DESIGN, MANUFACTURE AND TESTING OF THE GLOW DISCHARGE ELECTRODES FOR WENDELSTEIN 7-X

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The fusion device Wendelstein 7-X will need conditioning by glow discharges during commissioning, after shutdown phases and during experiment breaks. The W7-X glow discharge system has been developed as a low-maintenance and space-saving system. Ten stationary electrodes will be integrated into the first wall. The innovative electrodes' geometry consists of a calotte-shaped graphite anode mounted, electrically insulated, in a stainless steel housing. Comprehensive experiments in the W7-X DEMO plasma vessel have been carried out to optimize the electrode's shape and dimension and to study the long-time behavior. As a result a first prototype has been tested successfully both regarding the discharge performance and the electrodes' thermo-mechanic reliability.

Based upon the prototype tests the detailed design and construction of the electrodes has been further developed to meet the requirements coming from machine operation restrictions and diagnostics constraints:

- to limit the heat load onto the vessel wall during the glow discharge,
- to minimize the anode's temperature during stellarator plasma operation to avoid that thermal radiation would disturb infrared-diagnostics, and
- to allow efficient maintenance in spite of the limited machine access.

The first two requirements imply the need of sufficient cooling and are fulfilled with two design decisions. The housing will be actively cooled by integrating it into the water cooling system of the in-vessel components. In addition, a new mounting concept supersedes the need of an active cooling of the anode, thus avoiding a problematic, possibly fault-prone, high-voltage insulation of water pipes. It is based upon an enhanced thermal contact of the anode's fixation, while guaranteeing the high-voltage insulation: The central support is implemented as a cylindrical alumina block with a large contact area to both the hot anode and the cooled housing. A flexible graphite foil on both sides improves the heat transfer. Furthermore, the inside of the housing has been blackened to enhance the thermal radiation absorption. By this means, the cooling of the anode relying on radiation and thermal conduction ensures the required temperature limitation of the anode.

To meet the third requirement the electrodes' design has been optimized to allow quick and easy maintenance access to all parts that may need cleaning or repair during their lifetime (e.g. the anode or the insulator).

A prototype of the final design has undergone a series of extensive tests in laboratory and it has been used in the ASDEX Upgrade Tokamak during two operation campaigns. The electrode showed excellent and reliable discharge behavior and passed the long-time tests successfully. Some minor mechanical enhancements had to be developed due to experiences gathered in mounting and demounting the anode.

Today all the electrodes have been manufactured and verified, ready ahead of time to be assembled in W7-X.