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Thorium reactors may dispose of enormous amounts of weapons-grade plutonium

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Ass. Prof. Sergey Bedenko demonstrates a simulation model of high-temperature gas-cooled reactors with thorium fuel. Credit: Tomsk Polytechnic University

Scientists from the School of Nuclear Science & Engineering of Tomsk Polytechnic University are developing a technology for the creation of high-temperature, low-power reactors with thorium fuel. The scientists propose to burn weapons-grade plutonium in these units, converting it into power and thermal energy. Thermal energy generated at thorium reactors may be used in hydrogen industrial production and for desalinating water. The results of the study were published in *Annals of Nuclear Energy*.

Thorium reactors are used in areas where there are no large water bodies and rivers, which are needed for classical reactors. They can also be used in arid areas as in remote areas of Siberia and the Arctic. Associate Professor Sergey Bedenko from the School of Nuclear Science & Engineering says, "As a rule, a nuclear power plant is constructed on the riverside. Water is taken from the river and used in the active zone of the reactor for cooling. In thorium reactors, helium is applied, as well as carbon dioxide (CO2) or hydrogen, instead of water. Thus, water is not required."

The mixture of thorium and weapons-grade plutonium is the fuel for the new kind of reactors.

Sergey Bedenko says, "Large amounts of weapons-grade plutonium were accumulated in the Soviet era. The cost for storing this fuel is enormous, and it needs to be disposed of. In the US, it is chemically processed and burned, and in Russia, it is burned in the reactors. However, some amount of plutonium still remains, and it needs to be disposed of in radioactive waste landfills. Our technology improves this drawback since it allows burning 97 percent of weapons-grade plutonium. When all weapons-grade plutonium is disposed of, it will be possible to use uranium-235 or uranium-233 in thorium reactors."

Notably, the plant is capable of operating at low capacity (from 60 MW), the core thorium reactors require a little fuel and the percentage of its burnup is higher than that at currently used reactors. The remaining 3 percent of processed weapons-grade plutonium does not present a nuclear hazard. At the output, a mixture of graphite, plutonium and decay products is formed, which have no industrial applications and can only be buried.

Sergey Bedenko says, "The main advantage of such plants is their multifunctionality. First, it efficiently disposes of one of the most dangerous radioactive fuels in thorium reactors, and second, it generates power and heat. Third, it will contribute to industrial hydrogen production."

The authors of the study say that the advantage of such reactors is their higher level of safety in comparison with traditional designs, enhanced efficiency (40 to 50 percent), absence of coolant phase transitions, increased corrosion resistance, the possibility of using different fuels and their overload in operation, and simplified management of spent nuclear fuel.

Thorium fuel can be used both in thorium reactors and widely spread VVER-1000 reactors. The scientists expect these reactors to function at least 10 to 20 years, and when this fuel is spent, the core reactor may either be reloaded or disposed of. In addition, water can be desalinated at thorium reactors.

More information: I.V. Shamanin et al, Neutronic properties of high-temperature gas-cooled reactors with thorium fuel, *Annals of Nuclear Energy* (2017). DOI: 10.1016/j.anucene.2017.11.045

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