FUSION TECHNOLOGY DESCRIPTION

EUROfusion
TECHNOLOGY TRANSFER PROGRAMME

# Nanofluids For Improved Heat Transfer

*Research is underway into the use of nanofluids to improve the cooling of surfaces within fusion reactors that are exposed to extreme heat fluxes. Nanofluids are a mixture of liquids (typically water) with nanoparticles (<100nm) in a concentration that is usually less than 1% by volume. Nanoparticles being investigated are alumina, ceramics, and carbon nanotubes, as these are known to increase both the conductive and convective heat transfer coefficients by up to half an order of magnitude (5x), and the critical heat flux of current coolants by up to an order of magnitude (10x) for boiling heat transfer. Due to this, cooling systems that are based on nanofluids could deliver a step-change in the power handling performance of heat exchangers and other components.*

## Description of the technology

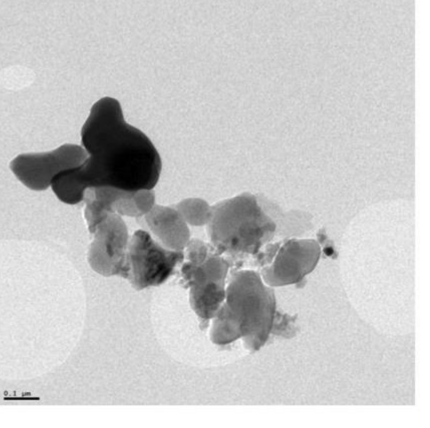
Nanofluids are suspensions of nanoparticles within a fluid. The nanoparticles are typically less than 100nm and are usually diluted within water at a concentration of less than 1%. From previous investigations nanofluids have been found to enhance properties such as thermal conductivity, viscosity, and convective heat transfer coefficients when compared to base fluids such water or oil.

Nanoparticles being investigated for nuclear fusion applications include: alumina, ceramics, and carbon nanotubes, as these are known to increase both the conductive and convective heat transfer coefficients by up to half an order of magnitude (5x), and to increase of critical heat flux of current coolants for boiling heat transfer by up to an order of magnitude (10x).

Two collaborative research projects are currently underway within the nuclear fusion industry to further understand the physics leading to the increased heat transfer rates. As nuclear fusion involves an extremely harsh environment, it can provide a highly robust technology that can be transferred into other industries to develop competitive advantages. In parallel, an experimental rig has been constructed with the aim of measuring the long--term effects of nanofluid flows inside a fusion–relevant heat exchanger. Nanoparticle quality, settling and surface erosion are also being assessed to determine the long-term effects that may be incurred by the system.

## Innovation and advantages of the offer

Nanofluids exhibit dramatically improved thermophysical properties in comparison with conventional coolants. This involves an increase in both the conductive and convective heat transfer coefficients by up to half an order of magnitude (5x), with up to an order of magnitude (10x) increase of critical heat flux of current coolants for boiling heat transfer. Such improvements in coolant performance are relevant especially for high heat flux applications including gas turbines, synchrotron X-ray components, and high-power laser diodes. Improvements in thermophysical properties translate to increased efficiency, which can mean lower construction and running costs as well as increased energy efficiency. These aspects also contribute to the green credentials of a technology or process.



*Transmission Electron Microscope (TEM) image of nanofluid (courtesy of CCFE-UKAEA)*

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## Non-fusion Applications

Nanofluids have the potential to enhance any application that uses water or oil-- based convective cooling. These include: Automotive, Electronics, Semiconductors, Medical, Nuclear, Aerospace, Heat exchangers, Gas turbines.

## Fusion Heritage

Developed for fusion to improve the convective cooling of the high heat flux hypervapotrons.



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