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Spin-off from Euratom-CEA association in fusion magnetic research

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Abstract

Significant spin-off from magnetic fusion research in Euratom-CEA association, over the last 40 years, has been induced and developed through a continuous process of exchange of scientific, technology and managerial expertise between the fusion scientists and manufacturing engineers. The growth in shared expertise, associated innovative applications and cooperative efforts with industry can be clearly identified (i) in the frame of the European Fusion Development Agreement (EFDA) and underlying technology programme, (ii) by the industrial applications induced from Tore Supra programme and the associated joint development of large test bed facilities for control and acceptance test, (iii) by the appreciation of the expected impacts of ITER from the companies involved in the Tore Supra construction.

Keywords: Magnetic fusion research; Euratom-CEA association; Tore Supra programme

1. Introduction

The involvement of industry in European fusion magnetic programme is not only essential for the construction of ITER and the long-term programme [1], but also directly valuable thanks to spin-off induced from fusion R&D and by the large benefits in terms of transfer of knowledge, technology and managerial improvement of complex systems. Although the technical requirements always required, from the beginning of the fusion research, new technologies and fabrication processes, the construction of larger devices such as JET and Tore Supra in the 1980s had amplified the demands for Quality Assurance of the fabrication and new technologies in particular in high heat flux components facing the plasma, magnet fabrication and cryomagnetism. This high level of expertise has favoured the synergy and strong interactions between fusion scientists and industry's engineers.

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2. Applications from EFDA and underlying technological programme

The large development presently carried out in the frame of the EFDA and underlying technological programme in terms of R&D in the field of superconducting magnet technology, nuclear safety, remote handling operation, material development and assembly techniques has produced innovations with applications that benefit many areas beyond the fusion programme and has also induced technology transfers to industry.

From the 1980s the fusion technology programme has grown regularly and more than 120 EFDA tasks were performed in 2001 by the Euratom-CEA Association [2]. Most of them are developed in collaboration with industry with a potential or actual capability of industrial spin off as the development of advanced fabrication techniques and in particular HIPing for fabrication of complex components or the development of Fe–Al coatings (use as tritium permeation barrier in fusion) which can also be considered for barrier application in other field such as petrochemistry or petroleum industry where they can be applied to other problems (hydrogen embrittlement, sulfurization, etc.). Some specific items can be selected to illustrate this capability.

One example is the fabrication and the bonding process of SiC–SiC ceramics which can be used as high heat flux plasma facing components or structural material with a view to future power plant. The very high heat exhaust capability of such materials (> 10 MW/m^2 at high temperature) is of major interest for spatial, aeronautical and military applications. Fig. 1 shows a W/SiC/W ceramic sample brazed at high temperature (1530 °C) for mechanical tests up to 800 °C. If the present SiC–SiC fabrication is in the range of kilograms, the closed SiC–C metallurgy is already at the level of tons thanks to the synergy provided by fusion, spatial and military applications. Lithiated ceramics could be used to breed tritium in a future fusion power plant. Zirconate (Li_2ZrO_3) and Titanate (Li_2TiO_3) are being developed by Euratom-CEA. In particular, the 1 mm diameter pebble fabrication process (extrusion–spherozination–sintering) has been designed, tested at lab-scale and successfully transferred to industry. More than 10 kg-batches of Li_2TiO_3 pebbles, representative of the fabrication process were supplied in 2000 and 2001. Lithiated ceramics are also capable of absorbing, storing and releasing carbon dioxide. An unexpected spin-off of this research could be the possible use of lithiated ceramics to capture carbon dioxide from power station and vehicles exhaust to limit thus the greenhouse effect.

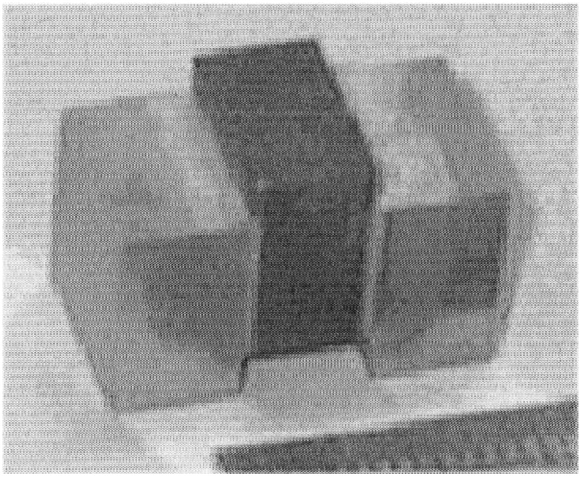

Fig. 1. View of a mechanical test sample W/SiC/W.

Other general items are the development of laser processes for cutting and welding as the high power Nd-Yag lasers carried out to weld the 60 mm thick ITER vacuum vessel (316 L austenitic stainless steel) or the development of robots

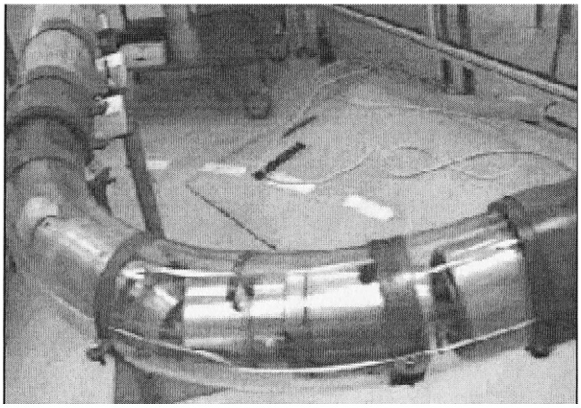

Fig. 2. Carrier navigating a bend.