HTR FUEL ELEMENT DEVELOPMENT IN THE FEDERAL REPUBLIC OF GERMANY

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The following summarizes the status of HTR Fuel Element Development.

Status end 1988:

- Production processes for spherical fuel elements containing high enriched uranium/thorium mixed oxide biso coated particles for the supply of the reactors AVR and THTR were fully established and licensed. Demonstration of successful operation by production of about 1 million elements with a very high yield had been achieved. Quality had been proven by the very low fission product inventory in the primary circuits of the plants.
- Quality control methods during and after manufacturing of the elements were sufficiently established and satisfy user and licensing requirements.
- Manufacturing processes for low enriched uranium oxide (LEU) fuel with triso coating, adopted in the early 1980s with respect to nonproliferation and reprocessing aspects, were successfully developed up to production scale. Significant reduction of uranium contamination in the elements had been achieved.
- Qualification of the LEU fuel elements by extensive irradiation testing and post irradiation examination under normal and hypothetical accident conditions enabled the reactor designers to develop a new passive safety concept for future HTR's (1600°C concept), which is based on the high fission product retention capability of the fuel elements under all accident conditions.

Status in 1989:

In 1989 fuel irradiation and PIE was continued, but the fuel manufacturing and development was subject to severe set backs.

- By increasing safety concerns the licensing authorities had requested additional safety measures for the handling of high enriched uranium, which could only be accomplished by the erection of new, expensive buildings for the fuel production. The costs would have partially been borne by the opertion costs of THTR and would therefore have increased the non-commercial costs of the reactor operation significantly.
- As a consequence of bribery scandals in the German fuel cycle activities the Federal government requested a restructuring of the fuel cycle industry to establish better defined responsibilities. Hence the Nukem company decided to abandon all fuel production and development activities and within this frame to shut down the HTR fuel producton.
- This was facilitated by the main decision for the HTR-development in 1989 in Germany; the decision to discontinue the operation of both reactors, the AVR and the THTR, of course for different reasons. Therefore fuel production was no longer needed. Since a short term follow-up project could not be expected, the license procedure for dismantling the production facilites was initiated. Simultaneously a programme was launched to maintain the manufacturing know how and to continue further fuel development work.

Status 1990 and future goals

1. Fuel manufacturing
   - In order to maintain the fuel production experience, one complete line of the modular systems of the THTR-production facilities supplemented by advanced devices from the development program, e.g. an automized 10 kg-coating furnace, is being re-erected in another builiding at the Hanau site. This line consists of all facilities needed for kernel, particle and fuel element manufacturing including all quality control methods developed and applied up to now. It will be oeprated by the highly experienced former Nukem/Hobeg experts. The lead is now with Siemens Brennelemente Werke operating on behalf of the HTR-system and marketing company HTR-GmbH in Frankfurt. The facilities will be taken into operation early next year. However, there is only a license for handling depleted uranium for this line.

     This R+D facility will now be utilized for several goals:
   - Preparation of a complete documentation of all process steps and parameters as well as detailed descriptions of all manufacturing devices in order to establish the basis for the construction of a commercial fuel production factory.

- Optimization of several process steps
- Optimization of the waste stream management in particular with regard to recycling possibilities
- Extension of the raw material basis of the fuel element matrix by investigation of the processing behaviour of several natural graphite and electrographite powders of different suppliers.
- Investigation of manufacturing process parameters for boron-carbide based absorber elements
- Improvement of corrosion resistance of the fuel element matrix as an additional preventive measure against water or air ingress accidents.

2. Fuel Qualification

- Demonstration of satisfactory fuel irradiation behaviour by full size fuel element tests under simlulated HTR-operation conditions in a material test reactor. Three tests in instrumented, swept capsules containing four elements each will be running during the next years.
- Continual exploration of safety margins by investigation of ultimate performance limits regarding power per element, burn up, fast neutron fluence etc.
- Continual extension of the statistical data sets for fission product retention under normal and accident conditions by post irradiation heat treatment of fuel elements (ensuring the 1600°C-concept) supported by extensive fission product transport model investigation and improvement.
- Continuation of post irradiation examination of AVR-LEU-fuel elements and preparatory work for the examination of THTR-fuel elements.

REVIEW OF CURRENT WORK ON INVESTIGATION OF HTGR FUEL IN THE UNION OF SOVIET SOCIALIST REPUBLICS

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At present works on the design of the pilot plant with the high-temperature gas-cooled reactor of modular type with a unit power of 200-250 MW(th), VGM, are under way in the USSR.

It is expected to be a prototype for creation of future commercial co-generation plants.

Earlier works on the 50 MW(e) VGR-50 and 400 Mw(e)VG-400 reactors, which were developed the detail design stage, were carried out.

In all above reactors the 60 mm diam. ball fuel elements based on graphite and low-enriched graphite were used. At the initial stage we investigated the possibility of application of the prism-shaped and ball fuel elements in HTGR.

The ball fuel elements were preferred for the following reasons:

- thermal and stress-strain operation conditions are easier comparing with blocks of larger sizes;
- a minimum margin of reactivity for burnup can be provided in the core, due to continuous in-operation refuellings;
- process of automatization and control of the fuel element quality in their large-scale production is easier, etc.

But the prism-shaped fuel elements have their own advantages.