SCIENTIFIC NOTES TO EDITORS

MAGNETIC CONFINEMENT FUSION: ENERGY THAT IMITATES THE STARS

A safe, sustainable and inexhaustible source of energy: a breakthrough in the path to decarbonization.

The test

The magnet, weighing about 10 tons, was cooled using the circulation of liquid helium at a temperature of -253.15° C (i.e. 20 degrees above absolute zero), which was kept constant in a vacuum containment chamber.

During the tests, an electric current of increasing intensity, up to about 40,000 Amper, passed through the magnet coils for predetermined periods of time and in different operating conditions, developing a magnetic field of very high intensity that reached 20 tesla (T).

Similar fields would be unattainable with normal cable materials (such as copper) or with LTS (Low Temperature Superconductors) which would be damaged by the generated heat.

This result was made possible thanks to the properties of the superconducting HTS (REBCO - Rare Earth Barium Copper Oxide) tapes - the active part of the magnet, in which the superconducting current circulates - that are able to reach much higher performances in terms of magnetic field associated.

The test showed the possibility of maintaining the magnet in the superconducting regime with a high stability of all the fundamental parameters for its use in a fusion power plant. Moreover, the test generated a significant amount of data that will be subject of in-depth analysis over the next few months.

The HTS technology is based on the discoveries on superconductivity at high temperatures that earned Johannes Georg Bednorz and Karl Alexander Müller the Nobel Prize in Physics in 1987. More recently, the commercial availability of high temperature tape has led to its use in supermagnets.

Technology

In the nuclear fission process, the bonds between the nuclei particles of the fuel, usually consisting of uranium isotopes (or plutonium, in the case of the so-called "self-fertilising" reactors) are broken by the neutrons emitted in the spontaneous nuclear decay and regulated to trigger a controlled chain reaction in order to release energy, which is

subsequently used for the generation of steam and the production of electricity through turbines and alternators.

During fusion the procedure is the opposite: once created the opportune conditions the fuel nuclei of light elements (such as deuterium and tritium, two isotopes of hydrogen) and reach a particular state of matter -the plasma- in which they can overcome the electrical repulsion barriers and fuse by collision, releasing more energy per unit mass than fission. This is the same process that underlies the generation of energy in stars.

This will be possible thanks to technologies able to guarantee an intrinsically safe process, capable of spontaneously extinguishing itself if the conditions that support it no longer apply, including the presence of intense magnetic fields for the confinement of the plasma inside the plant.

Context

Magnetic confinement fusion heralds a true revolution in energy because, once in use in industry, it will provide a clean, safe and practically inexhaustible energy source. In the perspective of a profound innovation able to lead in the medium term to a safe, clean form of energy with zero CO_2 emissions and very low fuel consumption, and therefore perfectly in line with the objectives of transforming the energy mix and sustainability requirements of the energy transition process, Eni has long started a program that commits on several fronts:

- investment in CFS: Eni has been a shareholder of CFS since 2018;
- direct collaboration with MIT in a scientific program called LIFT (Laboratory for Innovation in Fusion Technology) aimed at accelerating the identification of solutions in terms of materials, superconducting technologies, physics and plasma control;
- participation in the DTT (Divertor Tokamak Test facility) project launched by ENEA for the engineering and construction of a Tokamak machine of considerable importance for testing technologies that will manage the large amount of heat developed inside the fusion chamber. The industrial know-how, the management and development skills of large projects which distinguish Eni's innovation processes, combined with the excellence of ENEA's scientific research, will be the key to success for the realization of this important initiative and associated infrastructure, based primarily on Italian skills and technologies. The project, in phase of realization by ENEA and Eni at the Frascati Research Center, once again places Italy at the international forefront of research to achieve clean, sustainable and safe energy;

• collaborations with other Italian excellence research centers, which have long been part of the Eni network, such as CNR and the main universities involved in this field. In particular, the Eni-CNR Research Center in Gela focuses on physical and engineering modelling and resulted in the development of new competences in the field of fusion reactors through PhDs and grant activation.

Industrial integration

Developing magnetic confinement fusion is a global challenge that will involve a wide range of international talent in industrial science and technology. Everyone will have to put his skills and experience to use in the service of this revolutionary technology. At Eni, besides working with important research centres, we have made our HPC5 supercomputer available to researchers, who will use its huge calculating power for highly complex mathematical models that will describe the physics of plasma and simulate its behaviour. When we get fusion to a mature enough point that it can be used in industry, the stage will be set for unprecedented things. We will finally have a widespread supply of clean, safe, sustainable energy. Power stations fed by fusion reactors could meet the growing demand for energy at big production and population centres while maintaining high sustainability. Smaller stations, on the other hand, integrated with renewable sources, could make it easier to provide energy to small communities and off-grid businesses.

Environmental impact

The energy produced in the fusion process is virtually infinite, is safe and releases no emissions of climate-altering gases or pollutants whatsoever. Consider that to get the same energy produced by 60 barrel of oil you need just a single gram of “ fusion fuel” which has the added benefit of not releasing any greenhouse gases The road to this technological revolution is long, but by taking it we are heading for a more sustainable future.