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Burning like the sun

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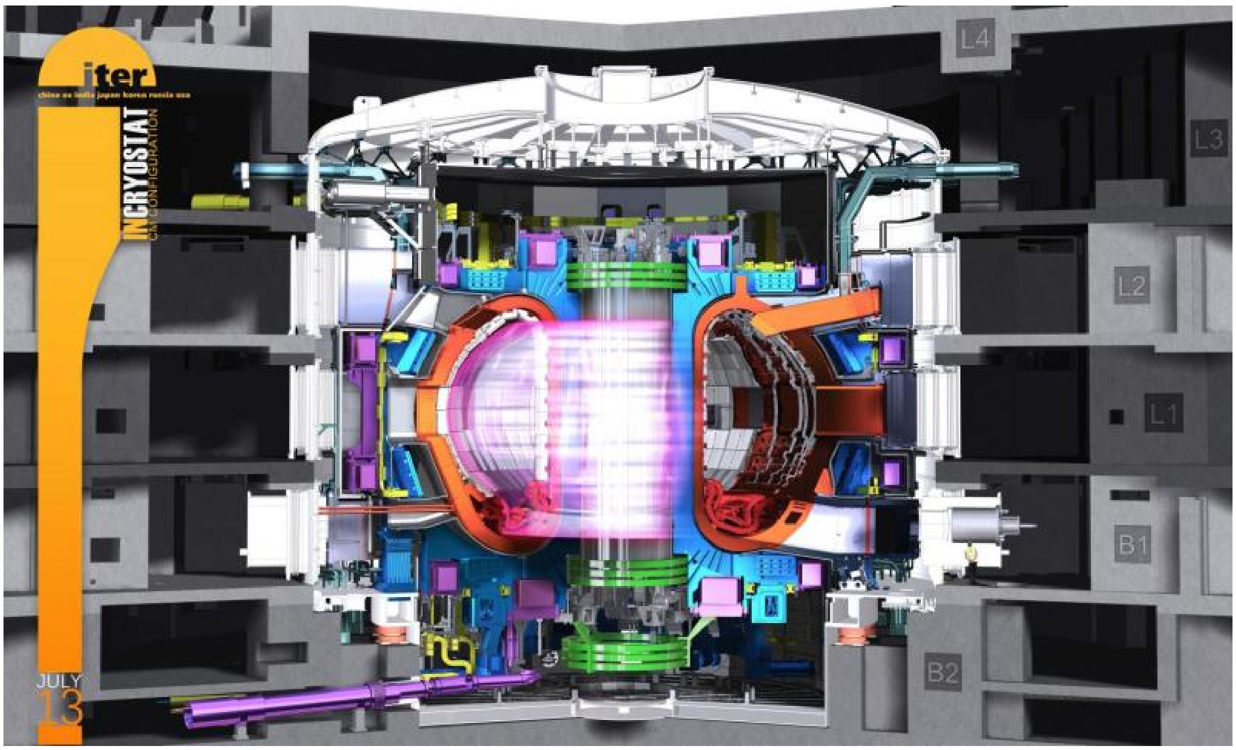


Design of ITER's Tokamak with its plasma. The nuclear fusion experimental plant to generate electricity is now under construction in southern France. More on ITER at www.iter.org.

Engineers building parts of a new type of power plant for generating green energy with nuclear fusion are using their expertise from building rockets like Europe's Ariane 5 to create the super-strong structures to cope with conditions similar to those inside the sun.

A technique for building launcher and satellite components has turned out to be the best way for constructing rings to support the powerful magnetic coils inside the machine.

Meaning "the way" in Latin, the International Thermonuclear Experimental Reactor, ITER, is the world's largest nuclear fusion experiment on generating electricity and is now being built in France.

Spanish company CASA Espacio is making the rings using a method they have perfected over two decades of building elements for the Ariane 5, Vega and Soyuz rockets, as well as for satellites and the International Space Station.

"Forces inside ITER present similar challenges to space," explains Jose Guillamon, Head of Commercial and Strategy.

"We can't use traditional materials like metal, which expand and contract with temperature and conduct electricity. We have to make a special composite material which is durable and lightweight, non-conductive and never changes shape."

At their centre of excellence in Spain with its track record in composites for space applications, CASA Espacio has been at the forefront of developing a technique for embedding carbon fibres in resin to create a strong, lightweight material.

On 30 September 2015, Ariane 5 flight VA226 lifted off from Europe’s Spaceport in French Guiana and delivered two telecom satellites, Sky Muster and Arsat-2, into their planned orbits. Credit: ESA

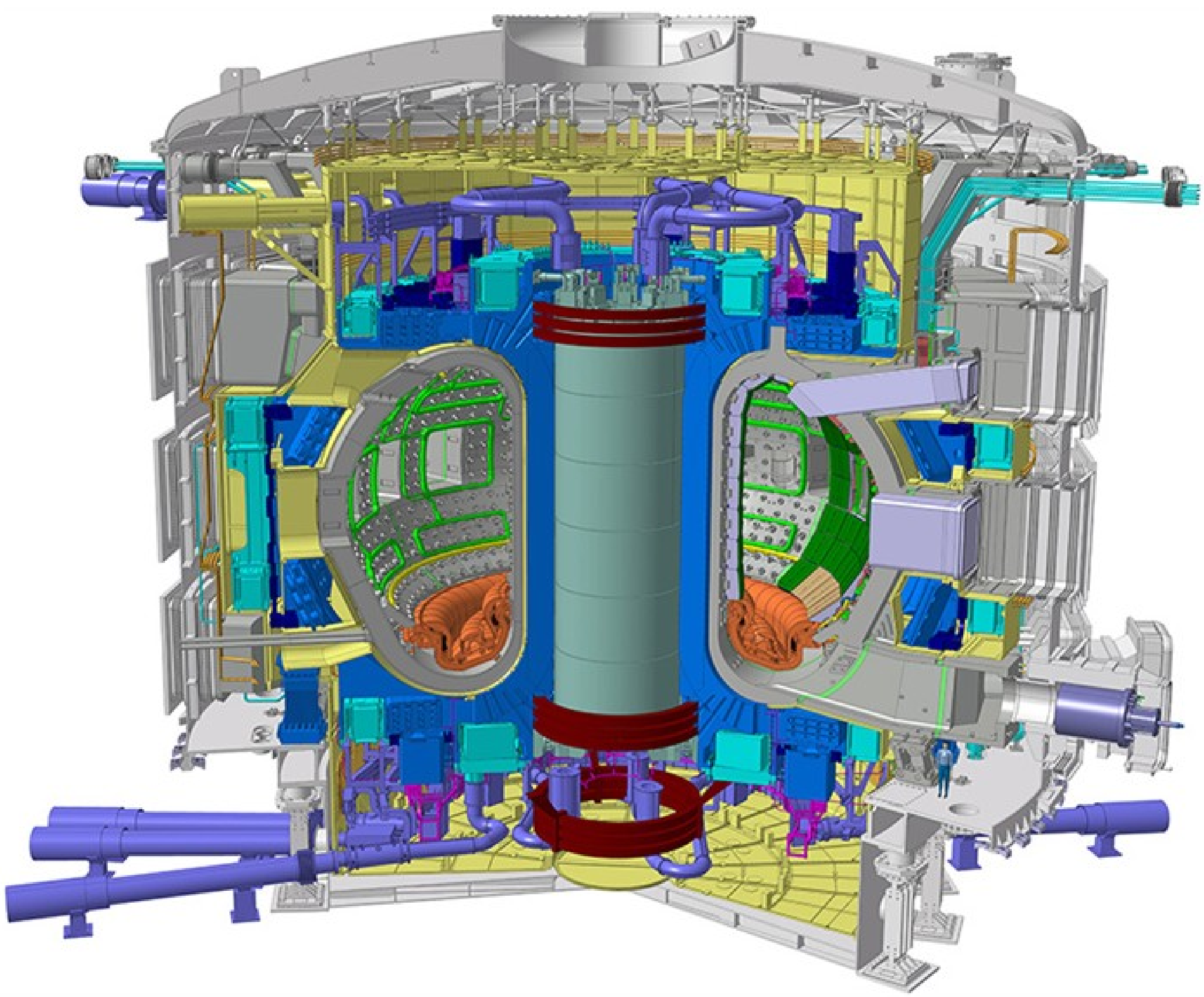
The composite is ideal for rocket parts because it retains its shape and offers the robust longevity needed to survive extreme launches and the harsh environment of space for over 15 years.

Now, the team is using a similar technique to build the largest composite structures ever attempted for a cryogenic environment. With a diameter of 5 m and a solid cross-section of 30x30 cm, ITER's compression rings will hold the giant magnets in place.

Harnessing star energy

Nuclear fusion powers the sun and stars, with hydrogen atoms colliding to form helium while releasing energy. It has long been a dream to harness this extreme process to generate an endless supply of sustainable electricity from seawater and Earth's crust.

In a worldwide research collaboration between China, the EU, India, Japan, South Korea, Russia and the US, the first prototype of its kind is now being realised in ITER.



ITER and its tokamak is an experimental machine designed to harness the energy of fusion. Inside a tokamak, the energy produced through the fusion of atoms is absorbed as heat in the walls of the vessel. Just like a conventional power plant, a fusion power plant will use this heat to produce steam and then electricity by way of turbines and generators. More on ITER at www.iter.org. Credit: ITER Organization

Construction is expected to be completed by 2019 for initial trials as early as 2020. A commercial successor for generating electricity is not predicted before 2050.

Designed to generate 500 MW while using only a tenth of that to run, ITER aims to demonstrate continuous controlled fusion and, for the first time in fusion research, produce more energy than it takes to operate.

Inherently safe with no atmospheric pollution or long-lived radioactive waste, one kilogram of fuel could produce the same amount of energy as 10 000 tonnes of fossil fuel.

At ITER's core is a doughnut-shaped magnetic chamber, 23 m in diameter. It will work by heating the electrically charged gases to more than 150 000 000ºC.

Hotter than the sun, the plasma would instantly evaporate any normal container. Instead, giant electromagnets will hold the plasma away from the walls by suspending it within a magnetic 'cage'.

Building something that can withstand this powerful magnetic field is an extreme engineering challenge.

CASA Espacio had the answer thanks to their expertise and method for making space components.

Now under construction, ITER's rings will each withstand 7000 tonnes –

the equivalent of the Eiffel Tower pressing against each one of the six rings.

Cut the cloth to fit the spacecraft

Carbon fibres are woven like fabric and embedded in a resin matrix to create a lightweight, durable and stable composite.

"In the same way that you'd weave a different fabric for a raincoat than you would for a summer shirt, we can lay the fibres in different directions and alter the ingredients to adapt the resulting material to its role, making it extra strong, for example, or resistant to extreme temperatures in space," explains Jose.

For ITER, glass fibres are laid to maximise their mechanical strength and can be built up in slices and stacked like doughnuts to create the cylindrical structure.

"Space expertise can provide a tremendous resource to so many companies in non-space sectors, helping them to improve their product and increase their revenues," says Richard Seddon from Tecnalia, worked with ESA´s Technology Transfer Network, which helps companies employ technologies from space to improve their businesses.

"In this case, CASA Espacio had just the right proven expertise to provide the best solution for ITER."

Provided by European Space Agency