HARWELL

Research Reactors Division

Technical Assessment- Thermal, Hydraulic, Stress and Structural

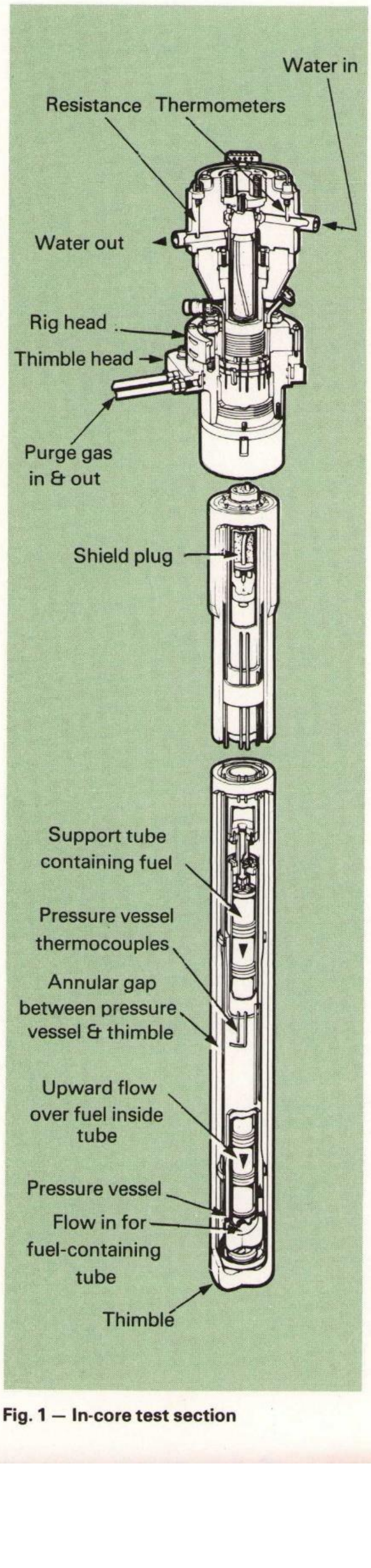

Fig. 1 — In-core test section

The requirements for well defined physical conditions imposed by scientists for their experiments in reactors often demand accurate prediction of the thermal environment. Similarly, modern safety requirements for pressurised equipment demand the ability to predict stress levels accurately in complex vessels. These demands, together with the interactions on them of reactor physics considerations have led to the development of a Section specialising in technical assessment. The professional engineers in the section have had experience in reactor operations and in project engineering, so that their technical assessments have a practical background. As well as work within the Division, a considerable proportion (typically up to 50%) of work is carried out for customers outside Harwell. Recent examples of contract work include a heat transfer and gas flow study for the bake-out of the Torus Vacuum Vessel for JET (the Joint European Torus fusion project), a thermo-hydraulic assessment of the proposed design for a high-flux research reactor at Kyoto University, Japan, and a comprehensive structural analysis of a power reactor steam drum. These studies included physical scale models in addition to finite element and finite difference computer models of the systems.

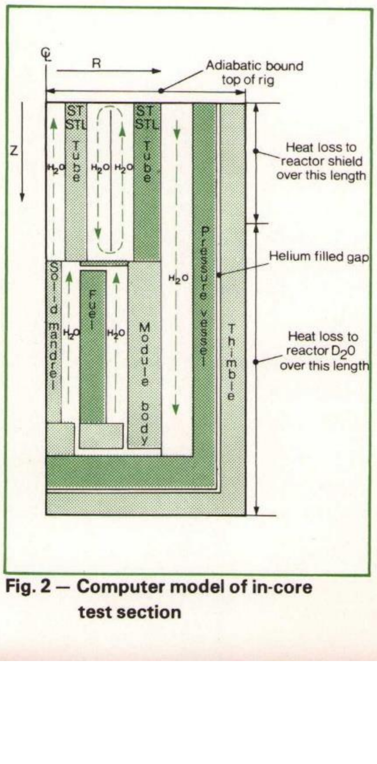

Fig. 2 — Computer model of in-core test section

A number of experiments in the reactors at Harwell are concerned with flowing coolants; these experiments are known as loops, and the coolant may be liquid or gaseous. The requirements for accurate prediction during design, and for knowledge within close limits of thermal conditions during the experiments, have led to the development of computer programs to analyse these conditions, which are affected by conduction, convection and radiation heat transfer. Where loss-of-coolant experiments are involved, the solutions must cover transient as well as steady state conditions. A typical water loop experiment is shown in Fig. 1, together with the two dimensional heat transfer computer model of the in-pile test section (Fig. 2) used to assist design in the first place, and later to analyse conditions during operation. The latter requirement arises from the difficulty of installing adequate instrumentation within the close confines of an in-core experiment. It is generally not too difficult to provide sufficient accurate instrumentation to monitor conditions at the 'rig head' (where the experiment's service lines enter and leave the reactor shielding). This information provides boundary conditions within which the computer model can provide a consistent thermal analysis of the in-core section.

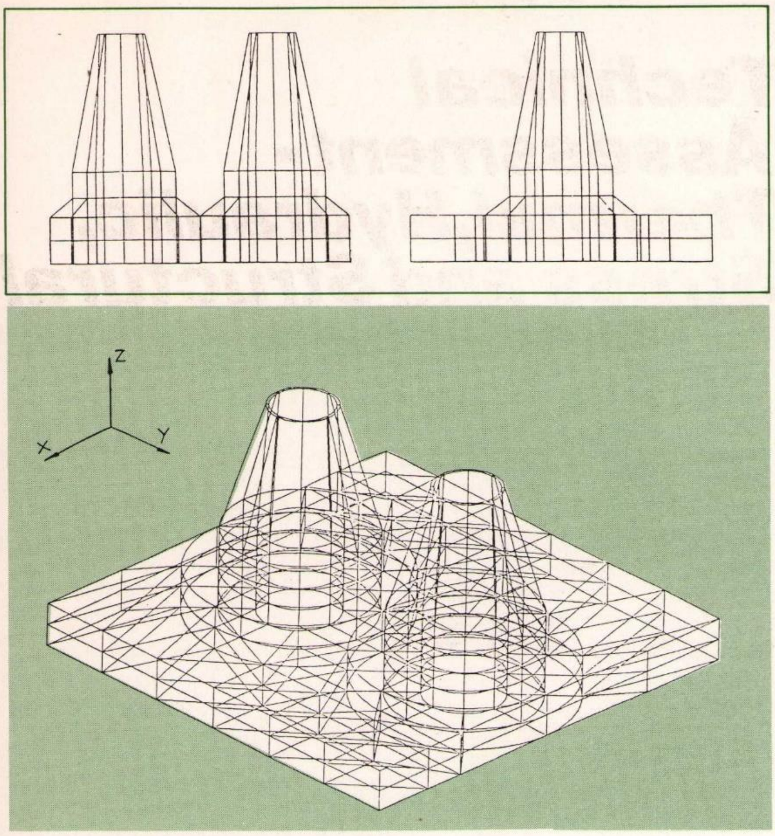

Fig. 3 — Finite element model of nozzle region

Pressure vessels in loss-of-coolant accident experiments are subject to sudden changes of temperature and pressure, and consequently transient stress analysis is required to ensure the safety of the vessel, which may include penetrations with irregular geometries. This analysis can only be done with the help of thermal hydraulic and 2 or 3-dimensional heat transfer and stress analysis computer codes. The section has built up an expertise in this area, and a typical 3-dimensional finite element model (of a nozzle region in a pressure vessel) is shown in Fig. 3.

Structural integrity is dependent on the absence of significant flaws in critical regions, and the Section is also involved in fracture mechanics; it can call on the assistance of experts in this field from Metallurgy and Materials Development Divisions at Harwell.

Full use is made of the reservoir of expert knowledge available at Harwell, e.g. in the JET 'bake-out' study, assistance with the heating-gas flow optimisation was given by the Heat Transfer and Fluid Flow Service (H.T.F.S.).

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