Some views on the design and fabrication of targets or fuels containing curium

J. Somers, A. Fernandez, R.J.M. Konings
European Commission, Joint Research Centre Institute for Transuranium Elements
P.O. Box 2340, 76125 Karlsruhe, Germany

G. Ledergerber
Kernkraftwerk Leibstadt AG, CH-5325 Leibstadt, Switzerland

The implementation of partitioning and transmutation of actinides has major implications for many processes in the nuclear fuel cycle. If not only plutonium, but also americium and curium are to be recycled, the increased gamma and neutron radiation dose will require significant shielding of the fuel cycle facilities (by lead and water/polyethylene) and makes remote handling and process automation unavoidable. Especially the neutron radiation of curium will pose serious problems in this respect. For this reason there is a need to simplify the processes, limit the number of process steps and minimise the waste produced.

In the present paper the implications of the presence of curium on the fabrication of fuels and targets for transmutation will be discussed. Traditional fabrication processes based on powder blending and pellet pressing are not suited for this purpose at all. Wet chemical processes are preferred as they do not produce dust, as is the case with powder blending, although the effect of radiation-induced dissociation of water has to be considered. The infiltration technique offers a solution to both problems. The actinide solution is infiltrated into precompacted pellet or spheres. After the final thermal treatment the pellets are stacked or the spheres are packed in a fuel pin. The infiltration of pellets has the disadvantage that the amount of actinides (curium) that can be incorporated in the matrix is low. Therefore the possibilities offered by the sphere-pac concept needs to be revisited and evaluated.

The fabrication of the sphere-pac fuel should consist of a sol-gel step to produce the fuel (e.g. ThO_2, $(Th,Pu)O_2$) or target (e.g. $(Zr,Y)O_{2-x}$) matrix in a glove box or in a normal laboratory, respectively. The curium is then infiltrated in these sol-gel spheres in a shielded unit of limited size. Once sintered, the spheres can be loaded into a fuel pin with minimal risk of contamination of the unit and a close-packed configuration can be reached by a simple vibration. The spheres produced must be monodisperse and two different sizes are required (e.g. 800 µm and 180 µm) to reach a smeared density of about 75-78%. In addition, the small size fraction could be a different material, e.g. a metal, to improve the thermal conductivity. The sphere-pac concept would have the additional advantage that sufficient porosity is present in the pin to accommodate swelling of the material due to accumulation of helium that is formed in the transmutation process of americium and curium. The feasibility of this concept will be discussed.