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Nuclear fusion plasma problem tackled

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Nuclear fusion could become a more viable energy solution with the discovery of way to prevent super-hot gases from causing damage within reactors.

The potential solution, tested at an experimental reactor in San Diego, US, could make the next generation of fusion reactors more efficient, saving hundreds of millions of euros a year. It could be incorporated into the latest prototype fusion station – the International Tokamak Experimental Reactor (ITER) – which is to be built in Cadarache, France, from 2008 at cost of €10 billion.

Fusion reactors generate power by heating hydrogen plasma to 100 million degrees Celsius. This causes hydrogen isotopes to fuse together and release energy. But the blistering plasma has to be contained within a vessel using a donut-shaped magnetic field, created using several powerful superconducting magnets.

Over time, the reactor's plasma-containing vessel will inevitably be damaged by instabilities known as "edge-localised modes" (ELMs) that occur when hot plasma bursts out of the magnetic field. Unless these ELMs can be controlled, expensive components need to be replaced regularly.

Small currents

Researchers at General Atomics, a company based in San Diego, California, US, discovered a simple way to prevent ELMs from occurring. By using a separate magnetic coil to induce small perturbations in the reactor's main magnetic field, they found they could bleed off enough of the plasma particles to prevent the ELMs from bursting out. The solution was tested at an experimental reactor based in San Diego called the DIII-D National Fusion Facility.

"We were very pleased to find out that we can actually use fairly small currents in these coils to completely prevent ELMs," says Todd Evans, a plasma physicist with the company. "We can eliminate them completely."

Evans says uncontrolled ELMs could be expected to damage a part of the ITER reactor called the diverter, which collects and removes helium (a by-product of the fusion reaction). This would have to be replaced every six months to a year, he says, at a potential cost of hundreds of millions of Euros.

Calculated results

Curiously, however, Evans notes that the theory behind the effect does not precisely match the results. According to their calculations, the perturbations should have released both particles and heat from the plasma. Instead, the heat was not bled off with the plasma but remained mostly contained within the magnetic field.

"I think it's a very interesting solution to a very important problem," says William Dorlund, a plasma physicist at the University of Maryland in College Park, US. But he warns it will be difficult to apply the solution to functional reactors until the theory behind the technique is well understood.

Any changes to the ITER must go before an advisory group, notes Bill Spears, a spokesman for the project in Garching, Germany. He adds that there is no consensus on the amount of damage ELMs will cause. Currently, the plan is to only replace the reactor's diverter every two-to-three years, he says.

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