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Assessment of Cavitation Erosion Risk in the Liquid-Lithium Flow in IFMIF-DONES

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The configuration of the Early Neutron Source (ENS) is the IFMIF-DONES (DEMO Oriented Neutron Source) approach, based on an IFMIF-type neutron source. It aims providing an intense fusion-like neutron spectrum with the objective to qualify on an accelerated time scale structural materials to be used in the future DEMO fusion reactor. IFMIF-DONES is based on the interaction of single 40MeV 125mA deuteron beam impacting a flowing liquid lithium target to simulate DEMO like neutron flux spectrum for fusion material irradiation experiments. Herein, the behavior of the high-speed (up to 15m/s) free-surface liquid lithium impacted by the deuteron beam is one of the key functional issues. Since it is practically unfeasible to avoid geometrical discontinuities such as steps, obstacles or gaps in engineering designs, a realistic assessment in terms of magnitude and location of the potential cavitation in the lithium system components is needed.
The present work focuses on the numerical investigation of cavitation phenomena in the lithium flow at IFMIF-DONES relevant operation conditions. The Lithium flow is affected by different geometrical discontinuities on the channel walls. This has been simulated by means of an unsteady Reynolds –averaged Navier-Stokes (URANS) method. Calculations reproduce different cavitation processes depending on the kind of the wall surface discontinuity. In case of the flow over the lateral gaps, in the channel lithium gaseous phase generated within the gap remains stable and does not collapse. Simulations of the lithium flow over the backward-step show the generation of the gaseous lithium phase within the flow separation area and formation of a stable sheet cavity on the wall surface. The subsequent breakup of the sheet cavity in the flow reattachment region is accompanied by generation and collapse of unstable vapor structures downstream. The development and collapse of the vapor structures can induce cavitation erosion of the wall surface. The risk of cavitation induced erosion on the wall surface is assessed using a function based on the mean value of the time derivative of the local pressure.
The applied method provided the efficient identification of cavitation areas with high erosion risk in the Lithium flow systems. The knowledge obtained from the analysis result is used for the optimization of the Lithium flow conditions in the new design of the Lithium target and quench tank systems.
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