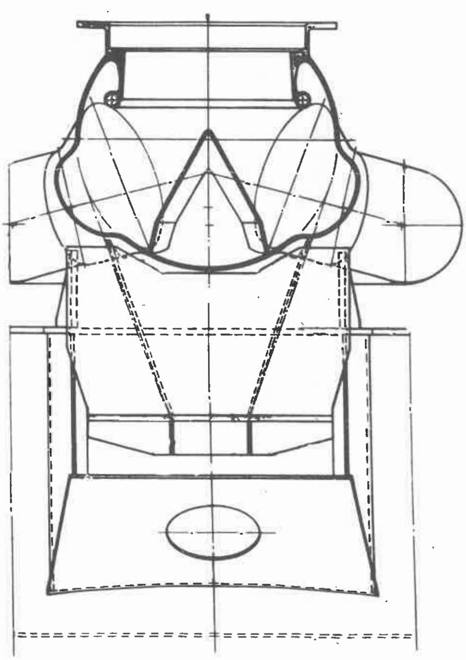


SPHERE SUPPORT DEVICE DURING THE COLD SHOCK



DIFFERENTIAL DISPLACEMENTS

FIGURE 7



PROPOSED MODIFICATION AND NEW DRAWING

FIGURE 8