The technofusion project for fusion technology development: opportunities for the inertial community

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Abstract: *The new Spanish installation for fusion research (Technofusion) has been approved by both the national and regional governments. Funding up to 80-100 M€ will be invested in the construction of seven laboratories to cover many aspects relevant to fusion technology development. This work discusses their utility for inertial fusion research.*

Table 1. Optimistic conditions assumed for ITER divertor and for a typical direct drive target of (yield 154 MJ) [1-3].

		Time (s)	Deposited energy (MJm^{-2})	Power (MWm^{-2})	Heat flux parameter ($MWm^{-2}s^{1/2}$)	Particle energy (eV)	Particle flux ($m^{-2}s^{-1}$)
Divertor	steady state	1000	-	15	-	1-30	$<10^{24}$
	ELM	0.2×10^{-3}	1	5×10^{3}	70	1-30	$<10^{24}$
	disruptions	1×10^{-3}	20	2×10^{4}	600	1-30	$<10^{24}$
Direct target	α-particles	200×10^{-9}	0.03	1.5×10^{5}	70	2.1×10^{6} avg.	1×10^{25}
	DT debris	1.5×10^{-6}	0.06	4×10^{4}	50	150×10^{3} avg.	2×10^{22}

1. Introduction

Technofusion [4] will be the new Spanish singular scientific-technical installation for fusion research. The research activities will be focused on seven areas of materials research considered the most relevant ones for further technological developments of fusion energy. With a budget of 80-100 M€ over five years, several top laboratories will be constructed.

In principle, most of the infrastructure in Technofusion will be useful for both, magnetic (MC) and inertial (IC) confinement fusion communities and most of the research and developments carried out for one of the fusion concepts will be valid and transferable to the other. However, some aspects related to first wall materials strongly differ in MC and IC approaches. This is due to the very different typical ion energy and deposited powers in both cases (Table 1). In the special case of IC with direct drive targets, large fluxes of high energy ions will reach the first wall of evacuated reactor chambers (e.g., HiPER). These ion fluxes are not easy to mimic by existing facilities and neither Technofusion will easily do it with the currently proposed facilities.

In this work we will emphasize how the Technofusion laboratories will contribute to R&D in IC. The service catalogue for fusion research offered by Technofusion will cover most aspects of reactor design significantly contributing to the technological development of fusion energy. Since specific aspects relevant to inertial fusion are not fully covered, possible solutions will be discussed.

2. Description of Technofusion

It is important to highlight that the necessary efforts to demonstrate technological viability of fusion energy are to a large extent common to both MC and IC approaches. The Spanish contribution to the R&D efforts on fusion energy, Technofusion, is a good example. Technofusion will address important technical difficulties in the construction of a fusion reaction chamber and will develop part of the required technological solutions to overcome them. According to current specific demands, Technofusion has identified seven research areas of interest:

2.1 Plasma-wall interactions

Technofusion has devised the construction of a facility to study high flux plasma discharges on materials. The facility will dispose of a linear plasma device and a plasma gun. The former will provide steady state plasma discharge while the latter will provide pulsed discharges. The combination of both will allow one to mimic MC divertor operation, including the most aggressive events, such as, ELMs and disruptions (see Table 1). In IC the facility may find applicability to study first wall materials in systems that use residual gas for radiation mitigation purposes (e.g., LIFE).

2.2 Materials Irradiation

The main goal is to build a facility to mimic neutron irradiation of structural materials. It will consist of a triple ion beam to implant simultaneously self-ions, hydrogen and helium. The first ones will mimic the primary knock on atoms produced by neutron collisions, while hydrogen and helium will be implanted at levels similar to those expected for transmutation reactions. This facility is clearly of common interest for both the IC and MC communities. In addition, the facility can be used to study synergistic effects originated by the simultaneous arrival of high energy ions in IC reactors (e.g., simultaneous C, He and D irradiation).

2.3 Liquid metals

Liquid blankets have been proposed since long ago. Examples are pure liquid lithium, liquid LiPb eutectic, and molten salts such as FLiBe. In any case corrosion problems under irradiation must be studied. The goal of Technofusion is to build a state-of-the-art liquid metal loop to study this problem. Cleary, a common goal of both, the IC and MC communities.

2.4 Development of new materials

Important efforts in new materials development with superior radiation-resistance properties are necessary for fusion energy. In the case of structural materials the MC community is carrying out R&D activities to develop low activation steels with reduced swelling and good mechanical properties upon irradiation. An example is the effort in developing new FeCr alloys and ODS steels. Technofusion is already working in the development of new ODS steels clearly beneficial for IC and MC communities. In addition, since the MC divertor components are subject to extreme irradiation conditions, the development of new materials is actively pursued. In particular new types of ODS-W alloys are being developed in the MC community and in Technofusion. These efforts can be useful to develop first-wall materials (armors) and coatings for IC reactors. Further efforts in Technofusion will allow us to produce new materials in a semi-industrial scale. In fact Tehcnofusion will dispose of a Vacuum Induction Furnace (VIM), a Hot Isostatic Pressing Furnace (HIP), a Furnace for Sintering assisted by a Pulsed Plasma Current (SPS), or a Vacuum Plasma Projection System (VPS).

2.5 Materials characterization techniques

TechnoFusión will dispose of a set of advanced devices and techniques to test materials and components. On one hand, there will be a number of (in situ) techniques for testing or characterizing materials during irradiation in the facilities mentioned above. On the other hand, there will be sophisticated (ex situ) techniques for appropriate characterization.

2.6 Remote handling systems

Nuclear Fusion consolidation as an energy source in the coming years will require an extraordinary development of robotic systems for Remote Manipulation. The main objective in the short term is to have an installation where performing telerobotic tasks for the maintenance and repair of nuclear fusion installations. The development of technologies in this area are of course useful for both communities.

2.7 Computational tools

To study conditions that cannot be reproduced experimentally and to accelerate the development of novel systems for a future commercial fusion power plant, TechnoFusión will stimulate an ambitious program of computer simulations, combining existing experience in the fusion field with resources from the National Supercomputation Network. TechnoFusión proposes the development of a large scientific infrastructure in order to make a significant contribution to the development of new technologies needed for the construction of commercial fusion reactors. Part of the codes may be oriented only to MC reactors, however, many aspects are common to both communities, in particular those related to materials studies.

3. Role in laser fusion

Most laboratories, instrumentation and R&D programs in these areas are applicable to both MC and IC fusion approaches. However, some specific crucial points for IC development have not been considered so far in Technofusion. They are related to the way radiation is emitted in IC reactors, i.e., by means of high intensity pulses resulting from the target explosions. In turn, this pulsed radiation has an effect on the reactor materials, in particular, first wall and final optics components.

Since it is essential for the development of advanced materials to mimic realistic irradiation conditions, our group is carrying out an important effort to identify, design or adapt different radiation sources for our purposes. In particular, we are studying (see contribution in this conference) appropriate ways to generate X-ray and ion pulses by means of high intensity lasers. In addition, by means of a keep-in-touch action we are adapting the proton and neutron laboratories of ESS Bilbao (neutron installation under construction based on high intensity proton beam).

4. Conclusions

In this work we will present the service catalogue offered by Technofusion, the new Spanish singular scientific-technical installation for fusion research. This catalogue will cover most aspects of reactor design significantly contributing to the technological development of fusion energy. It is important to note that most aspects are common to both IC and MC communities. We are carrying out efforts to increase the possibilities of Technofusion for sample irradiation to meet IC demands.

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References

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