

# Multi-Phase Modelling of Nanofluid Hydronic System

## Organizations

**TCT S.r.L.** is an Italian SME that has been developing nanomaterials since 2003. In 2017 TCT invented and patented a nanofluid "HTF Compact" with the purpose of improving the solution according to customer needs.

**CETMA** is a private research and technology organization which has acquired, in more than 25 years of applied research studies, skills and know-how focused on numerical modelling of complex phenomena.

**CINECA** is the largest Italian supercomputing centre with an HPC environment equipped with cutting-edge technology and highly qualified personnel, which cooperates with academia and industrial partners.



End User



Technology Expert



HPC Provider



CINECA is part of the Italian NCC.



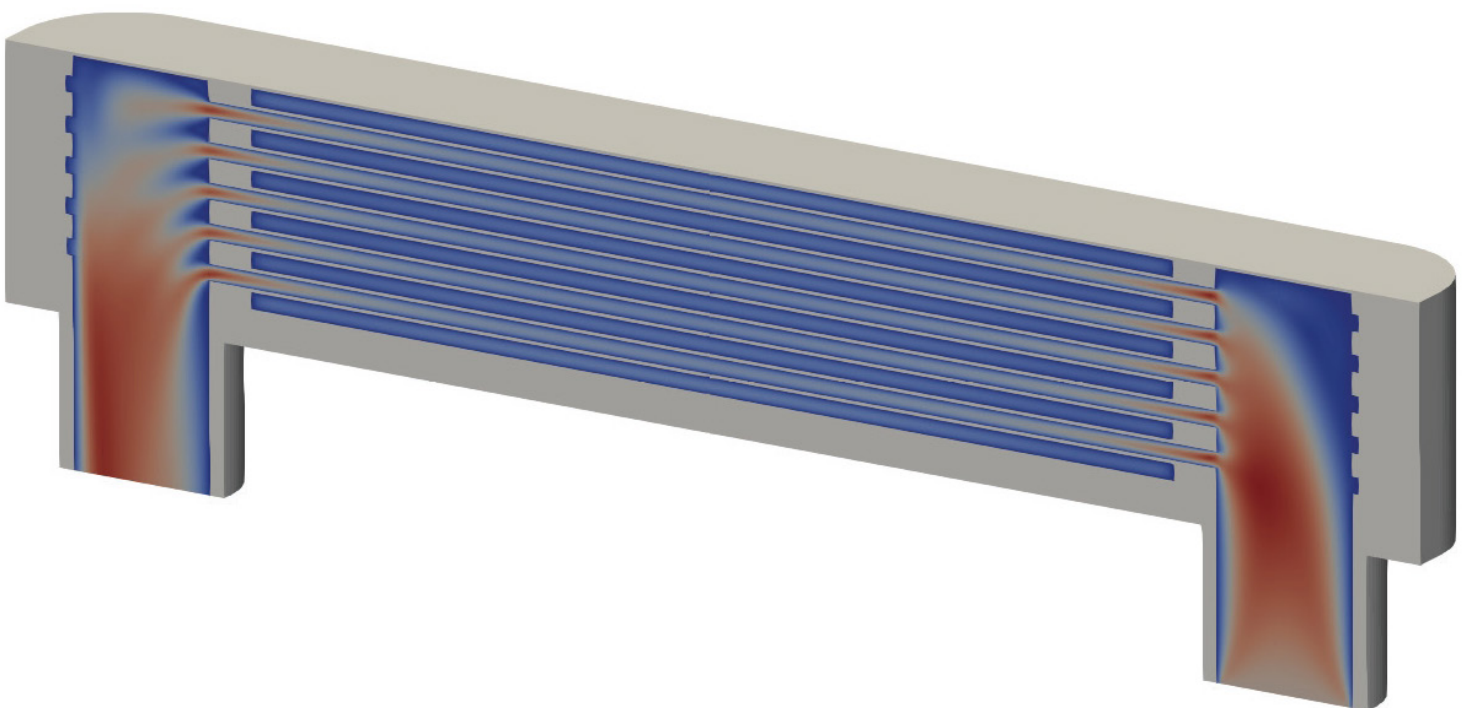
## The Challenge

In a wide range of industrial applications, hydronic systems use water or a water solution to transfer heat in heating and cooling applications. The HTF Compact solution (a dispersion of solid metal oxide nanoparticles in a base fluid), drastically improves heat transfer (25% improvement) in such systems.

The nanofluid performance depends on a high number of parameters. The interaction of these variables influences the nanofluid behavior, requiring expensive trial-and-error for optimal nanofluid design. The increased development time and costs reduces the competitiveness of an SME.

To better understand the nanofluid performance, numerical CFD simulations can be used, but applying a simplified single-phase model may result in underestimating the heat exchange performance. A more robust approach considers the nanofluids as a two-phase system where nanoparticles and the base fluid have different properties, but this has a high impact on computational costs.

The challenge is to optimise the nanofluid design and manufacturing process to maximise the heat exchange in the systems developed by TCT, while minimizing the time and high production costs. This optimisation has been done using two-phase CFD simulations on HPC.





Industry Sector  
**Manufacturing**

Technology used:  
**CFD Simulation**

## The Solution

This experiment developed a multi-phase numerical model to maximise the nanofluid performance that considers all intrinsic parameters and how they affect the heat exchange and energy efficiency of the hydronic system. The use of HPC is essential to simulate the behaviour of the second phase with its high number of nanoparticles and also their effects. Furthermore, HPC is necessary to create a mesh fine enough for accurate and reliable results. Such numerical models would take up to several weeks to compute on in-house workstations. Using HPC-based simulations allow partners to drastically reduce the computational time, to a few hours, and thereby minimise the necessary number of physical tests and associated waste.

## The Impact

The innovative technology created in this experiment has allowed TCT to improve its current design and production, abandoning the trial-and-error approach. TCT will use the HPC-based simulations to produce high-quality nanofluids at reduced time and costs thereby increasing its competitiveness. All these aspects can have an important impact on the market and could bring new business developments on a European and global scale. The expected business impact has been quantified at 1M€ three years after HYSY's end.

In all hydronic systems, adding nanoparticles into a base fluid (water or glycol/water) can increase the thermal conductivity and the heat transfer coefficients. This has a positive environmental impact, reducing CO<sub>2</sub> emission and electricity usage up to 25%. Moreover, by increasing the heat transfer, the size of heat exchangers can be reduced, saving production costs. Furthermore, a smaller heat exchanger requires reduced pump pressure, saving electric energy.

## Benefits

- TCT expects to reduce: time-to-market by 66% (to only 2 months), design costs by 50% (about 100,000€ saving per year), material waste by 70% (about 60,000€ saving per year), and energy power by 15% (about 150,000€ saving per year).
- CETMA expects new R&D projects and consultancy services with an increase in revenue of about 50,000€ per year.
- CINECA aims to become a TCT HPC resource provider at an estimated 20,000€ per year and to exploit the success story to attract new customers.