Thorium Fuel Performance in Light Water Reactors

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Thorium has several advantages over uranium as a fertile fuel for Light Water Reactors. These advantages are from the standpoint of both fuel reactivity and nonproliferation. During the past year, research has been performed at Purdue University on the utilization of thorium-based fuels in Light Water Reactors as part the Nuclear Energy Research Initiative (NERI) program. This research has investigated the performance of thorium in existing, as well as in advanced LWR concepts. The analysis was performed using the Studsvik/Scandpower lattice physics code HELIOS and the U.S. NRC neutronics core simulator PARCS coupled to the thermal-hydraulics code RELAP5. Equilibrium cycle cores fueled with thorium were developed for existing LWRs, for next generation LWRs such as the Simplified Boiling Water Reactor, as well as for high conversion LWRs such as the JAERI Reduced Moderator Water Reactor (RMWR) design. The results show that there are several advantages to utilizing thorium-based fuels in these reactors. These advantages will be described in terms of fuel conversion ratio, reactivity control, fuel non-proliferation and a reduced production of long-lived radiotoxic wastes. Of particular interest is the attractive safety performance of thorium in hard spectrum reactors. Unlike U^{238} fertile fuels, the void reactivity coefficient with thorium-based fuels is negative in a hard spectrum reactor. The disadvantages in thorium fuel cycles, such as slightly higher fuel cycle costs, will also be described. But in general, there appears to be sufficient motivation to consider replacing U^{238} with Th^{232} in

certain Light Water Reactor designs. In particular, thorium appears to be a suitable fuel for the next generation designs such as the SBWR and the advanced hard spectrum LWRs (AHSLWR), such as the Reduced-moderator reactor (RMWR) or the Supercritical reactor (SCR) which are currently being considered as "Generation IV" reactor concepts by the U.S. DOE. For the SCR an innovative "metal matrix" dispersion thorium fuel design was introduced which appears to be particularly attractive because of its improved fuel thermal performance.