The effects of powder real-time injection for achieving long-pulse H-mode discharges in EAST

W. Xu[1,2], X.C. Meng[1,2], Z. Wang[2], Z. Sun[3], G. Z. Zuo[2] and J. S. Hu[2]
[1] Institute of Energy, Hefei Comprehensive National Science Center, Hefei, Anhui 230026, China
[2] Institute of Plasma Physics, Hefei Institutes of Physical Science, Chinese Academy of Sciences, Hefei, Anhui 230031, China
[3]Princeton Plasma Physics Laboratory, 100 Stellarator Road, Princeton, NJ 08540, USA
e-mail (speaker): xuwei@ie.ah.cn

The great increase in plasma discharge duration and plasma energy in next step fusion devices will give rise to important plasma-material interaction effects that will critically influence the plasma operation and performance. Impurity and fuel recycling are both two key issues for the achievement of long pulse and high parameters plasma discharges.

EAST is a full metal wall machine with tungsten divertor and molybdenum armour which is similar to the entire tungsten wall in ITER. We report the basic behaviors of fuel recycling and impurity accumulation during >100s long-pulse H-mode plasma under full metal wall conditions on EAST. Significant fuel recycling and impurity rising, particularly from heavy impurities, have been observed when operating with a bare metal wall or a deteriorate real-time coated wall, which severely limits the duration of H-mode discharges. To address this issue, a novel dynamic wall coating technique combining feedforward and feedback controls has been successfully developed. The feedforward control regulates the Li powder injection rate based on pre-existing experimental data, whereas the feedback control dynamically modulates the Li injection rate in response to real-time Li-II line emission measurements. Using this approach, a 605-second H-mode plasma has been achieved with fuel recycling and impurity level maintained stable. This result extends the previous record of a 403-second long-pulse H-mode plasma by over 200 seconds. It demonstrates the effectiveness of the dynamic powder injection technique in controlling fuel recycling and impurities accumulation, while prolonging plasma duration. These findings offer valuable insights into potential applications of other low-Z powder, such as boron, in ITER.

References
[1] W. Xu et al., 2021 Phys. Scr. 96 124034
[2] W. Xu et al., 2023 Nuclear Materials and Energy, 34 101359

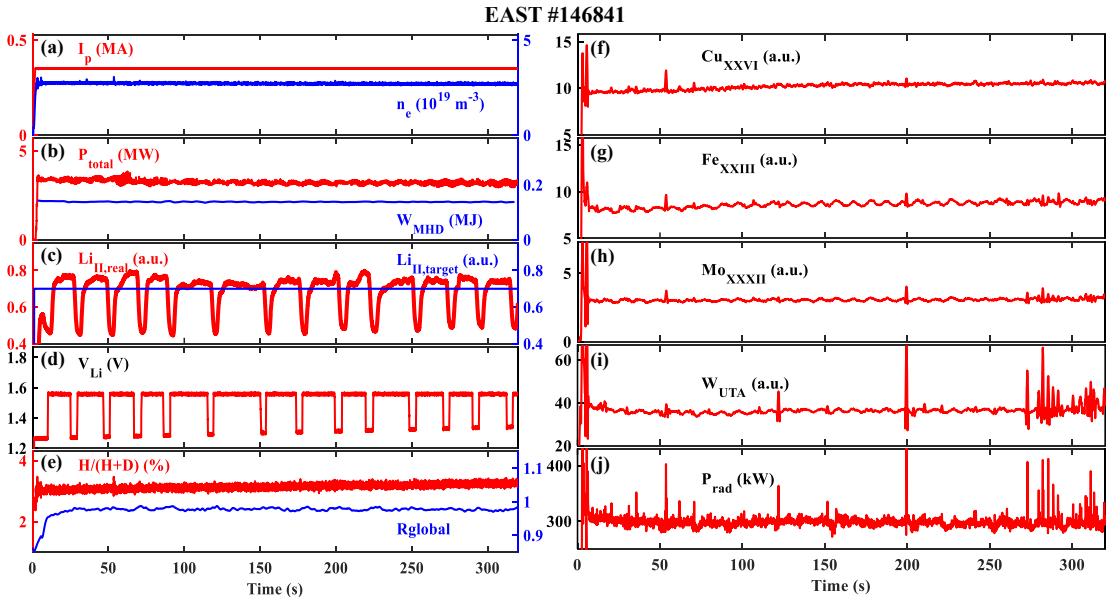

Figure 1. The minimum flow rates for boron powder actively conditioning first wall in EAST (#125403 without boron, #125393 with 1.0 mg/s and #125395 with 2.0 mg/s)