Dutch team has solution for troubled ITER nuclear fusion reactor

February 8 2012

(PhysOrg.com) -- The superconducting cables designed for the ITER fusion reactor (cost: 16 billion euros = $21.2 billion) are unable to withstand the planned forty to sixty thousand charge cycles. Barring a solution, the troubled mega-experiment will suffer still more delays and cost overruns. About one third of total expenditures for the reactor are devoted to the superconducting magnet system. UT researcher Arend Nijhuis thinks he has the solution. He has calculated that a different configuration will make the cables more robust. In the first week of March, ITER will run an experiment costing half a million euros to see whether this theoretical solution will actually work in practice.

The success of the ITER nuclear fusion reactor is dependent on the quality of the superconducting cables making up the superconducting magnets. These magnets keep the plasma in the reactor in check. The problem with the current cables is that they degrade too quickly. Tests were conducted in which the cables were subjected to tremendous electromagnetic forces at extremely low temperatures. The results show that the current cables are not capable of withstanding the scheduled 40,000 to 60,000 charge cycles, as recently reported in Nature and other sources. (The organization behind ITER itself is very cautious when it comes to publicizing any issues related to the reactor).

UT researcher Arend Nijhuis of the Energy, Materials & Systems research group of Professor Marcel ter Brake has designed a new cable configuration together with his project group. They have been working on their calculations for three years. The new configuration entails a completely different braid of the 864 individual wires of 0.8 millimeter thickness which make up the superconducting cables. The thin brittle wires run more in parallel in Nijhuis's configuration and are therefore better supported. The biggest problem was to devise a cable configuration that would not only provide good support for the wires, but that would also lead to reduced warming of the superconductors due to eddy currents causing AC loss. This solution means the cables can withstand greater mechanical loads and that they will heat up far less than the cables currently scheduled for installation in the reactor.

A test costing nearly a half million euros will be run in Switzerland in the first week of March to see if Nijhuis's solution is feasible. A 3.5 meter long cable will be subjected to an intense electromagnetic charge at extremely low temperatures several thousand times. If the tests show that the cable's performance does not deteriorate, then this configuration will be suitable for the ITER reactor. In addition to Nijhuis's design, three other cable configurations will also be tested. Nijhuis is fully convinced that his design will withstand the test with flying colours. "My model does not indicate even the slightest deterioration," states Nijhuis resolutely. The test results are expected in April.

ITER is an international project in which stakeholders are researching the scientific and technical feasibility of fusion as an energy source. The ITER reactor, which is being built in Cadarache, France, should be able to produce 500 megawatts of electricity.

Nuclear fusion requires extremely high temperatures of up to 150 million degrees in order to form plasma (ionized gas). Since no material can withstand these temperatures, the fuel (a mixture of two isotopes of hydrogen: deuterium and tritium) must be kept trapped in extremely energetic magnetic fields. The magnets that produce these fields are composed of giant coils of superconducting cables.

Nuclear fusion could potentially be a vital energy supply in the future. In nuclear fusion - a process that also occurs in stars - the nuclei of different atoms fuse, resulting in a different, heavier nucleus, and releasing tremendous amounts of energy. The main advantages of fusion are that the energy supply is (in principle) endless, and that hardly any radioactive waste is produced, as is the case with nuclear fission. Controlled nuclear fusion on earth has already been demonstrated, but the energy required to cause fusion was greater than the energy produced.

Provided by University of Twente