Optimization of the Route to Produce Magnetic Nanofluids

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To reduce the net greenhouse gas emissions and the use of toxic refrigerants, new heat transfer technologies are required. One such technology could be the use of aqueous ferronanofluids under the influence of external magnetic fields. The basic idea of such a strategy is the use of magnetic field gradients to influence water-based suspensions of ferromagnetic (e.g. Co, Ni) or ferrimagnetic (magnetite) nanoparticles, which are smaller than 100 nm, to enhance heat transfer processes. Such suspensions allow for example to switch convective heat transfer. Practical applications are the load control of electrical and electronic assemblies. In the event of an accident, an immediate increase in heat dissipation is required, which can be achieved by magnetically fuelling additional forced convection.

In order to produce such suspensions, an optimized preparation route of the ferronanofluids should be clearly oriented towards the thermodynamic application. Furthermore, the precise knowledge of the thermophysical properties of such suspensions is of great importance. Our study aims to investigate the optimisation of the production of water-based suspensions with magnetite nanoparticles.

Among other points, the following requirements define a thermodynamically optimised ferronanofluid:

- Newtonian flow behaviour,
- long-term stability regarding viscosity and the avoidance of sedimentation
- mechanical stability during pumping
- stability against thermal and magnetic gradients to avoid agglomeration

In contrast to conventional nanofluids, an increase of the thermal conductivity is not as important. The heat transfer enhancement results rather from a secondary movement generated by the applied magnetic field [1, 2].

The proposed routing is a one-step approach. The magnetite particles are the result of a precipitation reaction. Magnetic separation extracts the nanoparticles from the primary suspension. After repeated rinsing and drying, they are ultrasonified employing deionised water and the addition of various stabilising agents. Measurements of the particle size and the nanofluid properties in dependence on the amount and kind of additive lead to an optimised composition in order to achieve the stability mentioned. The result is a ferronanofluid with a Newtonian viscosity, a density comparable to water, and an environmentally friendly pH value of 6.5. Centrifugation at 300 g for 2 h and a waiting time of 24 h show the excellent sedimentation stability of the ferronanofluid. The particle size of about 16 nm is particularly noteworthy and very close to the theoretical value of 7.8 nm sought after to avoid magnetic agglomeration.

In summary, the study provides an optimised production route for an innovative heat transfer medium that is strictly oriented towards the expected thermodynamic application. Experimental work is currently underway to determine the specific heat capacity and thermal conductivity of the suspension. These data will enable a complete thermodynamic characterisation and thus the appropriate design of the corresponding heat transfer application.

References

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