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Comparison of radiative divertor behavior in Ar and Ne seeded plasmas in EAST

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In ITER and future fusion devices, a high radiation level for power exhaust will be mandatory to avoid thermal overload of divertor targets. Increasing divertor radiation by injecting impurities is a general and effective method to reduce scrape-off layer heat flux and to cool the divertor plasma to detachment. Impurities such as nitrogen (N2), neon (Ne) and argon (Ar) have been widely used in radiative divertor experiments on several tokamaks. Last two years, Ar and Ne impurities were seeded respectively as the radiator from EAST upper divertor which upgraded into ITER-like full tungsten PFCs in 2014 to investigate their effects to plasma behavior, especially in the divertor region.
According to the cooling factor of Ar and Ne, which is closely associated with electron temperature, mixture of Ar/D2 was firstly seeded from the upper divertor region as a radiator. To compare with Ar impurity, then experiments under similar plasma parameters'condition and the same gas puff position with Ne seeding, including pure Ne and Ne/D2 mixture, were carried in 2016 campaign. In this work, both Ar and Ne impurity showed the high efficiency in reducing particle flux and heat load on divertor targets. After impurity seeding, saturation ion current, Is, electron temperature, Te, and heat flux on divertor target, qt, decreased rapidly. In this case, the inner divertor first entered the detached state and the outer divertor followed the inner one soon. However, these two impurities showed clearly different radiation behavior. Compared with Ar impurity, the rise of radiation in Ne seeded plasma more located in the divertor region. It was more difficult for Ne to enter the plasma core region than Ar because the former belongs to a kind of low-Z impurity and has a lower cooling factor in the core region. After the gas puffing was terminated, it took 1~2s for the rise of radiation caused by Ar impurity to gradually drop down to the initial state, while the radiation after Ne seeding remained in a rising state until plasma burned out. The reason may be that Ar impurity quickly ionized but Ne impurity stayed in fluctuated ionization-recombination state due to the cooled plasma near the divertor target region where the low electron temperature as low as below 8 eV. With regard to impurities, there were notable increases and decreases of Li, C and tungsten impurity after the Ar impurity was seeded. These impurities, observed by the divertor impurity spectroscopy, dominated over all other kinds of impurity. However, these impurities presented a relatively low level in Ne seeded plasma. Therefore, it is indicated that using Ne as radiator preferentially in controlling PWI issue in radiative divertor experiments.
In addition, through Supersonic Molecular Beam Injection (SMBI) and divertor piezo valve collaborative control, we obtained the active feedback controlled radiative divertor operation last December. In this case, the rate of radiation loss, frad, could reach 40%, which is of great significance for the goal of long pulse high performance operations in EAST.

Eligible for student paper award?

Yes

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