3D electromagnetic analyses during plasma disruption for the Tore Supra PAM LHCD antenna

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A Passive Active Multijunction (PAM) Lower Hybrid heating and Current Drive (LHCD) antenna has been installed on Tore-Supra in 2009. The design and the fabrication of this antenna based on the passive-active multijunction concept is a major part of the CIMES project (Components for the Injection of Mater and Energy in Steady-state) on Tore-Supra. To achieve very long pulses (up to1000 s) with a power flux density of 25MW/m² in active waveguides, the PAM launcher has been designed with active cooling and is able to couple 2.7 MW of LHCD power to the plasma at 3.7 GHz in steady state conditions. On February 5th 2010, 2.7 MW where launched by the PAM for 35 seconds (98MJ) which is almost its steady state design performance since its thermal time constant is about 30 s.

The antenna made of copper and stainless steel has to withstand important electromagnetic forces due eddy currents during plasma disruption. 3D electromagnetic analyses have been performed with the code ANSYS to calculate the eddy currents and the electromagnetic forces. The validation of the method has been performed on a simple case by comparing the numerical results obtained with the ANSYS code and an analytical solution.

The 3D geometrical ANSYS model of Tore Supra has been developed describing a 20-degree machine sector composed of the plasma, the vacuum vessel, the magnets, the toroidal pump limiter and the antenna.

The eddy currents are derived from these calculations assuming a plasma toroidal current variation from 1.5 MA down to zero with a time constant of about 3 ms as measured on Tore Supra. Plasma movements during disruption have been also simulated to evaluate the most critical load to design the antenna and the support.

The analyses have permitted to provide the dynamic electromagnetic forces acting on the antenna. The main load component is a radial torque of about 110 kN.m.