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EX/P5-10: Efficiency of Fuel Removal: Overview of Techniques Tested on Plasma-Facing Components from the TEXTOR Tokamak

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Curtailing of long-term fuel inventory in plasma-facing components (PFC) is one of the most critical and challenging issues to be resolved in order to ensure safe and economically viable operation of a reactor, especially if the use of carbon target plates is considered. This paper provides an overview of results obtained with thermal, photonic, oxidative and plasma-assisted fuel removal processes studied on PFC and probes from the TEXTOR tokamak: graphite and metal (steel or tungsten) substrates. Comparative experiments were also carried out in laboratory devices. Three aspects have been taken into account in the assessment of each approach: efficiency of removal of fuel and co-deposits, effect on the surface condition of the PFC and dust formation caused by destruction and disintegration of co-deposits. To control the gas phase and surface morphology during subsequent stages of treatment a set of analysis techniques was used: e.g. thermal desorption spectrometry, optical and X-ray spectroscopy, ion beam analysis and microscopy. The main results are:
(a) Oxidative methods remove fuel and carbon but the rate strongly depends on the overall film composition; the presence of non-volatile impurities (B, Si, metals) slows the process.
(b) Nitrogen-assisted discharges do not lead to a noticeable fuel removal.
(c) Desorption at 623 K, i.e. at the maximum baking temperature of the ITER divertor, removes only 15% of hydrogenic species. Effective fuel release requires heating above 850-900 K, but baking at such conditions results in cracking and peeling-off of co-deposits thus leading to the dust formation. The same is observed under oxidation at that temperature level.
(d) Laser-induced ablation generates large amount of dust which may still contain substantial amount of fuel. The irradiation may result in substrate damage.
(e) Efficient local fuel release from C layers occurs with low-power laser-induced desorption.
The ongoing study shows that no single method alone would provide solution to efficient fuel removal especially from shadowed regions in a reactor. The whole activity indicates that hybrid scenario, involving mechanical methods and hovering of dust, would be needed to reduce fuel inventory. Fuel re-absorption by depleted layers is also now examined.

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