Concept Design and Thermal-hydraulic Analysis for Helium-cooled ADS

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ABSTRACT

The Accelerator Driven Subcritical Reactor System (ADS) is a kind of nuclear reactor which can burn minor actinide waste products produced from conventional reactors with inherent safety features. In this paper, a concept design of 10MW helium-cooled experimental ADS with prismatic reactor core and solid target is presented.

The subcritical core is divided into a fast neutron zone and a thermal neutron zone. There is only one kind of hexagonal prism fuel assembly in the fast neutron zone, and the coated fuel particles disperse in these assemblies. And there are three kinds of hexagonal prism pin-in block type fuel assembly which contains hexagonal graphite block and annular fuel rods in thermal neutron zone. Because of the characteristics of a subcritical reaction process, the fission chain reaction is maintained by additional neutrons generated in spallation target induced by proton beams. Tungsten is chosen as the spallation target material and is modeled into the honeycomb structure. The high pressure helium is used as coolant for both the core and the spallation target.

The thermal-hydraulic model and corresponding code for ADS was built, in which the solid domain was simulated with three-dimensional heat conduction model and the fluid domain was simulated with the one-dimensional quasi-static model. The results indicate that the peak temperature in core and target is lower than the limiting values under operating state.

KEYWORDS
ADS, Helium-cooled, Prismatic block core, Solid target

1. INTRODUCTION

With the large-scale application and development of nuclear energy, post processing of spent nuclear fuel became a subject of much attention, because of the radioactivity of fission products (FPs) and minor actinides (MAs), as well as the low utilization of fuel. Recently the Accelerator Driven System [1,2] (ADS) is introduced for transmutation of spent nuclear fuel. In ADS, a high-energy proton beam strikes a heavy element target [2,3], which yields copious neutrons by (p, x n) spallation reaction, and the target drives fission chains in a subcritical core.

The liquid-metal-cooled ADS [4,5,6] attracts the most attention in the field of ADS, in this framework the liquid-metal spallation targets (such as window target and windowless target) [7,8] are the scheme most talked about. Meanwhile, with the established technologies and the inherent thermal safety of High Temperature Reactors (HTR), the gas-cooled ADS [9,10] which we adopted is also a promising scheme. As for the spallation target, liquid-metal target and gas-cooled solid target are all the candidates. In view of

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