THERMOHYDRAULIC INVESTIGATION ON THE OPERATION OF THE ITER TORUS AND NEUTRAL BEAM CRYOPUMPS

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The ITER high vacuum cryogenic pumping systems are composed of 8 torus, 2 cryostat (assumed to be identical to the torus), 3 Heating Neutral Beam (HNB) and 1 Diagnostic Neutral Beam (DNB) cryopumps. Even if the torus and Neutral Beam (NB) cryopumps both consist of an active charcoal cryosorption pumping system and a radiation shielding system, they are completely different in terms of geometry, size, mass and cryogenic routing. During the pumping operation of the cryopumps the active pumping system is supplied with supercritical helium at about 4.5 K and the radiation shielding system is supplied with 80 K gas helium. After a certain pumping duration, depending on the plasma scenarios, the cryopumps have to be regenerated at 100 K to perform a basic release of hydrogen or isotopes in order to avoid hydrogen deflagration safety hazards. Less frequent high temperature regenerations up to 470 K are also foreseen to release heavy gases and impurities. In the present work, pumping and regeneration operations of the torus and NB cryopumps regarding the cryogenic supply are investigated.

Each cryopump is connected via flexible cryojumpers to a Cryopump Valve Box (CVB) which handles the control of the various operations of the pump using a set of valves connected to the cryogenic lines and the regeneration lines which are supplying helium at different temperatures (~ 4.5 K, 80 K, 300 K and 500 K) and collecting it back. The heat loads on the cryopumps, the required temperature difference across the cryogenic circuits and the allowed time to perform the various regeneration operations lead to high mass flows to operate the cryopumps. As a consequence, critical issues of the cryogenic supply are the pressure losses in the cryopumps and cryodistribution cryogenic circuits.

In the case of large and complex systems such as the torus and NB cryopumps a descriptive approach using coefficients of hydraulic resistance which combine many complex phenomena under a single factor has been adopted. The present work outlines the experimental and empirical approaches used to estimate the resistance coefficients of the various components. Then, steady state calculations at various temperatures have been performed in order to assess the maximum mass flows in the cryopumps, giving a first idea on the way to perform the transient phases of the regeneration operations. Finally, the complete regeneration operations of the cryopumps showing helium and cryopump temperatures time and space evolution and the associated pressure losses are presented.

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