3.4 THERMAL ANALYSIS OF CHTR CORE UNDER NORMAL OPERATING AND POSTULATED ACCIDENT CONDITIONS

A detailed thermal analysis is essential in design, to ensure fuel integrity under all foreseeable scenarios, without operator intervention. A steady state analysis of the reactor core has been carried out to determine the prevalent temperatures under normal operating conditions, to estimate the thermal stresses. A steady state parametric analysis has also been carried out to estimate and minimise the heat loss from the reactor core, through the gas gaps by all modes, under normal operating conditions.

In the analyses it has been assumed that under postulated accident conditions, the reactor power stabilizes at a peak neutronically limited value of, twice the normal operating power and the entire heat is transferred to an outer heat sink by conduction, through the reactor vessel wall. The maximum fuel temperature has been calculated by a FEM analysis under steady state conditions. This has been followed by a transient analysis, to estimate the available time for safety devices to act. In this analysis it has been assumed that all heat sinks have been lost along with a sudden rise in power. It has also been assumed that an adiabatic boundary condition prevails for all surfaces. The initial temperature distribution has been applied from a steady state analysis and a step increase of twice the reactor power is assumed.

In all the above analysis the thermal contact resistances at all interfaces were assumed negligible. The heat generation in nuclear fuel and moderator has been considered. Appropriate material properties have also been assumed.

The temperature distribution given in the figure, at planes through the top, mid and bottom of the active length shows that the maximum temperature gradient occurs just outside the outermost location of the fuel channel and hence becomes the prime candidate for failure due to thermal stresses.
The variation of total heat loss with respect to inner gas gap shows that increasing this gap beyond 20 mm will not affect any significant economy in core heat.

The temperatures distribution obtained under postulated accident conditions with heat rejection to the outer heat sinks have been obtained by considering aluminium, indium and tin in the gas gaps which yielded maximum fuel temperatures well below the maximum allowable value for the fuel (1600°C).

The results from the transient analysis show that even after fifty minutes have elapsed after overpower, the fuel temperature does not exceed 1510°C, well below the limiting temperature of the fuel.