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The fourth-generation reactor "Neptune" is a step towards closing the nuclear fuel cycle

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Periodic pulsed reactors were suggested for the first time by Dmitry Blokhintsev in nineteen-fifty-five. The new idea solved the problem of low neutron flux after choppers in constant power reactors to create neutron pulses for the time-of-flight method. And the problem of low flux needed to spectroscopy in aperiodic pulsed reactors. The maximum power of these reactors can reach to a very high levels for a very short time combined with a very high neutron flux at the peak of pulse. Far away from the pulse, the reactivity has a constant negative value, and the reactor power in this period (between pulses) also has a constant value depending on the delayed neutron source. And as the moving part of the reactor approaches the rest of the reactor parts, the reactivity increases until it reaches a certain moment (-t0) and the pulsebegins. The reactivity continues to increase until the moving part begins to move away from the rest of the reactor parts, and the reactivity begins to decrease until the moving part moves away completely then the reactivity returns to zero at the moment (+t0). Between these two moments the number of fissions increases rabidly and the reactor power starts to increase and accumulate until the reactivity returns to the zero then power production stops and begins the cooling process.The half width of neutron pulse which called (ceta-half) is comparable with aperiodic pulsed reactors. And the average power which defined as (the total energy released during the pulse divided by the duration of the pulse) is comparable with constant research power reactors, the main advantage of these reactors is that the power can reach a very high level for a very short time while the constant power reactors can't do the same. Np-237 is an artificial isotope with a half-life of 2 million years. It is formed in nuclear uranium fuel as a result of the beta decay of U-237, which is formed in fast reactors by the (n, 2n) reaction from U-238, or by double capture in U-235 in thermal reactors. Neptunium is considered one of the most significant spent-fuel wastes; one VVER reactor unit produces 13–14 kg of neptunium per year.The main features to choose the Np as a fissile material instead of uranium or Pu are shown in the slide. Recovering and reusing Np as a nuclear fuel helps solve the spent-fuel problem and close the nuclear fuel cycle. The main feature of Np is the very short prompt generation time (the generation time is the time from the birth of neutron to its absorption which leads to fission and production a secondary neutrons). The short generation time increases the total number of fissions in Np 7 times more than that in Pu at the same power, and enable having a short pulse of neutrons. Because of the Np is a threshold isotope, with a fission threshold of 0.4MeV, the effective delayed neutrons will be very low, and the background power will be at the minimum.The fission threshold property of Np allows using a moderating material to modulate the reactivity. The neutron radiative capture in Np will produce a good fissile material, there is no reactivity effect from the fuel burnup.

Summary

Presenter: Dr ХАССАН, Ахмед (ОИЯИ - ЛНФ)

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