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Liquid lithium loop system to solve challenging technology issues for fusion power plant

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Steady-state fusion power plant designs present major divertor technology challenges, including high divertor heat flux both in steady-state and during transients. In addition to these concerns, there are the unresolved technology issues of long term dust accumulation and associated tritium inventory and safety issues. It has been suggested that radiation-based liquid lithium (LL) divertor concepts with a modest lithium-loop could provide a possible solution for these outstanding fusion reactor technology issues, while potentially improving the reactor plasma performance. The application of lithium (Li) in NSTX resulted in improved H-mode confinement, H-mode power threshold reduction, and reduction in the divertor peak heat flux while maintaining essentially Li-free core plasma operation even during H-modes. These promising results in NSTX and related modeling calculations motivated the radiative liquid lithium divertor (RLLD) concept and its variant, the active liquid lithium divertor concept (ARLLD), taking advantage of the enhanced Li radiation in relatively poorly confined divertor plasmas. To maintain the LL purity in a 1 GW-electric class fusion power plant, a closed LL loop system with a modest circulating capacity of ˜ 1 liter/second (l/sec) is envisioned. We examined two key technology issues: 1) dust or solid particle removal and 2) real time recovery of tritium from LL while keeping the tritium inventory level to an acceptable level. By running the LL-loop continuously, it can carry the dust particles and impurities generated in the vacuum vessel to the outside where the dust / impurities can be removed by relatively simple dust filter, cold/hot trap and/or a centrifugal separation systems. With a 1 l/sec LL flow, even a small 0.1% dust content by weight (or 0.5 g per sec) means that the LL-loop could carry away nearly 16 tons of dust per year. In a 1 GW-electric (or ˜ 3 GW fusion power) fusion power plant, about 0.5 g / sec of tritium is needed to maintain the fusion fuel cycle assuming ˜ 1 % fusion burn efficiency. It appears feasible to recover tritium (T) in real time from LL while maintaining an acceptable T inventory level. Laboratory tests are also planned to investigate the Li-T recover efficiency with the SCT concept and also to assess the viability of the centrifugal Li-T separator with consultation with the manufacturer.

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