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Study on the Compatibility of Argon Seeding with Helium Exhaust in a Radiative Divertor

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The simultaneous management of extreme heat fluxes on divertor targets and the efficient removal of helium (He) ash are critical challenges for steady-state fusion reactor operation. This study investigates the compatibility of the argon (Ar) seeding radiative divertor strategy—a primary heat mitigation technique—with the essential requirement of helium exhaust.

A systematic scan of the argon injection rate was conducted to achieve varying degrees of divertor detachment. The analysis reveals a non-linear relationship between the detachment degree and helium exhaust efficiency, characterized by an optimal window. During the deep energy detachment phase, the neutral pressure in the divertor initially increases, benefiting helium accumulation and compression. However, pushing detachment too far leads to a subsequent drop in neutral pressure, which becomes detrimental to exhaust. This finding underscores that an optimal detachment level must be precisely controlled to balance heat load reduction with efficient ash removal.

In conclusion, this study confirms that compatibility between an Ar-seeded radiative divertor and efficient helium exhaust is achievable. The key to success lies in operating within an optimal window of detachment. This approach simultaneously enables robust heat flux control and maintains high helium exhaust efficiency, providing a crucial integrated solution for the design of next-generation fusion reactors.

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