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Section 4. Breeding blanket materials

Handling of beryllium

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Abstract

The proposed Helium Cooled Pebble Bed (HCPB) blanket uses binary bed of beryllium pebbles. At Forschungszentrum Karlsruhe experiments have been performed to measure the heat transfer coefficients of such beds and their behaviour in case of thermal cycling. The main point of the paper will be the description of the adopted procedures and techniques for the handling of beryllium in these experiments.

1. Introduction

In the Helium Cooled Pebble Bed (HCPB) blanket [1] beryllium in form of a mixed bed of 2 mm and 0.1–0.2 mm size pebbles is used as neutron multiplier. In order to characterize the thermomechanical behavior of beryllium pebble beds and their heat transfer coefficients experiments have to be performed, in which, as beryllium is an extremely toxic material, the problem of a safe handling of beryllium has to be solved.

World-wide different safety standards are adopted for the beryllium handling, whereas each standard is intended to prescribe the maximum allowed beryllium concentration in the atmosphere of the work place, and how to handle beryllium in order to take its concentration in form of dust and fumes under this limit. Usually beryllium is manipulated in enclosed areas, where a local ventilation system equipped with filtration is provided. Measured volumes of air are drawn through filter papers over a known period of time and afterwards the amount of beryllium in the filter papers can be measured by using an absorption spectrometer or by chemical analysis. These are a posteriori monitoring techniques. A better method were to use real-time beryllium measurement systems, but unfortunately they are complex, expensive and as yet they are not reliable enough and not legally accepted. In the following the procedures and the devices which have been used in the handling of the beryllium pebbles for the experiments at Forschungszentrum Karlsruhe are described in details.

2. Experimental facilities

Large (2 mm) and small (0.1–0.2 mm) beryllium pebbles are used in the experiments; these particles are heated up to 550°C and helium flows through the bed. Because of the mechanical abrasion and the high temperature inside the test rig dust and fumes could arise with consequent risk of contamination. In order to solve the problem special equipment is used, which is described below.

2.1. PEHTRA (PEbble Heat TRAnsfer)

The pebble bed is in a closed steel tube and helium flows through it in the axial direction. A fine pored filter at the gas entrance holds back dusts from the gas system (see Fig. 1). The test section upper part is connected with a glove box using a flange (see Fig. 2) and filling and emptying of the test section are done inside this box. In the box the flowing helium is conveyed in a long flexible metallic tube and along this tube there are a filter and a valve which is used to regulate the helium pressure in the pebble bed. Therefore the purge gas is cooled and filtered before getting in the box.

Fig. 3 shows a schematic of the safety system used for the PEHTRA experiment. Two independent systems, P_1 and P_2 in the figure, control and maintain the pressure in the glove box about 6–10 mbar under the

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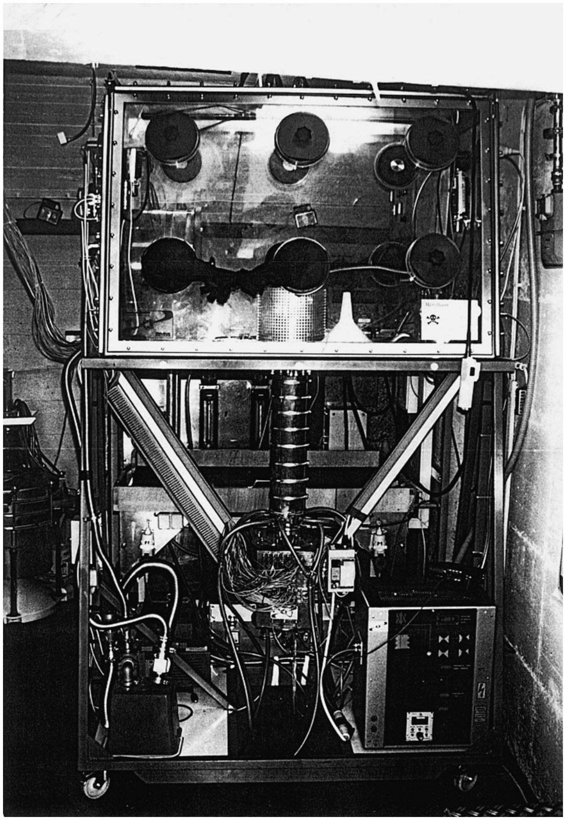

Fig. 1. Overview PEHTRA test facility.

atmospheric pressure. At the outlet of the vacuum pumps paper filters are located and the volume of gas pumped through the filters is measured with a positive displacement gas meter. The paper filters are periodically changed and the amount of beryllium in them is measured by mean of a chemical analysis. The glove box is normally filled with nitrogen and there is no oxygen inside. The concentration of oxygen is controlled permanently, in case of presence of oxygen an alarm is activated. The same happens if the pressure in the box increases, and in this case a second vacuum pump (the one that is normally used for the material lock of the box) helps reducing the pressure in the box. If, for any reason, large amount of air can penetrate in the box the pressure will increase even if both pumps are running and the oxygen concentration will equalize the atmospheric one. In this case a fine oil spray covers everything in the box. Therefore, if there was dust of beryllium, it will be bound to the walls of the box. After such an accident it can easily be wiped off and there is no danger that anybody has inhaled a toxic concentration of beryllium dust. Fig. 4 shows the PEHTRA experiment facility where, on the right, it is possible to see the oil spray device.

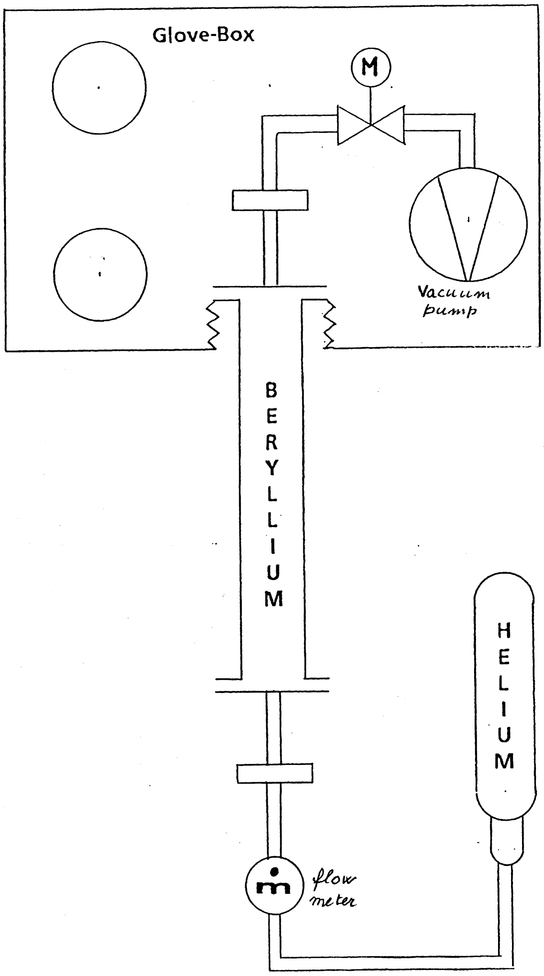

Fig. 2. Schematic of the purge gas flow in PEHTRA.

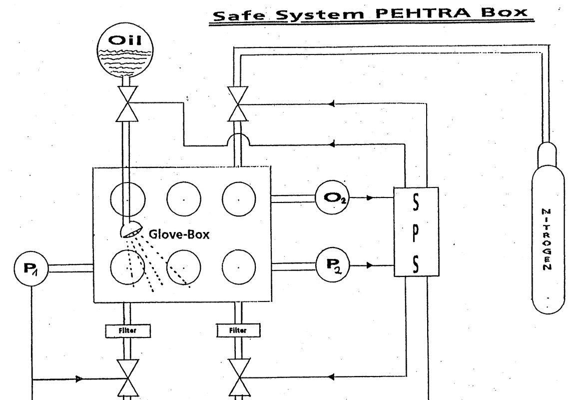

Fig. 3. Schematic of the safety system for the glove box in the PEHTRA facility.

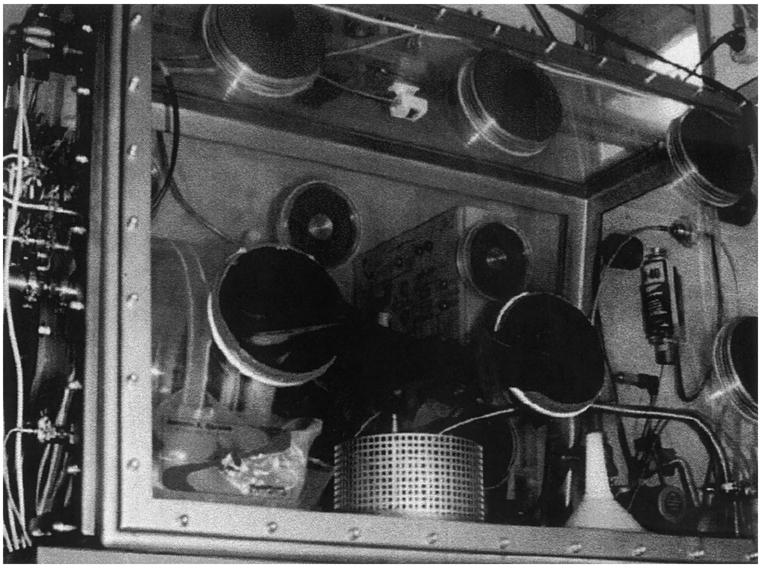

Fig. 4. PEHTRA glove box with oil spray device.

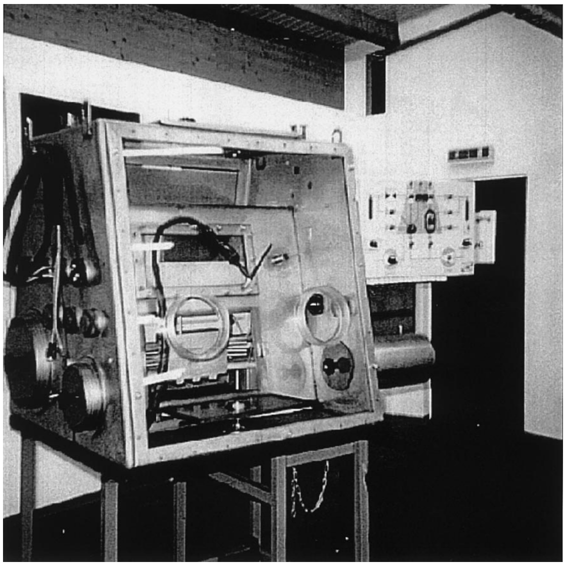

Fig. 5. HEBLO filling facility.

2.2. HEBLO (HElium Beryllium Test LOop)

In order to study the behaviour of beryllium pebble bed in presence of thermal cycling the HEBLO facility has been designed and realized in Forschungszentrum Karlsruhe (see Fig. 5). It is a box of stainless steel with many tubes and flanges. The test section has to be filled with the pebbles and then is closed by welding. According to this shape we build up a glove box with two material locks. A little one for the tools and a big one for the HEBLO test section. The safety requirements in the case of this facility do not need to be so restrictive as for the PEHTRA experiments because the glove box is only needed during the filling of the test section and its cleaning it can be used outside the box without any danger of beryllium contamination.

3. Future work

The safety system used for the PEHTRA facility is not expensive and it is reliable, therefore after the experience done with the first test section it is planned to build at Forschungszentrum Karlsruhe a new PEHTRA facility allowing the measurement of the mechanical pressure of the pebble on the containing walls of the test section. In this case a large glove box is also planned for the storing of the beryllium pebbles needed for the experiments.

References

[1] M. Dalle, Donne et al., KfK 5429, November 1994.