IMPROVED DESIGN OF GEMINI+ CORE, THE VERSITILE HTGR FOR POLIGENERATION

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GEMINI 4.0 is a project initiated by the Nuclear Cogeneration Industrial Initiative, the last one of a series of Euratom funded projects dedicated to nuclear high temperature process heat supply to industry. Within the previous project (GEMINI Plus) the design of the core, internals and reactor pressure vessel (RPV) was proposed. GEMINI+ is high temperature gas cooled type reactor with core made of graphite prismatic fuel blocks cooled by helium with the thermal power of 180MW. It has large height-to-diameter ratio in order to maximize passive heat removal through RPV wall but also to allow the transport as a module. Safety analyses performed for selected accident scenarios showed low margin to limits agreed for the fuel and RPV. In the context of GEMINI 4.0 project, a strategic decision was made to enhance and refine the design for improved performance and safety. The primary goals were carefully outlined to address critical aspects of the reactor's operation under various states. Among the most significant objectives were the reduction of the maximum fuel and RPV temperatures during both the Pressurised Loss of Forced Cooling and the Depressurized Loss of Forced Cooling scenarios. Achieving a decrease in these temperatures is essential to maintaining the integrity of the reactor core during these emergency situations. Another key goal was to optimize the reactor's physical configuration by reducing the height of the core and control rods. This modification aims to improve reactor transportability. Furthermore, attention was directed toward limiting neutron fluence within the RPV by adding extra replaceable reflectors, an important factor in extending the life of the reactor and ensuring its structural integrity over the long term. By managing the neutron flux more effectively, the design aims to minimize material degradation and enhance the overall sustainability of the reactor. Additionally, a critical design consideration was to separate the reserved shutdown system from the channels and devices associated with control rods. This separation ensures that the shutdown system remains fully functional and independent, even in the event of failures affecting the control rod system. Such a design choice enhances the overall safety and redundancy of the reactor, offering greater assurance that it can be safely shut down under any circumstances. To achieve these objectives, several core configurations were thoroughly proposed and evaluated. Each configuration was designed with careful consideration of the interplay between fuel management, heat dissipation, neutron flux control, and the structural design of the reactor. These proposed configurations were rigorously assessed for their potential to meet the defined safety and performance criteria, ensuring that the enhancements would lead to a more efficient, reliable, and safe reactor design.

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