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STUDY OF NANOFLUIDS FLOW THROUGH A PANEL RADIANT

R. S. LUCIU [1] T. MATEESCU[1] V. CIOCAN[1] I. CAZACU[1]

Abstract: *This work presents the thermo-hydrodynamic behaviour of a nanofluid consisting of water and Al_2O_3 particles in a radiant panel. The study was performed by comparison with a classical heat transfer fluid (water) in steady state regime with ascending laminar flow. . It has been found that the use of nanofluid causes an increase of approximately 25% in heat transfer rate, compared to the base fluid used.*

Key words: *nanofluid flow, heat transfer, panel radiant.*

1. Introduction

This article examines digital thermo-hydrodynamic behaviour of a nano-fluid consisting of water and Al_2O_3 particles used as heat transfer agent in a radiator panel. The study was prepared under laminar flow upward scheme.

The concept of "nano-fluid" was developed by the National Labs of Chicago argon by Choi [1], describes a new fluid to the suspended particles of the order of nanometers (<100 nm).

Nanofluids show a remarkable increase in the coefficient of thermal conductivity and convective heat transfer fluids based on classical - water, glycol, oil -.

Due to limited thermal conductivity, heat transfer fluids classical measures such as intensifying turbulence, increasing the heat exchange surface, etc. They are useless. Hence the idea of improving the thermal conductivity of these fluids [2, 8, 9].

In this study it aimed to show the influence of nanoparticles on convective heat transfer coefficient and loss of pregnancy affecting the pumping power.

For this purpose were used working fluids made with particles of aluminum oxide (Al_2O_3) with dimensions of about 47 nm and having thermal conductivity of 36 W/mK, density 3800 kg/m^3 and the specific heat equal to 773 J/kg.K, the volumetric concentration of 1% in water.
Numerical analysis was performed using the computer program FLUENT [3].

Fluent software is a code CFD (Computational Fluid Dynamics), which was developed for solving the equations of heat transfer and flow characteristics using the finite volume. This method is based on the spatial integration of the equations of conservation, turning them into algebraic equations which are solved by the physical sequentially analyzed.

2. Numerical Modelling

The CFD uses numerical technique to solve equations governing the flow in

[1] Department of Building Services, Technical University *"Gheorghe Asachi"* of Iasi

various types of geometries depending on the boundary conditions; reduce the number of experiments required and deliver results that would be difficult to determine experimentally.

The fields of temperature and flow for single phase fluids are determined by solving the following equations:

The equation of conservation of mass:

$$\frac{\partial p}{\partial t}+\nabla(\rho U)=0 \tag{1}$$

Momentum conservation equation:

$$\frac{\partial}{\partial t}(\rho U)+\nabla(\rho UU)=-\nabla P+\nabla\tau+B \tag{2}$$

Energy conservation equation:

$$\frac{\partial}{\partial t}(\rho h)+\nabla(\rho UCpT)=\nabla(k\nabla T) \tag{3}$$

To solve equations set thermo-physical parameters should be evaluated of nanofluids used as follows:

The density and specific heat:

The calculation formulas determined analytically [4], [5], accepted by the majority of researchers form:

$$\rho_{nf}=(1-\phi)\rho_f+\phi\rho_p \tag{4}$$

$$\left(\rho C_p\right)_{nf}=(1-\phi)\cdot\left(\rho C_p\right)_f+\phi\left(\rho C_p\right)_p \tag{5}$$

Viscosity:

In 2005, Nguyen et al. [6] Starting from the experimental results Al_2O_3, developing a polynomial formula of the specific viscosity of the order of 47 nm particles:

$$\eta_{nf}=\left(1+0.025\phi+0.015\phi^2\right)\eta_f \tag{6}$$

Thermal conductivity:

Hamilton and Crosser [7] have developed a mathematical model for describing thermal conductivity of a mixture of solid particles - liquid:

$$\lambda_{nf}=\frac{\lambda_p+2\lambda_f+2\left(\lambda_p-\lambda_f\right)\emptyset}{\lambda_p+2\lambda_f-\left(\lambda_p-\lambda_f\right)\emptyset}\lambda_f \tag{7}$$

These equations were used to perform the calculation of the temperature distribution and the geometry of the gear fields studied.

2.1. Geometry Studied

The radiant panel has a length l = 50 cm and H = 70 cm height, equipped with 42 polyethylene tube having an inside diameter d = 3 mm, a wall thickness of 0.5 mm and the pitch p = 3d, embedded in a layer of δ plaster thickness = 10 mm Figure 1.

Heat transfer fluid is made from inner tubes (nanofluids) to the outside environment (air) through the wall radiant.

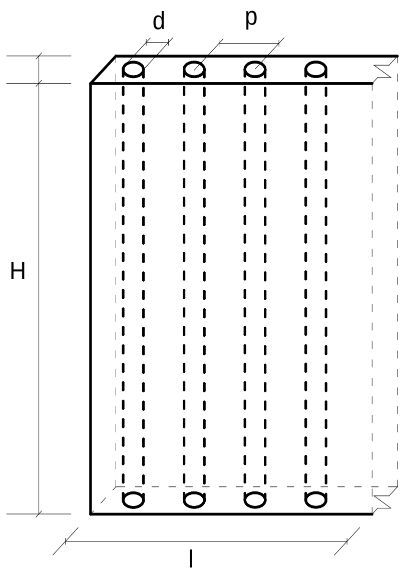

Fig 1. *Geometry radiant panel*

So-fluids will be heated to a temperature depending on the case, and the air will take an amount of heat by convection through the thermal boundary layer at the solid-liquid interface created.

2.2. Working Assumptions and Boundary Conditions

2.2.1. The working hypotheses
- 2 concentrations of the nanoparticles: 0% (water) and 1%;
- March 14 flow regimes, 22, 28 l/h;
- Three temperature regimes: T_i = 30, 40, 50 °C;

2.2.2. Boundary conditions:
Upon entering the exchanger:
- Speed: $v_z = v_y = v_0$;
- Temperature $T = T_0$
On leaving the exchanger:

$$\frac{\partial v_x}{\partial y}=\frac{\partial v_y}{\partial y}=\frac{\partial T}{\partial z}=0 \quad (8)$$

3. Results and Discussion

The performance of the nano-fluid heat water compared to the laminar flow regime.
In order to compare the two types of fluids: water-fluids and numerical simulations were carried out for the correlations identince convective transfer coefficient α and the pumping power Pp.
The convective heat transfer coefficient was determined by the relationship:

$$\alpha_{nf}=\frac{Nu_{nf}\cdot\lambda_{nf}}{d_e} \quad (9)$$

in which:

$$Nu_{nf}=0{,}28Re_{nf}^{0,35}Pr_{nf}^{0,36} \quad (10)$$

is Nusselt criterion;

$$Re_{nf}=\frac{\rho_{nf}\cdot v_m\cdot d_e}{\eta_{nf}} \quad (11)$$

is Reynolds criterion;

$$Pr_{nf}=\frac{Cp_{nf}\cdot\eta_{nf}}{\lambda_{nf}} \quad (12)$$

is Prandtl criterion;
and:

$$d_e=\frac{4A}{P}=\frac{\pi\left(D^2-d^2\right)}{\pi(D+d)}=D-d \quad (13)$$

the equivalent diameter,
Pump power was determined by the relationship:

$$P_P=\frac{\dot{m}\cdot\Delta p}{\rho} \quad (14)$$

Figure 2 is the convective heat transfer coefficient actually α_{ef}, equal to the ratio between the convective heat transfer coefficient of nanofluids and convective heat transfer coefficient of water, depending on the flow or heat the temperature. If nanofluids are registered an increase of 25% compared with water at a flow rate of 28 l/h.

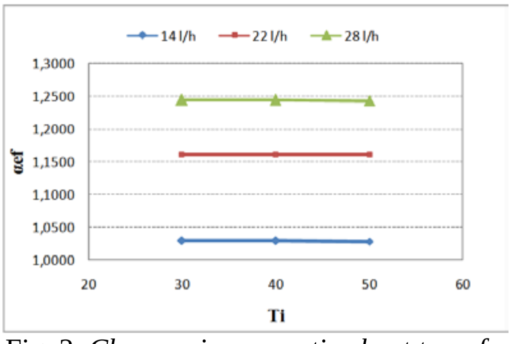

Fig. 2. *Changes in convective heat transfer coefficient α_{ef} at q = 14 l/h*

Figure 3 represent Pp_{ef} effective pumping energy, equal to the ratio between pumping power of nanofluids and water pumping power. If the flow rate of 28 l/h is about 6% growth.

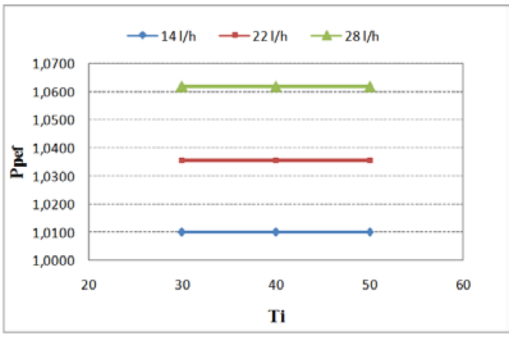

Fig. 3. *Changes in pumping power Pp_{ef}*

4. Conclusions

In this paper it was analyzed compared with water under laminar flow upward and nanofluid having a concentration of 1% Al_2O_3 particles in water, used as the primary agent.

The analysis aimed at highlighting the influence of nanoparticles on convective heat transfer coefficient and miscarriages.

The results show a clear improvement in terms of heat transfer convective when adding nanoparticles in a fluid classic and intensified by about 25%, and an increase in loss of pregnancy by about 6%, with consequences for energy pumping.

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