Contribution ID: **126** Type: **Poster**

Conceptual design of the DEMO NBIs: main developments and R&D achievements

Friday, 21 October 2016 08:30 (4 hours)

In the framework of the EUROfusion Work Package Heating & Current Drive, a conceptual design of the Neutral Beam Injector (NBI) for DEMO, has been developed by Consorzio RFX in collaboration with other European institutes. High efficiency is a fundamental requirement for DEMO, this has been taken into great consideration for the DEMO NBI, as a fundamental part of the maximization of RAMI performance. To increase the efficiency of the system, innovative solutions have been introduced for the neutralizer and the vacuum pumping systems. In particular, the design of a neutralizer based on the "closed recirculating cavity with nonlinear gating"(RING) photo-neutralizer concept, using the second harmonic of a laser trapped in cavity through which the beam passes, has been implemented in the DEMO NBI conceptual design. The DEMO NBI has been designed to be also compatible with a gas neutralizer. Non-Evaporable Getter (NEG) pumps are foreseen to provide the required vacuum pumping inside the vessel. Compared to the cryopumps, NEG pumps present numerous advantages: they are more resistant to neutron radiation and they do not need any continuous energy supply system for the operation. In order to increase the reliability and availability of the beam source, the DEMO NBI features a beam source composed of 20 sub-sources (two adjacent columns of 10 sub-sources each), following a modular design concept. Each sub-source features its Radio Frequency driver. Such a modular solution is capable to provide a better alignment among the corresponding apertures of the accelerator grids, because the modules have a significantly smaller size than the whole accelerator, hence the horizontal and vertical deformations are also reduced compared with a non-modular solution. To increase the maintainability of the system, the DEMO NBI has been designed in such a way that all the main components can be substituted without removing other components. For example, the beam source can be removed from the lateral opening of the beam source vessel, the neutralizer and the residual ion dump from dedicated upper flanges, the duct from the equatorial port close to the NBI port. Several analyses have been carried out to investigate and optimize this conceptual design, namely optics, electrostatics, magnetics, neutronics and thermo-mechanics assessments.

Paper Number

FIP/P7-5

Country or International Organization

Italy

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Session Classification: Poster 7

Track Classification: FIP - Fusion Engineering, Integration and Power Plant Design