MATERIALS CHALLENGES IN THERMO-NUCLEAR FUSION REACTOR RESEARCH

Current status of fusion research and related materials needs – Ing. P. Agostini, ENEA-Brasimone

A short introduction will present the main international fusion reactor projects (ITER, DEMO) and the main components of a *tokamak*.

Low-activation structural and functional materials are needed for the components of future fusion reactor since fusion has been originally conceived as a "clean" source of nuclear energy. In fact, neutron activation effects in a fusion environment will be one order of magnitude higher compared to fission due to the correspondingly higher energy of the produced neutrons (14 MeV). Therefore, highly activating elements, such as Ni, commonly utilized in fission technology cannot be utilized for fusion and have to be replaced by more favorable ones such a Fe, Cr and W.

Structural materials

Up to now, the Eurofer97 steel, developed by Germany and somehow duplicated by Japan (F82H) and China (CLAM), appears as the best one. It is a reduced activation ferritic/martensitic steel exhibiting mechanical properties and thermal conductivity well suited for blanket applications. Difficult weldability, low yield strength above 550°C and irradiation embrittlement below 300°C are its main drawbacks when compared to austenitic steels, reducing its operational window. In fact, the high temperature limitation conflicts with the helium cooled blanket and the low temperature one with the water cooled blanket. These are currently the main technical challenges for blanket designers on one side and for metallurgists on the other side: Eurofer97 variants with a more adequate temperature range are being in fact developed by suitable

modifications of elemental composition and of the preliminary treatments.

Plasma-facing components

Plasma facing components, namely the first-wall and the divertor, must be protected by the high thermal fluxes originated by direct exposure to the burning plasma. Their design must include: a) a refractory metal protective surface, b) a high thermal conductivity material, c) an effective heat exhaust material.

For the first-wall, 1 MW/mq thermal flux is expected, therefore a thin W layer has simply to be deposited on the Eurofer97 structure, cooled to temperatures lower than 550°C by helium or water

For the divertor, a thermal flux of 10 MW/mq or more is expected, therefore W tiles coated are utilized, cooled by refrigerating Cu-alloys tubes: these complex structures, potentially exposed to the development of strong stress gradients concentrated at the W/Cu interface.

Uncertainty on neutron damage in a fusion reactor

Intense 14 MeV neutron sources are needed to reliably investigate radiation damage effects in a fusion environment. The EUROfusion consortium is spending consistent efforts to develop an accelerator based such facility, the DONES project, to be built in Spain with strong Italian participation. Demonstrative fusion reactors might also be utilized for a limited number of reduced activation materials.