Convection Heat Transfer in Water-based Alumina Nanofluids

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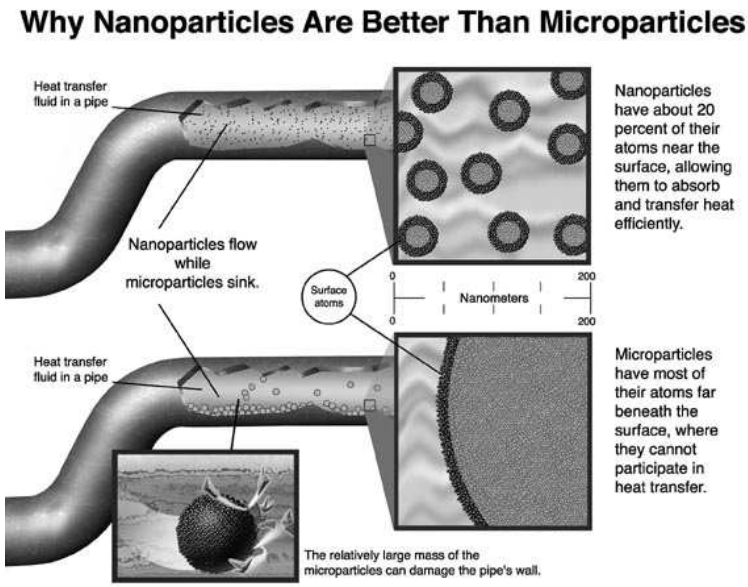
Introduction

Nanofluids are colloidal suspensions of nanoparticles in a base fluid

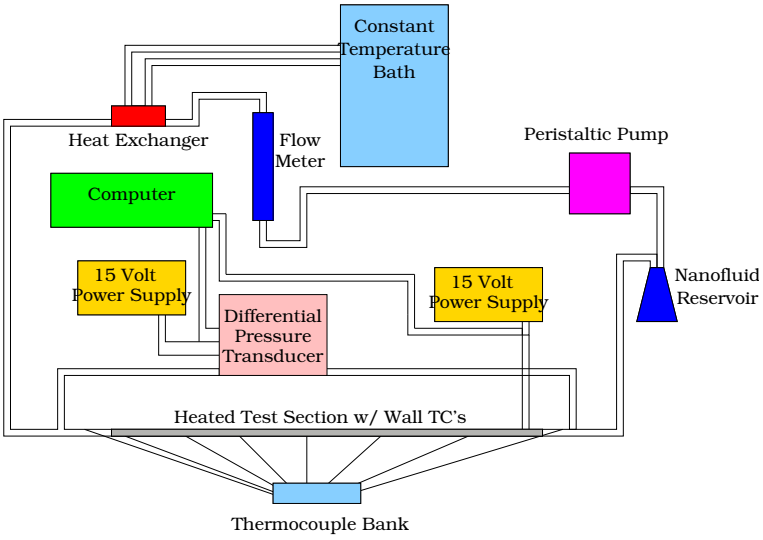
- Typical nanofluid properties
  - particles made of chemically stable metals, metal oxides or carbon in various forms
  - particles range in size between 1 and 100 nm
  - base fluid usually water and organic liquids
- Effects of nanofluids
  - greatly enhanced energy, momentum and mass transfer
  - reduced tendency for sedimentation and erosion of containing surfaces
- Applications of nanofluids
  - refrigeration
  - manufacturing
  - chemical and pharmaceutical processes
  - medical treatments

How do nanoparticles enhance thermal transport?

- suspended nanoparticles increase surface area and heat capacity of the fluid
- suspended nanoparticles increase the effective thermal conductivity of the fluid
- interaction and collision among particles, fluid and the flow passage surface are intensified
- mixing fluctuation and turbulence of the fluid are intensified
- dispersion of nanoparticles flattens the transverse temperature gradient of the fluid (changes the thermal boundary layer)



Experimental Setup: Convection Coefficient Measurement

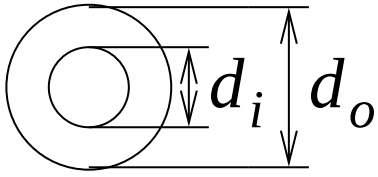


Key measurements

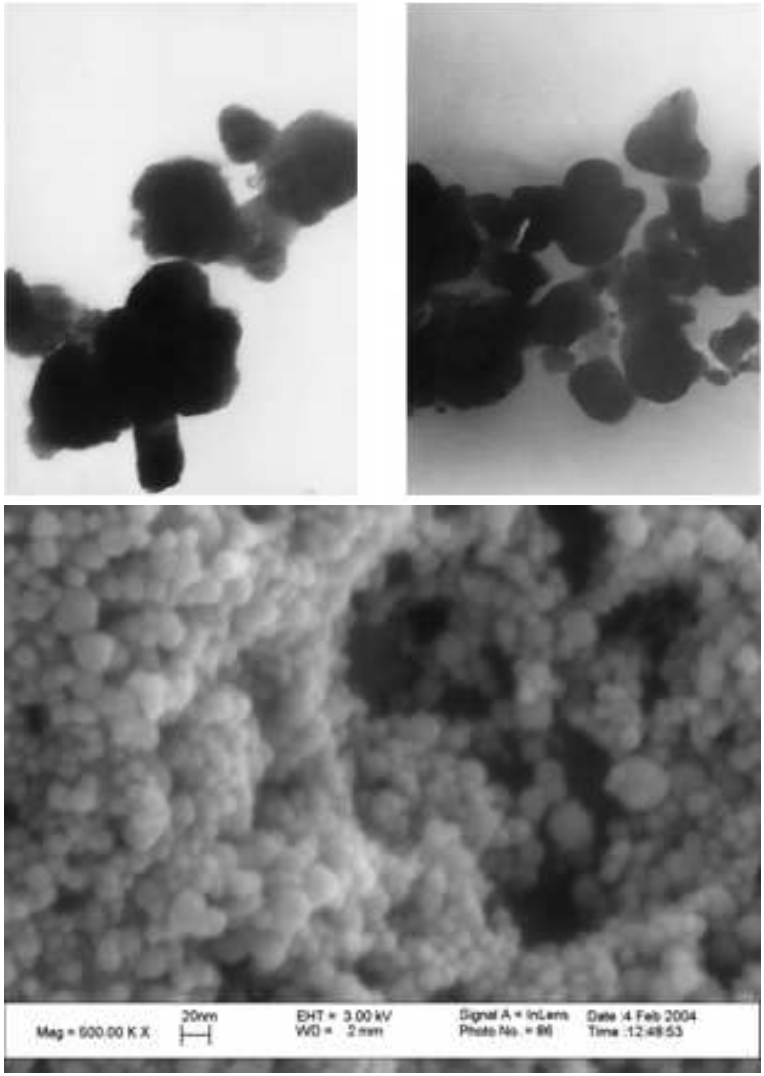
- pressure drop along test section
- temperature profile along outside of test section (12 TC's)
- inlet and outlet fluid temperatures
- heat dissipation from heater wire
- volumetric flow rate

Test section properties

Tube	d_i (mm)	d_o (mm)	l (m)
17 Ga	1.07	1.47	0.9144



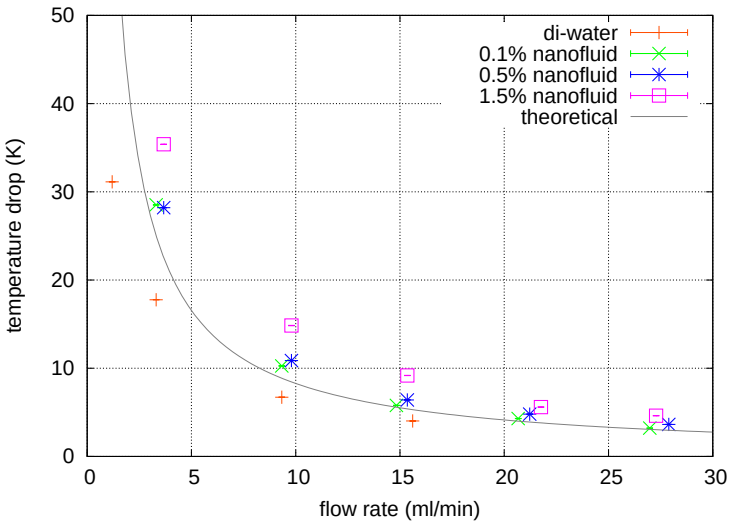
Nanoparticles and Preparation

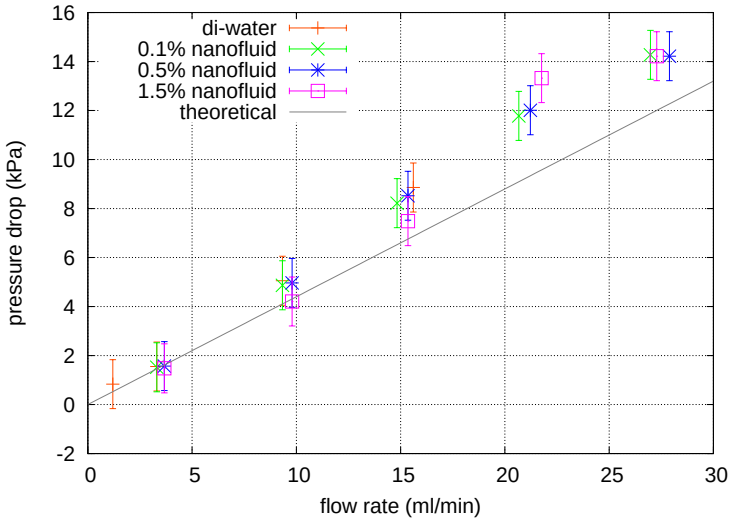


- Nanoparticles (Al_2O_3)
  - γ 10 nm
  - γ 20-30 nm
- Preparation
  - Nanoparticles are weighed and added to de-ionized water for different particle loadings
  - Nanoparticles are ultrasonicated for 1 hour to break up agglomerates
- Stability (from DLS)
  - γ 10 nm unstable in de-ionized water
  - γ 20-30 nm stable in de-ionized water

Results: Pressure and Temperature Drop/Increase

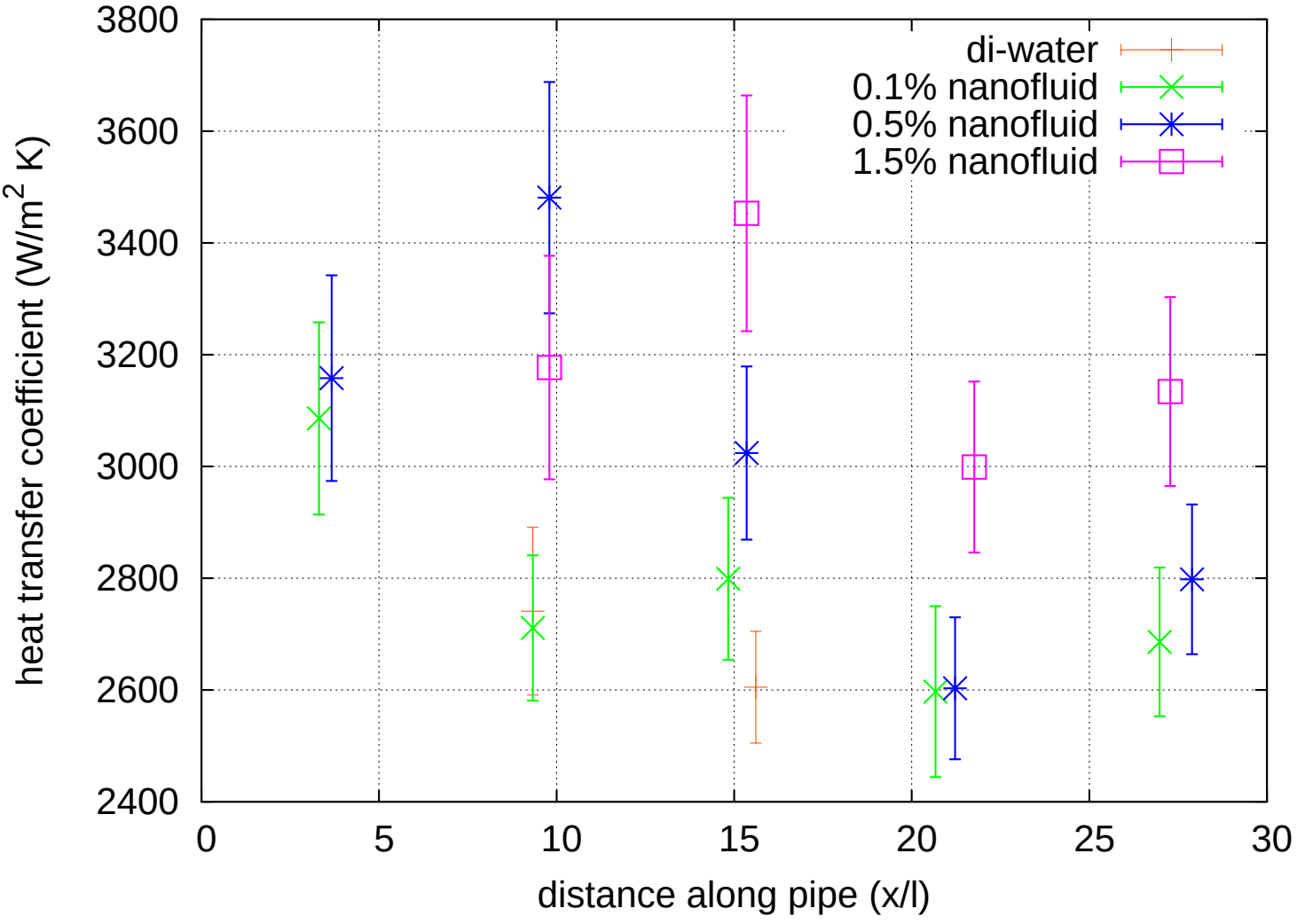
- Nearly equal pressure drop across the tube for all fluids
- Slight deviation from theoretical pressure drop for DI-water due to experimental setup



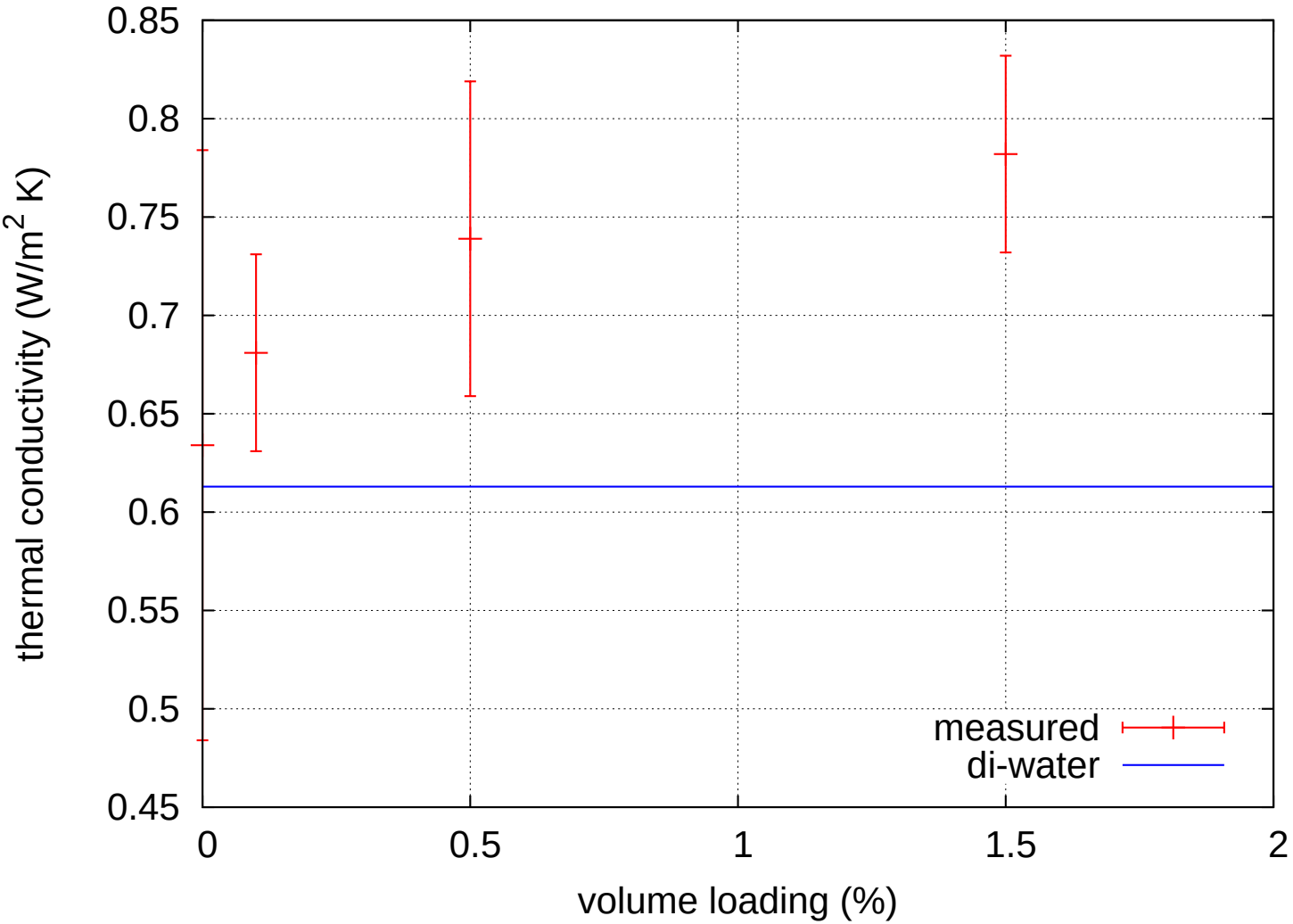


- Nearly equal temperature gain across the heated tube for the DI-water and the 0.5% nanofluid
- Greater temperature gain in the 1.5% nanofluid due to enhanced convective heat transfer

Results: Average Convection Heat Transfer Coefficients



Results: Calculated Thermal Conductivity



Conclusions/Future Work

- Observed enhancement in convection heat transfer coefficient in laminar flow regime
- Enhanced thermal conductivity with increasing volume loading
- No noticeable settling of nanoparticles or development of aggregates within hours
- Further investigation effects of nanoparticle size on heat transfer enhancement in water and ethylene glycol (want to find the limits of particle size, loading, etc.)
- Investigate nanofluids beyond laminar flow regime
- Compare nanofluids to base fluid in commercial and industrial systems
- Investigate long term properties/performance of nanofluids
- Develop model for enhancement in convection heat transfer coefficients and thermal conductivity