

The DEMO fuel cycle – novel technologies for tritium inventory reduction

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In the framework of the EUROfusion Programme the EU is preparing the conceptual design of the fuel cycle for a pulsed fusion DEMO. Over the last years, a completely novel and most innovative fuel cycle architecture has been developed, driven by the need to reduce the tritium inventory to an absolute minimum.

To achieve this goal, batchwise processes used in the fusion fuel cycle so far were replaced by continuous processes wherever possible. This includes the change from discontinuous cryopumping to mercury based continuous vacuum pumping with zero demand on cryoplant power, and the introduction of thermal cycling ab- and adsorption processes for isotope separation in the tritium plant instead of large cryogenic distillation columns with tritiated liquid hold-ups. To further reduce inventory, the well-known approach to route all exhaust gas through the tritium plant has been abandoned in favor of a three-loop architecture. There, superpermeable metal foils are introduced in the divertor ports to separate a pure DT stream which is then immediately recycled to feed the pellet injection systems. Continuous re-injection of the exhaust gas can artificially increase the wall recycling coefficient and hence allows to increase the burn-up fraction which results in reduced gas throughputs needed to maintain a stable plasma operation at acceptable fuel dilution. To increase the core fueling efficiency, optimization potentials in the design of the high field side guiding tube systems are being exploited. The tritium accountancy system under development will rely on modern, real-time and online tritium instrumentation. Finally, a unified fuel cycle simulator is under development on a commercial software platform in order to identify optimization potentials within the fuel cycle, to allow impact studies, and on a long term to support the development of tailored control and operational strategies.

The paper presents the first integrated and consolidated design point of the fuel cycle based on the 2017 European DEMO baseline. It is shown how the DEMO requirements are picked up and affect system level performance. Examples are given for integration issues and how they were solved. Finally, a roadmap is delineated which illustrates the remaining R&D efforts needed to achieve at a validated and complete conceptual design until the mid 2020s.

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