Abstract for ICONE-9

Date: 13 Oct 2000

Title: Impact of Proton Beam Trips and
Pulsation on Accelerator-Driven Subcritical System
(ADSS)Control

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Abstract

Presently accepted ADSS system concepts use a source consisting of a proton beam directed into a high-Z target, such as tungsten or lead, driving a (p,n) spallation reaction. This results in a neutron source which is meant to sustain a constant rate of fission power production in the fuel.

However, conceptual ADSS studies to date have not taken two special attributes of these sources into account, usually using the simplifying assumption that the spallation source is constant and continuously variable. These are: (1) proton beams under consideration for ADSS sources are pulsed at a certain frequency, which would suggest that the neutron source for the ADSS is also pulsed since the spallation reaction is prompt; (2) while shutting off the beam is the usual answer to safety questions, this poses its own set of issues. Even state-of the-art proton beams are prone to routine and frequent trips, with beam restart times ranging from seconds to hours.

Both of these attributes could place system components under severe thermal stress from temperature pulsing and cycling. The strong, subcriticality-level-dependent feedback effects that occur in an ADSS can introduce transient power swings and oscillations that may need to be controlled or abated by source modulation and/or control rod motion. Earlier work [1] indicates that such feedback effects may lead to unpredictable behavior, affecting restart performance and requiring active control measures to prevent or mitigate such effects.

And there is a further consideration. Since efficient operation of ADSS-based systems may suggest that a system operates near, though below, critical, the actual operation of such a system means that the operator would need to walk a fine line between safety and efficiency [2]. Routine and relatively frequent beam-source trips introduce new issues of beam restart strategy and post-trip criticality control, since a tripped just-subcritical fuel-moderator system which had been at full power with no criticality controls could cool to criticality -- or decrease the margin of subcriticality -- with cooling, so that a tripped beam would be restarting into a different and possibly more reactive fuel-moderator system.

The intent of this effort is to examine control and safety issues posed by pulsed and trip-prone neutron sources in near-critical ADSS's, using spreadsheet-based simulations [informed by the results of earlier work] to develop scenarios and highlight control issues posed by pulsed sources and various trip/restart scenarios. Our preliminary results demonstrate the feasibility of this approach.

References

1) M.L.Woosley and R.A. Rydin, Nuclear Science and Engineering, May 1998, vol. 129, no. 1

2) P. Sullivan and R.A. Rydin, "Control Issues in Accelerator-Driven
Subcritical System Design" [paper 8555], ICONE-8, April 2000,
Baltimore, Maryland