PBMR Safety Analysis: Aerosol Modelling for Generation IV Nuclear Plants

L. Naicker and A.Ramlakan

Department of Nuclear Engineering Analysis, Pebble Bed Modular Reactor (Pty) Ltd, Centurion, 0046, Gauteng, South Africa

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The Pebble Bed Modular Reactor (PBMR) is a 400MW$_{th}$ Generation IV High Temperature Gas Reactor (HTGR). The PBMR core utilizes about 451000 low enriched uranium TRIple coated ISOtropic (TRISO) fuel spheres ('pebbles') in an annular fuel region that is surrounded by a fixed central graphite reflector and an outer graphite reflector.

The annular core of pebbles acts as a fixed bed through which the Helium coolant gas passes. The core is continuously loaded at the top and unloads at the bottom, maintaining a pebble inventory, and resulting in downward migration of pebbles. Pebble-to-pebble and pebble-to-reflector abrasion is expected, as well as abrasion of pebbles within the fuel handling and storage system that services the core. Abraded graphite dust can be transported though the cooling loop together with small amounts fission products which manage to escape the fuel spheres. Modelling the transport of graphite dust and fission products allows prediction of the radiological burden imposed on workers and public under accident conditions and is imperative for licensing of the design.

Our present modelling ability involves the use of the thermo-hydraulic code FLOWNEX and the RADAX code to model primary circuit aerosol processes using input from FLOWNEX. Under an accident condition, considered to be a rupture in the primary circuit, a release through the confinement compartments to the venting shaft is modelled using FLOWNEX for thermo-hydraulics and NAUA for aerosol processes.

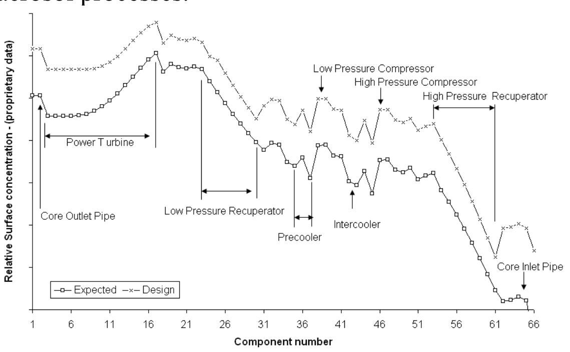

Figure 1. Ag110m primary circuit concentration after 36a

The work discussed here is part of a longer term collaborative modelling effort towards a PBMR specific code that can be generalized to model accident scenarios in HTGRs. Future code development plans include fully coupled aerosol and thermal-hydraulic modules, a mechanistic account of dust and fission product interaction, chemical interaction between fission products all of which are important improvements to the model especially when re-suspension is considered in the primary circuit (figure 2) depressurization scenarios. In addition, multi-components effects are being investigated.

Isotopes such as Ag, Cs, I and Sr are expected to circulate in the primary loop over the plants lifetime. The primary loop chemical environment is considerably different from LWR and PWR conditions. We discuss the predicted chemical interactions occurring and the kind of uncertainties involved in modelling these reactions. Further discussions will include the licensing framework and release limits for the different accident scenarios, the physical conditions in the primary circuit and confinement building and how these relate to the amount and size distribution of graphite dust, more detailed results from primary circuit and confinement analysis, the aerosol phenomena that are expected to dominate in HTGR accidents, knowledge gained from the AVR(Arbeitsgemeinschaft VersuchsReactor GmbH) and its applicability to PBMR, the experiments required as part of the rigorous verification and validation framework to improve our modelling inputs.

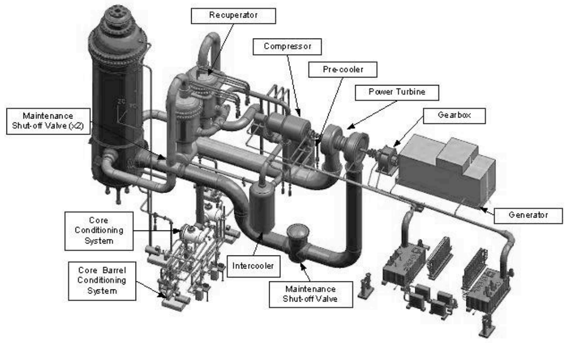

Figure 2. PBMR primary circuit

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