Wendelstein 7-X

NEWSLETTER

Nr. 9 / February 2013

Advanced Materials for the In-Vessel Components

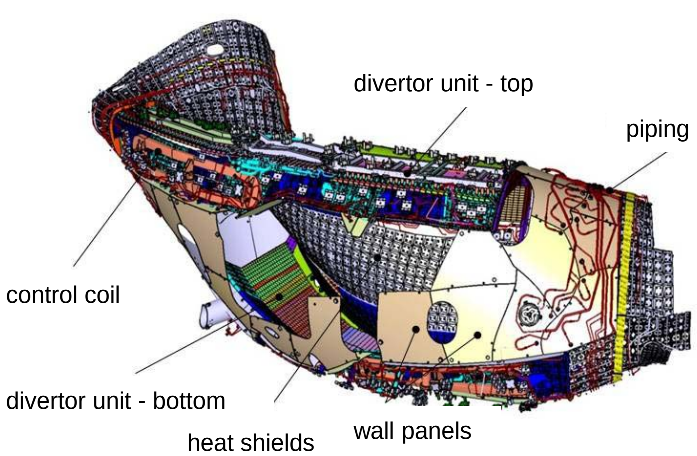
A major goal of Wendelstein 7-X is to prove that a stellarator can be operated continuously. Therefore the plasma has to be confined by means of the magnetic fields of the superconducting coils and sufficiently high densities and very high temperatures have to be generated in the plasma. The external plasma heating must first create the plasma and then maintain it for as long as 30 minutes. To reach a stationary equilibrium requires that the energy supplied to the plasma must be dissipated continuously. This can proceed in different ways: on the one hand by radiation which causes a more or less equal load on the in-vessel components facing the plasma. On the other hand by heat transport or convection along the magnetic field lines which at the plasma edge hit specially designed wall components and thus lead to a directed energy and particle

photo: IPP, Robert Haas

Wall protection for a port of the neutral particle heating

Continuous heat flows are a challenge for the in-vessel components. In most of the present fusion devices the discharges typically have up to 10 s duration. Such a mode of operation allows a short-term load and the time between pulses can be used for cooling down the relevant systems. However, for experiments with 30 minutes duration, as planned for Wendelstein 7-X, such a discharge corresponds to 200 to 2000 conventional pulses. Therefore suitable materials have to be chosen for the in-vessel components which can withstand the thermal and mechanical loads permanently. Moreover, the components have to be shielded against plasma interaction and protected from irradiation (e. g. stray radiation from the microwave heating). Therefore the relevant Wendelstein 7-X components must be continuously water-cooled. Eighty ports, and thus one third of the ports at Wendelstein 7-X, are used to feed water pipes into the plasma vessel. Inside the plasma vessel four kilometres of piping will be installed. Accurate predictions for the expected thermal load are critical for the design of these components in particular of the divertor, the component exposed to the highest heat flows.

As a result Wendelstein 7-X will go through two different operation phases. For the first operation phase with short pulses of 5 to 10 s a temporary test divertor unit (TDU) with inertially cooled copper plates coated with graphite tiles will be installed.This TDU allows precise measurements of the local thermal loads for all important operating scenarios. These measurements form the basis for the optimization of the water-cooled target modules of the high-performance heat-exchanger (high-heat-flux divertor). After about two years of operation there will be enough data to replace the test divertor by the actual high-heat-flux (HHF) divertor for the long discharges of up to 30 minutes. The HHF divertor will be installed during a shutdown of two years. This HHF divertor is used for the areas with the highest thermal loads and has to dissipate 10 million watts per square metre continuously. This load is about twenty times higher than usual in heat exchangers used for conventional power plant technology. It is also higher than the load placed on the edges of the wings of the space shuttle when it re-enters the atmosphere - 6 million watts per square metre for “only” several hundred seconds. The HHF divertor consists of 890 elements with tiles made of 8 mm thick carbon-fibre-reinforced carbon which are connected to water-cooled metal blocks by means of a patented process. The serial production of these elements is going on and their installation is scheduled for 2017.



Graphic: IPP, Jean Boscary

Ten divertor modules, heat shields, baffle modules, wall panels as well as protection structures for the ports will be installed in the plasma vessel. A complex system of cooling water supply lines for these elements guarantees the dissipation of energy from the plasma. Additionally control coils and cryo-pumps are necessary – altogether the 2500 in-vessel components comprise about 710,000 parts.

photo: IPP, Torsten Bräuer

Heat shields in the plasma vessel of Wendelstein 7-X

The majority of the in-vessel components has already been delivered to Greifswald and is being prepared for assembly within the machine. For the installation of these components the first modules have been cleaned thoroughly and air locks and venting systems were mounted. Using a positioning robot about 1200 bolts and brackets for fixing the different components are being welded to the vessel wall in each module.

Status Wendelstein 7-X: The assembly of the plasma vessel modules has been completed and the connection of the module with each other is proceeding as scheduled. The ports of the modules are completely assembled and welded to the vessels. The ports for three module planes, the transition zone between two neighboring modules, are welded as well. The welding of the ports at the fourth and fifth module planes will be finished during the first and second quarter, respectively. The four trim coils of type A manufactured in cooperation with Princeton Plasma Physics Laboratories and Everson Tesla have been delivered to IPP on schedule. Manufacturing of the type B coil is still proceeding. The serial production of the current leads at the Karlsruhe Institute for Technology has been completed and the first pair has been installed on Wendelstein 7-X.

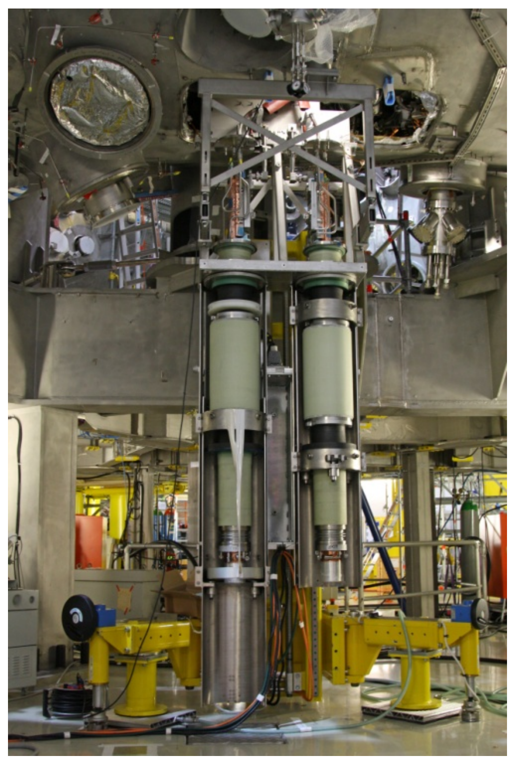


photo: IPP, Beate Kemnitz

Current leads for the superconducting coils

Wendelstein 7-X Newsletter
published by
Max-Planck-Institut für Plasmaphysik Greifswald
Association Euratom – IPP
Wendelsteinstraße 1
Germany - 17491 Greifswald
PDF copy of newsletter available at:
http://www.ipp.mpg.de/ippcms/eng/for/publikationen/w7xletters/index.html

Coordination: Prof. Dr. Robert Wolf
Contact: Dr. Andreas Dinklage
Phone: +49 3834 882328
Fax: +49 3834 882509
email: w7xnewsletter@ipp.mpg.de
www.ipp.mpg.de