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# NUMERICAL STUDY ON THE INFLUENCE OF NANOFLUIDS ON THE BOREHOLE HEAT EXCHANGER THERMAL RESISTANCE

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**ABSTRACT** Energy consumption in buildings covers approximatively 40% of the total energy demand and about 36% of the total greenhouse gases emission in Europe. The majority of this total energy demand can be ascribed to air conditioning systems, thus, more and more interest on energy-efficient air conditioning system has kept growing over the last years. In this context, air conditioning system based on renewable energy sources could represent a viable alternative to meet building energy demand and to address climate change. Among several renewable energy sources technologically mature, nowadays the interest towards geothermal one is growing, due to its great potential to provide significant energy saving compared to conventional systems. While the direct conversion of geothermal energy (high-enthalpy) into electricity is widely diffused, the use of geothermal sources in low energy heating-cooling systems (medium and low-enthalpy) employing ground source heat pumps is still limited by their high initial costs and long pay-back period. In the systems with vertical borehole heat exchanger, the majority of these costs are due to the high required borehole length, because of the low thermal conductivity of employed conventional heat carrier fluid.
In order to make ground source heat pumps more economically competitive, the heat transfer between borehole wall and circulating fluid could be improved replacing conventional ethylene/water mixture by nanofluids, that are two phase systems comprising a carrier medium (liquid or gas) and very small (1 nm – 100 nm) dispersed nanoparticles. Although the heat transfer coefficient of nanofluids is much higher than the common-base fluid, it should be taken into account that the thermo-physical properties of nanofluids are strongly depend by the concentration of added nanoparticles: the highest convective heat transfer coefficient is reached when the nanoparticles volumetric concentration $\phi$ is between 0% and 1%; increasing the volumetric concentration above this range, the thermal conductivity of nanofluids remains more or less constant, while the viscosity increases a lot, causing a rise in a pressure drop without an improvement of heat transfer.
In this paper, one-dimensional energy and momentum balances were used to carry out a numerical investigation on the use of nanofluids as heat carrier in BHE. Varying $\phi$ in the range reported above, the effect of various nanoparticles (Ag, Cu, Al, $Al_2O_3$, CuO, Graphite, $SiO_2$) on the borehole heat exchanger performances was evaluated, choosing the best solution that ensures both the lowest increase in pressure drop and the highest thermal borehole resistance reduction. Moreover, an economic analysis was carried out, in order to analyse the influence of the use of nanlofluids on the costs of borehole heat exchanger system. Moreover, a comparison with previous published results was done.