MANUFACTURING PROCESS AND TESTS OF A LOWER HYBRID PASSIVE ACTIVE MULTI-JUNCTION LAUNCHER FOR LONG PULSE EXPERIMENTS ON TORE-SUPRA

D. Guilhem, F. Samaille, B. Bertrand, M. Lipa, J. Achard, G. Agarici, A. Argouarch, A. Armitano, JH. Belo[*], Z. Bej, G. Berger-By, F. Bouquey, C. Brun, M. Chantant, E.Corbel, E. Delmas, L. Delpech, L. Doceul, A. Ekedahl, F. Faisse, P. Fejoz, M. Goniche, JC. Hatchressian, J. Hillairet, M. Houry, JP. Joanard[***], P. Joubert, R. Lambert, G. Lombard, M. Lyonne[**], S. Madeleine, R. Magne, L. Marfisi, A. Martinez, M. Maury[***], M. Missirlian, P. Mollard, S. Poli, C. Portafaix, M. Preynas, M. Prou, D. Raulin, E. Rousset[**], A. Saille, B. Soler, D. Thouvenin, JM. Verger, D. Volpe, K. Vulliez and B. Zago

CEA, IRFM, F-13108 Saint Paul-lez-Durance, France.
** Instituto de Plasmas e Fusão Nuclear /IST Av. Rovisco Pais 1049-001 Lisboa Portugal*
*** SDMS, ZI - RN 532, Les Condamines, 38160 St Romans, France*
**** SUMIX Cite st pierre, 84500 Bollène, France*

Corresponding author: dominique.guilhem@cea.fr

A new concept of multijunction-type antenna has been proposed, the Passive Active Multijunction (PAM), which allows an improved cooling of the waveguides and a much better damping of the neutron energy compared to full active multijunction. After the design, thermo mechanical assessment and behaviour modelling during plasma disruption, we started the fabrication of the PAM antenna, made of the PAM launcher (2 superimposed blocks) and the 16 mode converters (dividing the input power in 3 equal output power ports). Due to the complexity of the structures, prototypes have been successfully fabricated and tested to validate the different manufacturing processes and the manufacturer's capability to face this challenging project. The first difficulty was to assemble each of the 2 blocks of the PAM which are composed by 2x17 individual plates of SS cladded with Cu by explosion process. Even after realizing a shear stress annealing procedure in an oven at 900°C, the machining of the individual plate has been difficult. This led to uncontrolled and unpredictable deformation of the plates all along the industrial machining procedure. The principal observed default of the first block after the brazing process (830°C, 1 week), was a large number of unacceptable braze flaws which could lead to arcs formation during plasma operation. After the development of a new brazing procedure it has been successfully mended and the fabrication has been finalized by an electron welding (1/10 mm of acceptable looseness) of the two blocks together (2 tons each), another challenging step of the project. We finally achieved smoothly the fabrication and validation tests, i.e. low power Radio Frequency measurements (scattering matrix), vacuum and hydraulic leak tests (200°C, 60 bars). The commissioning of the antenna before its implantation on the tokamak was achieved at the end of august 2009. After the development of a common support for the 2 launchers available on Tore-Supra, and a modification of the outside machine ports, the PAM launcher has been installed and is now in operation since October 2009. On March 2010, ~ 2.8 MW were launched by the PAM for 77 seconds (~ 213MJ total) which is its design performance in term of power density (25 MW/m^2 x 0.11 m^2) and cooling performance (thermal time constant τ ~ 30s). It has to be noted that in agreement with calculations near the cut-off density at the antenna mouth, the averaged power reflection coefficient is ~ 2 % with a distance of the coupler to the plasma of ~ 10 cm, confirming that this PAM concept is an ITER relevant design.
On the LH transmitter side, 16 new 3.7GHz klystrons (700 kW, CW instead of 500 kW, 60s) are being installed to study both ultimate power and energy limits of the ITER like PAM.