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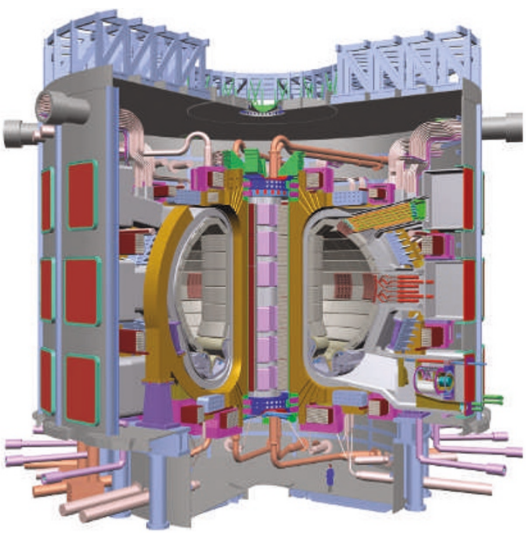
Materials needs for fusion

Last summer, when word came down that ITER, the international thermonuclear reactor, would be built in France, fusion scientists breathed a collected sigh of relief. The start of construction of the reactor had been stalled for a year and a half while negotiators argued over whether it would go to the French site, at Cadarache, or the Japanese site in the northern city of Rokkasho. Now, it seemed, things would finally move forward. The joke has long been that commercial fusion energy was only fifty years away, but now, many researchers hope that it could actually be true.



ITER

TOKAMAK POWER PLANTS SUCH AS ITER (ABOVE) WILL PROVIDE RELIABLE AND RELATIVELY CLEAN ENERGY ONLY IF THEY ARE MADE OF THE RIGHT MATERIALS.

But not so fast: a lot of materials work needs to be done before fusion can even begin to approach commercial viability. There are some pressing needs to do with ITER itself, but the real problems are with the fusion reactor that researchers want to build after the first plasma is expected to be generated in 2016. Dubbed DEMO, that reactor is supposed to show that fusion can be a commercially competitive energy source, but it may show just the opposite if it's built out of the wrong stuff.

The problem comes down to one subatomic particle: the neutron. Helium and neutrons are the two main by-products of fusion. Helium atoms are held inside the reactor by the magnetic field that keeps it going, but the electrically neutral neutrons fly straight out of the hot core. Travelling at 14 MeV, they're moving quickly and can do a lot of damage to anything in their path, including the wall of the machine. In fact, as neutrons are the main conduit by which energy leaves a fusion reactor, the wall must actually do its best to absorb as many damaging neutrons as possible and convert them to heat, which can then be used to generate power.

Inside ITER, the plan is to use conventional materials, such as stainless steel. Those should stand up well to the relatively low temperatures and pressures of the experimental reactor. But DEMO and commercial reactors that follow must withstand much more punishing neutron fluxes, and there's general agreement within the fusion community that the walls of any future fusion reactor will have to be made of stronger stuff than simple iron. Then too, there is the problem of irradiation. Scientists don't care too much about the radioactive shell that will be left behind when ITER is decommissioned, but it will matter a great deal to the commercial power industry, which must absorb such liabilities into the cost of running their plant.

To try and address the problem, the International Energy Agency has proposed building a US$2.6 billion International Fusion Materials Irradiation Facility (IFMIF). Most likely to be sited in Japan, the proposed facility would simulate high-energy neutron fluxes like those inside fusion reactors, allowing researchers to test how different materials can hold up to the stress.

Unfortunately, it is uncertain if IFMIF will ever be built because money in the world of fusion research is tight at the moment. At US$5.5 billion, ITER itself will suck up much of the basic fusion research funding in donor countries, especially within the European Union, which will pay for half of the machine. Japan, the other major ITER partner, has experienced recent cuts in research funding, making the prospects of the facility appear somewhat remote, at least for the moment.

A commentary on page 77 offers one way to help reduce IFMIF's overall cost. Some of the fusion materials research needed could be done by computer simulation. Multiscale modelling, which is already used in atmospheric and quantum mechanics studies, might be able to provide an effective baseline from which to plan carefully targeted experiments. There will still be a need for some sort of IFMIF to be built, of course, but modelling could reduce the total number of experiments, and hence the overall cost, of the facility.

Regardless of how researchers do it, the bottom line is that they need to start thinking now about the needs of a commercial reactor. As the human race's energy consumption continues to grow, and supply continues to dwindle, nations must develop safe and relatively clean alternatives to fossil fuels. Construction of ITER should have begun years ago, but international wrangling and fears over costs have delayed its construction. By working diligently on materials now, scientists can make up some of that lost time and ensure fusion power is ready when the world needs it the most.