FUEL PARTICLE DESIGN FOR A FLUIDIZED BED REACTOR

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INTRODUCTION
This article describes the dimensioning of fuel particles and the fundamental reactor physics mechanisms of a fluidized bed reactor [1]. The reactor consists of a graphite cylinder with outer diameter of about 3 meters and height of 8 meters. Inside the cylinder, a core cavity with cross section of 1 m² and height of 6 meters is partly filled with small spherical particles, so-called TRISO particles [2], containing a fuel kernel surrounded by graphite and SiC layers. The outer diameter of these particles was varied. Low enriched UO₂ is used as fuel. Helium is used as coolant, which flows through the core cavity in upward direction, thereby suspending the particles.

The design of the reactor ensures inherently safe operation. In collapsed state, the core is strongly subcritical. Upon increasing the helium flow, the particle bed becomes fluidized and the effective moderator-to-fuel ratio increases, giving rise to an increase of $k_{eff}$. For helium flows too large, the reactor is overmoderated and $k_{eff}$ decreases again. As a consequence, with a proper choice of system parameters, the reactor is critical only for a very limited range of coolant flows.

Besides the inherently safe character of the reactor, other advantages are the high specific power (power per unit mass of fuel inventory) and the on-line fueling capability. Like pyrolytic carbon layers, the silicon carbide layers of the coated particles prevent the escape of fission products from the fuel particle. Furthermore, the design of the core and reactor is very simple, which together with the modular concept paves the way to cheap and safe nuclear power.

CALCULATION PROCEDURES
First, the $k_{infty}$ of the fuel particles was calculated for different diameters of the fuel kernels and for different moderator-to-fuel atomic ratios. The fuel enrichment of the UO₂ fuel kernel was 17%. Because the neutrons mean free path is much larger than the thickness of the TRISO layers, these were homogenised. The resultant atomic densities are $6.94 \times 10^{22}$, $8.11 \times 10^{21}$, $2.0 \times 10^{16}$ and $8.05 \times 10^{16}$ atoms per cm³ for C, Si, $^{10}$B and $^{11}$B, respectively. The particles were assumed to be at room temperature. The coolant density is $2.42 \times 10^{-3}$ grams per cm³ which corresponds with He at temperature of 1000 K and pressure of 50 bars.

The calculations were performed by use of the CSAS driver of the SCALE system [3]. This uses the codes BONAMI-S and NITAWL-II to calculate resonance-shielded cross sections by the Bondarenko method in the unresolved region and by the Nordheim method in the resolved region. The discrete-ordinates code XSDRNP-PM-S was used to calculate the neutron spectrum and the eigenvalue and to produce cell-weighted cross sections for the core calculations described further on. The