UT-TBM/BB-He

Task Title: HELIUM COMPONENTS TECHNOLOGY PROBLEMS AND OUTLINE OF SOLUTIONS

INTRODUCTION

A review of problems related to helium technology, and a proposal of studies and experiments had been done in the previous year (2003).

Four subjects have been addressed in 2004.

First, the leaks of helium and of tritium have to be evaluated, for a typical design, in order to know which points must be improved, and/or which mitigation systems must be designed, in order to reduce tritium release to admissible values. The task was, in 2004, to evaluate leaks other than by permeation, this aspect being dealt with by CEA/DEN/DM2S, in 2004.

Second, tribological materials must be identified, and tested. In 2004, experiments on several of them have been done.

Third, the leak tightness of commercial or prototype static seals must be tested. A bench called HETIQ (figures 1 and 2) has been built, for this. It has been commissioned in 2004.

Fourth, the pipe containing helium from the divertor will convey a gas at about 740°C, 9.65 MPa.

A technological solution deduced from helium cooled fission reactors might consist in protecting the pressure vessel by an Inner Thermal Barrier (ITB). A mock-up called HETHIMO (figures 3 and 4) has been commissioned in 2004, in order to test several designs of ITBs.

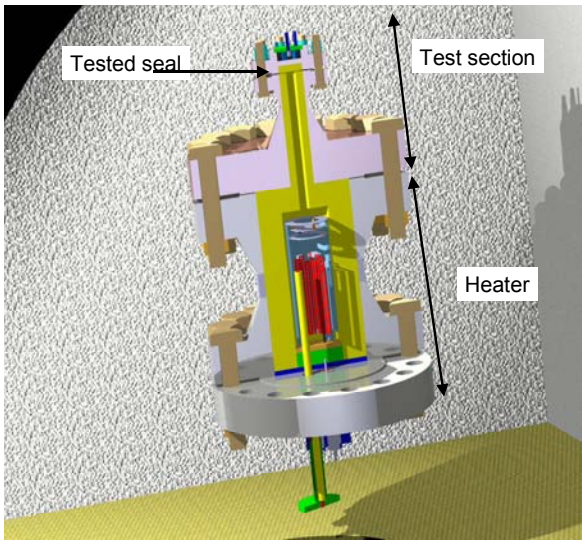

Figure 1 : HETIQ / principle

2004 ACTIVITIES

The helium leak flow of blanket cooling circuits of a 1500 MWe PPCS has been evaluated, for all leaks but those by permeation. Since rotating seals lead either to high leak flows, or to complicated circuit designs, it was assumed that these seals will be eliminated by using immersed electric motors. For other elementary leak sources, elementary data from fission reactors were extrapolated. The following table gives the detail of the leak flows. It leads to a global leak of 0.4 Nm^3 per hour, which is equivalent to a loss of 2% of the total inventory per year.

Recapitulation of helium losses of PPCS BKT and DV cooling circuits, other than by permeation

	Total leaks in m^3/h at Normal conditions	Comments	Possibility of reduction
Static seals	9.72×10^{-6}		Yes (welding)
Rotating seals	0	Electric motors immersed in helium	
Steam generator	ε	Depends on the detection capability of measurements in the water side	
Maintenance operations	0.24		Yes (lower the pressure to a fraction of p_{atm})
Isolating components	0.19		
Purification & inventory management	0	Cost of 0 leak to be evaluated	No : can only increase
Total	**0.4 Nm^3/h** 2×10^{-2} inv./y		

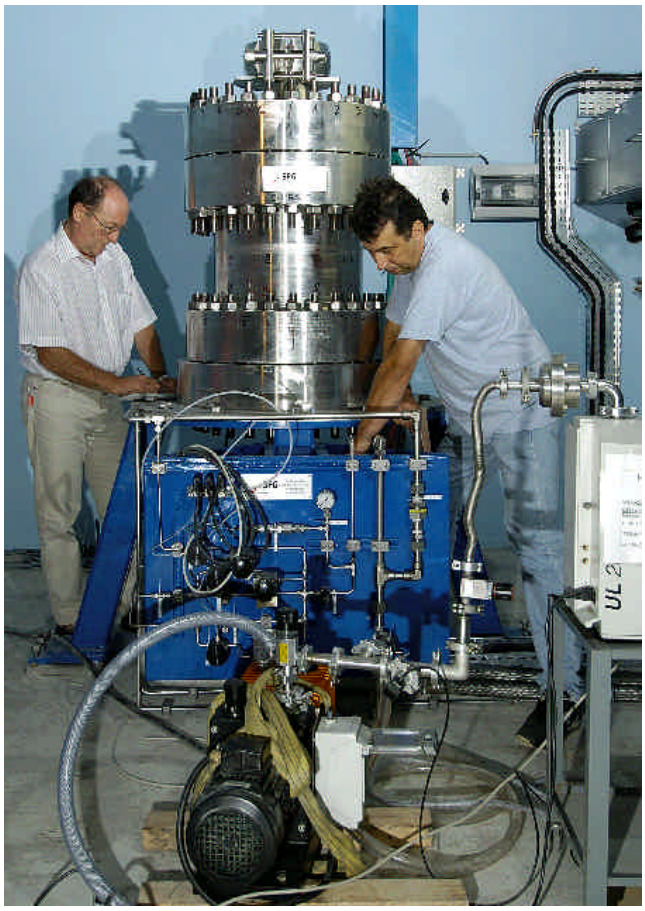

Figure 2 : HETHIMO / photograph

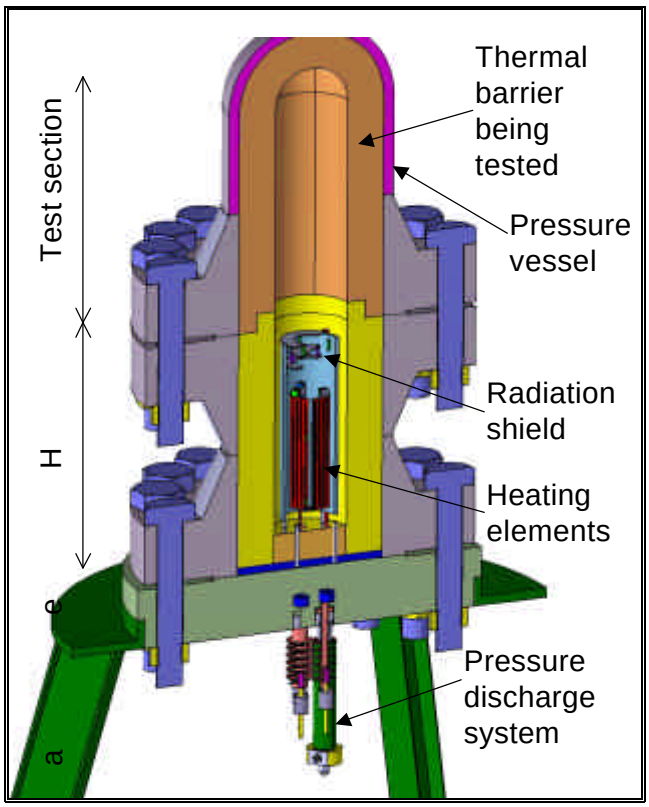

Figure 3 : HETHIMO / principle

The experience of past gas cooled fission reactors shows that leak flows have often been severely underestimated at the draft stage (by a factor 5 at DRAGON, and 20 at Fort-St-Vrain), which shows that great care must be taken for all potential leak sources.

The helium TRIBOMETER allows experiments at temperatures up to 1000°C, with controlled impurity content.

The first tests in 2004 have shown that friction materials have difficulties to go beyond 800°C, for instance with zirconia with contact pressures of 2 MPa.

This is disappointing, when compared with the performances seen in the literature, showing tests performed on zirconia at 950°C and 5 MPa of contact pressure without excessive damages. Nevertheless, this leaves some hope even for the higher DV helium temperatures (720°C or 740°C), but with a moderate margin.

The leak tightness bench, called HETIQ (Helium TIghtness Qualification) and the Inner thermal Barrier Bench, called HETHIMO (Helium THermal Insulation Qualification) have been commissioned this year.

They were tested at 1000°C, 5 bars and at 20°C, 100 bars, but not at both 1000° and 100 bars. The outer wall of the pressure vessel is at about 100°C, when helium is at 1000°C, 10 bars.

Figure 4 : HETHIMO / photograph

After a few temperature cycles, two problems occurred:

1) Cracks several centimetres long were found in the thermal barrier of the heating section, which was made of a solid material.

2) The composite graphite resistor was oxidised, to a point where it was broken.

Solutions have been found, namely, the thermal barrier is now ceramic felt, maintained by a Ni base alloy liner, and a new start-up procedure is applied, in order to avoid burning the graphite resistor. If necessary, the resistor would be changed for new materials like $MoSi_2$, or SiC, for example.

CONCLUSIONS

It seems possible to limit the leaks of the PPCs, other than permeation, to about 0.4 Nm^3/h, provided that great care be taken for the design and realization of the circuits. This assumes also that immersed rotors be used.

Candidate materials have been found for friction parts in helium. Fortunately, the higher temperatures in the PPCS are lower than 720°C or 740°C, which is lower than the limit of use of friction materials which were tested. This limit seems to be 800°C, according to the provisory results obtained.

The benches for seal tests and for internal thermal barriers tests have been commissioned, and youth problems are hopefully solved. Experiments should give first results during year 2005.

REPORTS AND PUBLICATIONS

[1] J.L. Berton - Helium and tritium leaks in the PPCs BKT & DV cooling circuits - CEA Report NT DEN/DTN/STPA/LTCG/04/032, august 2004.

[2] J.L. Berton - Report of experiments on static benches - CEA report NT DEN/DTN/STPA/LTCG/04/069, december 2004.

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