Assessment of the feasibility and advantages of beryllium recycling (P3-J-219)

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This paper proposes a generic route for the recycling of beryllium from fusion reactors, based on critical issues associated with beryllium pebbles after their service life in the HCPB breeding blanket. These critical issues are the high tritium inventory, the presence of long-lived radionuclides (among which transuranics due to traces of uranium in the base metal), and the chemical toxicity of beryllium.

On the basis of the chemical and rodiochemical characteristics of the neutron irradiated beryllium pebbles, we describe a possible recycling route. The first step is the detritiation of the material. This can be achieved by heating the pebbles to 800°C under an argon flow. The argon gas avoids oxidation of the beryllium, and at the proposed temperature the tritium inventory is readily released from the pebbles. In a second step, the released tritium can be oxidised on a copper oxide bed to produce tritiated water, which is consistent with the current international strategy to convert all kinds of tritiated waste into tritiated water, which can subsequently be treated in a water detritiation plant.

Removal of radionuclides from the beryllium pebbles may be achieved by several types of chloride processes. The first step is to pass chlorine gas (in an argon flow) over the pebbles, thus yielding volatile BeCl2. This beryllium chloride can then be purified by fractional distillation. As a small fraction of the beryllium chloride contains the long-lived 10Be isotope, 10BeCl2 has to be separated from 9BeCl2, which could be achieved by centrifugal techniques. The product can then be reduced to obtain high-purity metallic beryllium. Two candidate reduction methods were identified: fused salt electrolysis and thermal decomposition. Both these methods require laboratory parametric studies to maximise the yield and achieve a high purity metal, before either process can be upgraded to a larger scale.

The eventual product of the chloride reduction process must be a high purity beryllium that can be used to produce beryllium rods through a powder metallurgy route, which is a mature industrial process. Beryllium rods feed the Rotating Electrode Method to manufacture beryllium pebbles for re-use in the HCPB breeding blanket.

The proposed recycling route features a number of remaining uncertainties that need to be resolved, including the development of remote handling techniques and the development and optimisation of the chloride processes. These uncertainties make it impossible to assess the cost of the recycling route at this moment.