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INVESTIGATIONS ON HEAT AND MOMENTUM TRANSFER IN NANOFLUID

Grzegorz DZIDO, Michał DRZAZGA, Marcin LEMANOWICZ, Andrzej GIERCZYCKI
Department of Chemical and Process Engineering, Silesian University of Technology, Gliwice, Poland
E-mail: gdzido@polsl.pl, michal.drzazga@polsl.pl, marcin.lemanowicz@polsl.pl, andrzej.gierczycki@polsl.pl

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A concept of nanofluid was introduced by Choi, et al. (1995). Recent development of nanotechnology makes possible the preparation of highly stable suspensions of solids characterized by relatively high heat conductivity coefficient. Nowadays, a lot of researches on intensification of heat transfer with CuO or alumina based nanofluid are observed.

This work presents results of investigations on heat transfer and pressure drop for CuO-water nanofluid in a circular, 6 mm I.D. and 1 m length straight tube. For preparation of nanofluids CuO 30-50 nm nanoparticles (NPs) were used at concentration 2.2 and 4.0 vol.%. Before experiments NPs were stirred vigorously for 2h with the ultrasonic horn in 0.15% wt. water solution of triammonium citrate. Measurements were conducted in the Reynolds number range 4000 < Re < 12 000. The experimental loop is shown in Fig. 1.

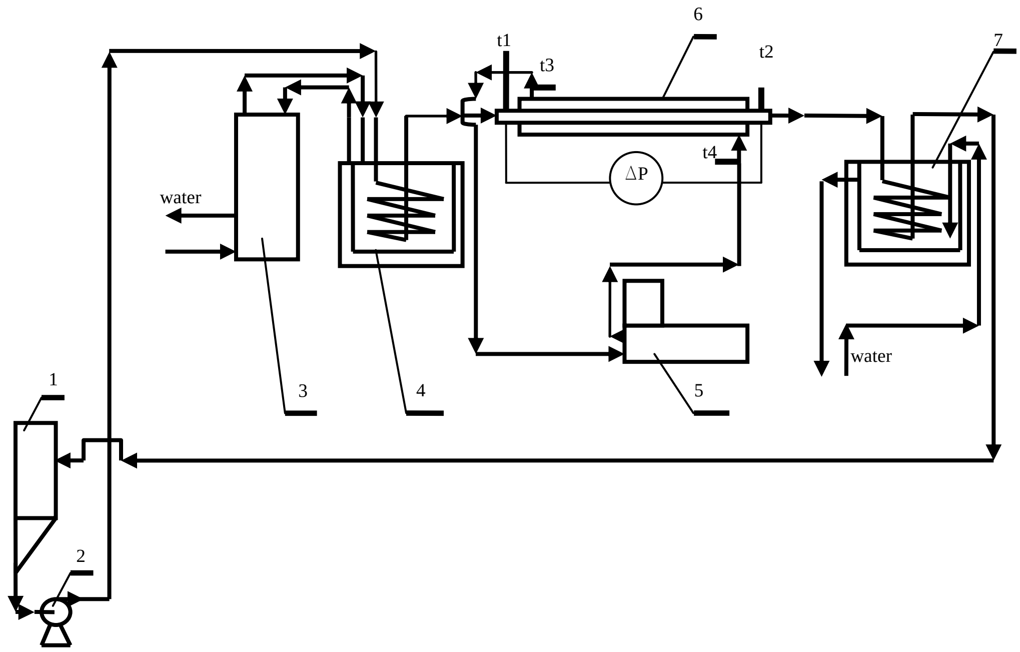

Fig. 1. Experimental set-up. 1 – nanofluid container, 2 – pump, 3 – chiller, 4 – secondary cooler, 5 – thermostat, 6 – shell-tube heat exchanger, 7 – primary cooler, t1, t2, t3, t4 – K-type thermocouples, ΔP – pressure transducer

For steady state condition transferred heat Q was determined by energy balance for shell and tube sections. Assuming unchanged average temperature difference Δt_m, overall heat transfer coefficient U was calculated (1):

$$U = \frac{Q}{F \Delta t_m} . \qquad (1)$$

With given U and heat transfer coefficient for shell section calculated according to Yang et. al. (2005) the heat transfer coefficient for nanofluid was calculated. A pressure drop was measured directly by means of pressure transducer. Table 1 presents properties determined for nanofluids.

Tab. 1. Properties of investigated nanofluids

CuO load [% vol.]	heat capacity [J/kg K]	density [kg/m^3]	viscosity [Pa·s]	heat cond. coeff. [W/m K]
2.2	3856	1074	0.00165	0.620
4.0	3415	1214	0.00219	0.682

A measured heat conductivity coefficient of nanofluids is larger than that for water but as it is seen in Fig. 1, this is not the only factor that influences heat transfer which is almost the same as in case of host liquid. Pressure drop in the flow significantly exceeds determined for water (Fig. 2).

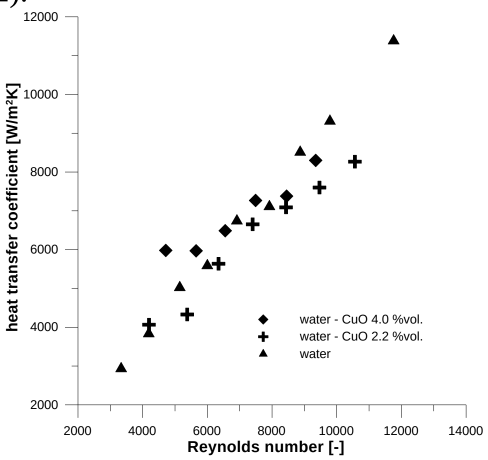

Fig. 1 Heat transfer coefficient for nanofluids and water

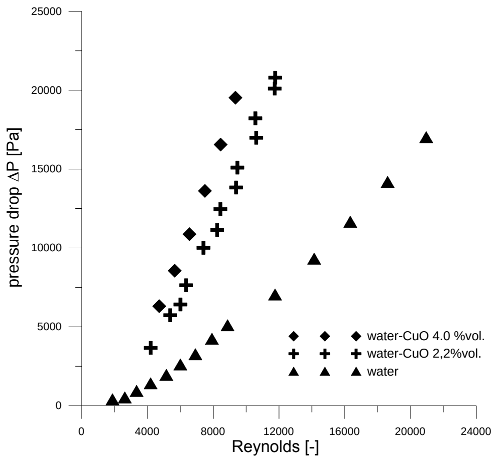

Fig. 2 Pressure drop for nanofluids and water

Application of nanofluids in turbulent flow regime may be limited due to high pressure drop and relatively small influence on heat transfer. A conclusion is consistent with results of Pantzali et. al. (2009).

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