Wendelstein 7-X – a technology step towards Demo

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Abstract: The optimized stellarator Wendelstein 7-X is under construction in Greifswald. Most of the components have been fabricated already and four out of ten half-modules of the magnet system have been assembled already. This paper presents an overview of the status of construction and a summary of the future developments.

The Wendelstein 7-X stellarator, presently under construction in Greifswald, will be the first "fully-optimized" stellarator device which combines a quasi-symmetric magnetic field configuration, a steady state exhaust concept, superconducting coils and a size sufficient to reach high $nT\tau$-values. W7-X has been optimized numerically by J. Nührenberg et al., based on the concept of quasi-isodynamicity. Its key element is an optimized magnetic field configuration, generated by 50 non-planar superconducting coils. It is the mission of this project to demonstrate the reactor potential of the optimized stellarator line.

One key element of this mission is obviously to verify the numerical optimization. The other key element in demonstrating the reactor potential is steady state operation, required for an economic fusion reactor. Steady state operation is an intrinsic feature of stellarators/heliotrons, unlike of tokamaks where steady state operation is difficult to achieve and still requires extensive research and development efforts. However, the technical realisation of steady-state operation of fusion-relevant plasmas in a stellarator still has to be demonstrated. Therefore, Wendelstein 7-X has taken this as a key element of its mission.

Steady state operation constitutes a complex task, composed of more technically oriented and more physics oriented issues. To be economically attractive, magnetic field coils in a steady-state fusion device have to be superconducting. Wendelstein 7-X has a system of 70 superconducting coils, one of the largest superconducting magnet systems worldwide.

To provide steady-state power exhaust, Wendelstein 7-x will be equipped with an island-divertor which has already proven successful in the predecessor, Wendelstein 7-AS. Equipped with CFC-target elements and a correspondingly designed steady-state water-cooling system, this divertor has been designed to exhaust 10 MW in steady state. In addition to these technological aspects, however, also physics poses specific questions to steady state operation of a divertor and to the plasma-wall aspects of stellarator operation, like impurity confinement, neutral gas balances, helium transport and exhaust etc.

This paper gives a broad overview of the construction status of Wendelstein 7-X with a special emphasis on those components, mentioned above, which constitute a genuine step in steady state technology towards Demo. Also the future works and the strategy for a two-staged approach to steady state-operation will be discussed.