5.1 POST IRRADIATION EXAMINATION ON FUEL

- High Burnup PHWR Fuel

PIE of two fuel bundles with a burn up of ~15,000 MWD/TeU was carried out to give a feedback on the possibility of increasing the discharge burn up. The outer fuel elements had released 15% of the fission gas leading to an internal gas pressure of ~ 20 atmosphere in the cold condition.

Detailed metallographic examination and β-γ autoradiography carried out did not show pellet-clad interaction. However significant fission product redistribution was observed.

The estimated temperature at the center of the outer fuel pins was about 1600°C. Microstructure of the central zone revealed grain boundary decorated with interconnected porosity leading to higher fission gas release.

- Irradiated MOX Fuel

PIE was carried out on experimental MOX (UO₂-4%PuO₂) fuel elements of AC-4 cluster, that contained fuel elements pellets
produced by different fabrication routes and varying pellet clad gaps and filler gas composition, after test irradiation in pressurised water loop (PWL) of CIRUS.

Fuel pins with controlled porosity pellets and pellets with central hole showed very low fission gas release even at 110 W/cm² heat flux.

Fuel pin containing low temperature sintered pellets showed abnormal gas release. Presence of CO which was found in the fill gas probably has caused the abnormal behaviour.

**PIE OF ThO₂ FUEL**

Post Irradiation Examination (PIE) was carried out on ThO₂ fuel bundles of KAPS irradiated up to 3164 n/Mb, which is equivalent of 11725 MWD/T of burnup. Detailed PIE studies showed excellent behaviour of ThO₂ fuel during reactor operation. Fuel samples cut from one of the outer pins were subjected to radiochemical burn up measurement and isotopic analysis. The results of burn up measurements were close to estimated value. However, the measurement of isotopic content of U²³² differed significantly from the theoretical estimation. The PIE results are being used for verification and up gradation of the computation code and the cross sectional parameters used for calculations and predictions of ThO₂ fuel. Gamma scanning was carried out on irradiated ThO₂ and UO₂ fuel pins of different burn-up to generate information on axial burn-up distribution and power distribution profile in the fuel bundle using the Cs¹³⁷ as fission monitor.

The relative power profile of UO₂ and ThO₂ fuel bundle showed significant difference. The inner ring fuel elements in ThO₂ fuel bundle showed higher power than the outer fuel elements in the

---

**Power Profile In ThO₂ and UO₂ Fuels**

---

**Cross Section of Failed Fuel**

---

**DHC Crack**

---

**Microblister**
bundle showing effect of epithermal neutrons.

- **Low burn up Fuel Failure**

  Detailed investigation carried out on low burn up failed PHWR fuel indicated high center temperature of fuel.

  The failure has been caused by in situ power ramping leading to pellet clad interaction and internal hydriding of fuel cladding.

- **Analysis of Fission Gases**

  The content of released fission gases and their composition was measured for the MOX, UO$_2$, and ThO$_2$ fuels, irradiated in research and power reactors.

  The isotopic composition of gases released from the fuels is given below. The irradiated ThO$_2$ fuel did not release much gas. The PHWR UO$_2$ fuel released gases, the quantity being dependant on the location of the fuel element in the bundle.

Formation of microblisters on inner surface of cladding and through wall clad cracks at multiple locations were observed.