DESIGN OF ROTATING PLUGS

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I. INTRODUCTION

All Liquid Metal cooled Fast Breeder Reactors have rotating plugs as a common feature. The rotating plugs provide easy and safe access to the sub-assemblies for their transfer to, or from the core, and act simultaneously as biological and thermal shield to allow personnel movement at the top of the plugs.

II. DESCRIPTION

Let us consider a typical example in FBTR rotating plugs.

There will be two rotating plugs, one called the large plug which will be placed inside the reactor vessel like a stopper and the other called the small plug which will be accommodated in the large plug. The assembly is such that the large plug and the reactor core will have a common axis, the small rotating plug will have an axis parallel to it but offset by 390 mm.

This configuration will result in an eccentric housing in the rotating plugs. The plug assembly will have a diameter of 3 meters in its largest part and will have an overall height of 3 meters.

The rotating plugs will be supported from top by angular contact ball bearings. Steel and Boronated Graphite blocks placed inside the plug structure will constitute the main shield having a height of 2.1 meters. Three horizontal plates and four shells will form the main structural elements for a plug enclosure. An example of large rotating plug is shown in fig.1. The middle plate serves to provide a step at middle height to obstruct radiation streaming from the reactor through the gaps. Vertical tubes pass through the three plates and provide access to the reactor core and for instrumentation. These tubes are welded to the top and bottom plates.

III. DESIGN CONDITIONS

Each plug will be tested for absence of leaks by pressurising to 1 Kg/cm^2 of helium after its fabrication. During normal operation, however, the internal pressure will be governed by the gas pressure of the plug coolingsystem and it is not expected to be higher than 0.1 Kg/cm^2. The temperature of the bottom plate will be about 400°C, whereas the step plate temperature will be maintained at

80°C and that of the top plate at 40°C by the cooling system. The shielding materials above the step will exert a load of 4.5 tonnes on outer and inner peripheries of the step plate and a load of 7 tonnes on bottom plate due to shields below the step plate will be uniformly distributed. The two vertical tubes traversing the plug will cause restraint on deflection of the bottom plate. The neutron radiation flux on the bottom plate is expected to be $\sim 10^{10}$ n/cm^{2}-sec. The top plate will be in carbon steel and all the other structural components will be in Austenitic Stainless Steel.

IV. ANALYSIS

The available literature does not provide means to design such structures.

There are two ways to solve this problem. First, to make simulated studies on scaled down models as was done at RED/BARC for finding the deflection of top plate of the large plug. They arrived at an empirical relationship between the stiffness and thickness of the top plate and consequently, the thickness was fixed at 200 mm. The second is analytical method. Either a detailed computer programme can be made, or it can be analysed after making some simplifying but conservative assumptions. The second alternative was resorted to while designing the bottom plate with an eccentric hole. The outer periphery of the plate was assumed to be extended to make it concentric with the hole. The same loading per unit area was assumed to be distributed on the extension. The resulting simpler geometry was analysed for stresses. The stiffening effect of the tubes was neglected. The plate was assumed to be simply supported for calculating the thickness. Nevertheless the discontinuity stresses were calculated at the edges where the shells join the plate. ASME Code Section III was used for guidance and for max. allowable stresses. The structure was separated into free bodies with end moments and forces. Free displacements, and angular rotation were calculated for each of the two shells and the plate. The resulting simultaneous equations gave the Moments & Forces and thereby, the stresses. This method will result in higher plate thickness than the actual requirement because of conservatism involved.

An accurate analysis, however, is needed for future applications in fast reactors' programme, where rotating plugs of about 4m. in diameter, and about 3m.in height will be used. The overall geometry and the loading would also be similar.

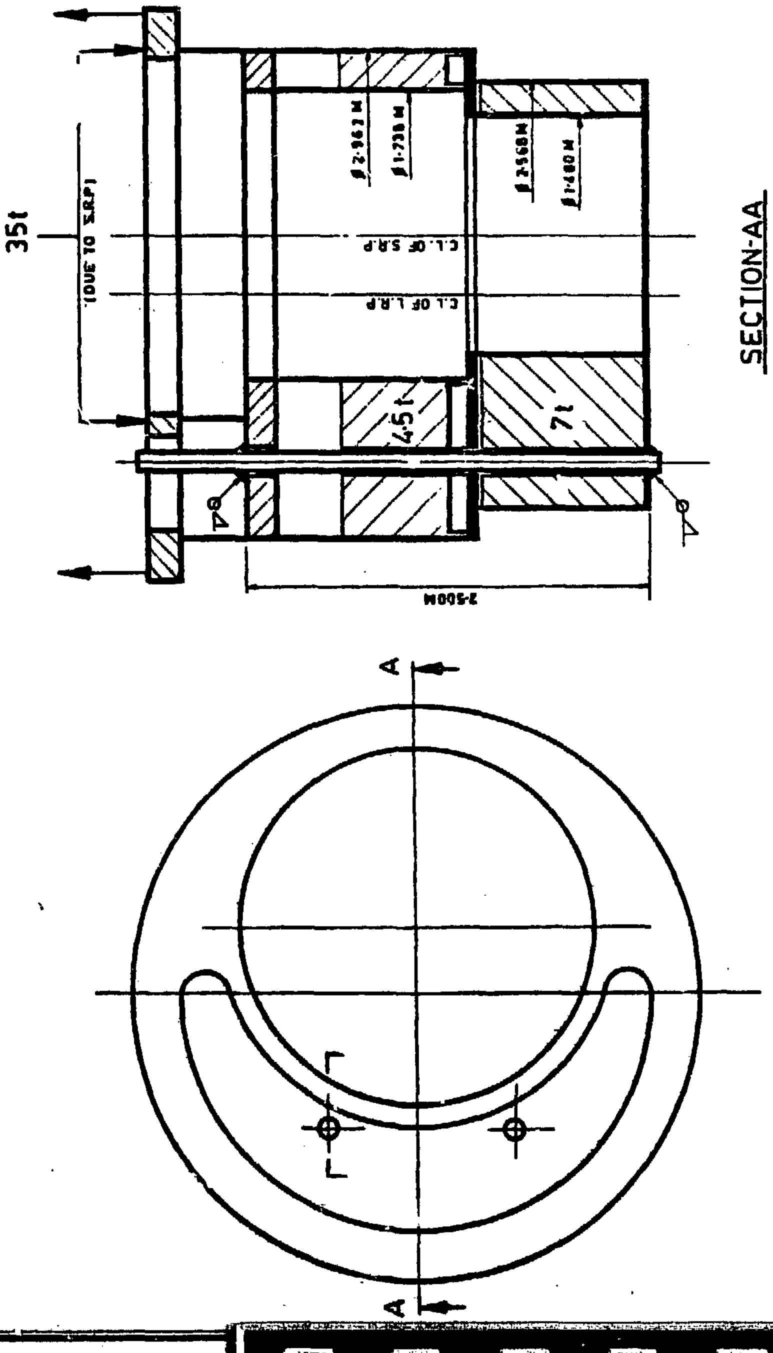
35t
(DUE TO ΣR.P)
Ø2·962 M
Ø1·738 M
Ø2·568M
Ø1·480 M
C.L OF S.R.P
C.L OF L.R.P
4.5t
7t
2·500M
SECTION-AA
A
A

FIG-1