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Impurity Seeding on JET to Achieve Power Plant like Divertor Conditions

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Power exhaust is recognised to be one of the major challenges to achieving power generation by magnetically confined thermonuclear fusion. In order to reduce the power density conducted to the divertor targets to a level that can be tolerated by available technologies it will be necessary to radiate close to 100% of the exhaust power. Although it is foreseen that a significant fraction of this radiation will be from within the separatrix, H-mode confinement requires the threshold power to be radiated from the scrape-off layer and divertor. Such high radiation levels necessarily require detachment of the divertor plasma, a regime which to present has not been convincingly modelled by state of the art boundary codes. It is therefore essential that relevant experimental results are used to justify the existence and practicality of such a solution.
The main challenges and uncertainties of a highly radiating solution are: whether the required edge radiation levels and distribution can be achieved, along with acceptable core dilution; understanding the exact requirements to achieve H-mode confinement; and establishing the overall thermal stability. JET with its all metal wall and the absence of an intrinsic edge and divertor radiator is particularly suited to investigating these issues, and targeted experiments began in 2013. At varying input power levels feed-forward impurity seeding of neon, nitrogen, and argon, has been used in moderately fuelled low triangularity vertical target configuration plasmas to push to the maximum achievable radiation levels.
To present only up to 75% radiated power fraction has been achieved for nitrogen seeded plasmas with ~20MW of input power. It has not yet been determined whether this is the limit, but the increase in radiation fraction becomes an increasingly weak function of the seeding rate as the rate increases. Slightly lower maximum radiation levels were achieved with neon and argon (63% and 70%), and the details of the radiation distribution and its dynamics were markedly different. The results of these experiments and the implications for a power plant will be discussed in this paper.
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