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EVALUATION OF THE SPECIFIC HEAT CAPACITY (SHC) OF WATER-Al_2O_3 NANO FLUIDS BASED ON A THEORETICAL MODEL

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Abstract: Adding of nanoparticles in a base working agent leads to Nano fluids representing of a new type of working fluid. Due to an increase surface area, there is a gain in the surface area needed for heat transfer between nanoparticles and base fluid. Sein the poor heat transfer properties of water, water base Nano fluids present improved heat transfer performance and require smaller heat exchangers. This paper deals with the estimation of specific heat transfer capacity of water-Al_2O_3 Nano fluid. The decrease of volume concentration, from 13% to 3%, will reveal a gain in SHC of 27% - for nanoparticles diameter of 60 nm and a gain of 40% - for 30 nm diameter. At high temperature, SHC shows better values, also when the volume concentration is lower.
Key words: water, heat transfer, performance, specific heat capacity, Nano fluid**.**

1. INTRODUCTION

We name as heat transfer fluid the working agent used to transfer heat from mediums with different temperature.

In modern times, the wise use of energy is a major issue; it is aimed the ensuring of a safe future and a sustainable development.

This desiderate might be achieved by the use of new sustainable heat transfer fluids.

Heat transfer fluids are chosen in compliance with the technical application, given temperature range, specific to a proper exploitation, and life time of heat transfer fluid.

The heat transfer fluid should respond to the following characteristics:
*high thermal stability when working with high temperature values,
*good resistance degradation in the above mentioned situation,
*good correlation between pressure and temperature values,
*low freezing point,
*non aggressive behaviour to the materials used in the system,
*safe behaviour from toxicity and flammability point of views,
*good environmental behaviour.

When working with liquids, the following benefits appear:
*generous temperature range of operation,
*quick temperature variation,
*diminished heat losses in comparison to the case of vapour systems,
*low operating pressure values,
*smaller pipe dimension compared to vapour systems.

Nanotechnology is an engineering science working at nanoscale, meaning 1÷100 nm. This technology, which enables the work with individual atoms and molecules, is involved in many traditional sector, such as physics, chemistry, engineering sciences, etc.

With the implementation of nanotechnology, appeared a new type of heat transfer fluids, called Nano fluids. Nano fluids results from adding Nano size particles in a base fluid; these nanoparticles might be metallic, metal-oxide and even not metallic provenience.

Nano fluids are known for an improved thermal conductivity, found in an improvement of heat transfer rates. That is why the use of Nano fluids leads to a better energy efficiency, higher performance and diminished operating costs [1].

Nanoparticles, present in Nano fluids, improve the properties of the base fluid, such as: viscosity, density, specific heat capacity, thermal conductivity, etc. – properties that influence the heat transfer process; for this reason Nano fluids might replace successfully water in heat transfer processes [2].

Given the situation described above, in the specific literature are provided the following advantages of Nano fluids [3]:

- thermal conductivity of Nano fluids;
- fluids is enhanced due to dispersed nanoparticles;

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- there is a better connection between the base fluid and nanoparticles, resulted from the surface of these nanoparticles;
- added nanoparticles generate Brownian motions that have positive effect on the interaction base fluid-nanoparticles;
- added nanoparticles increase turbulences and mixing fluctuation;
- there is a lower need in pumping power compared to the use of the base fluid.

The preparation of Nano fluids needs special attention. The reason is that Nano fluids must be characterized by specific durability, stable suspension of added particles, no chemical reactions, negligible agglomeration of nanoparticles.

The two methods use to prepare Nano fluids are as given [4]:

- one step method – when the preparation of added particles and their dispersion in the base fluid occur simultaneously
- two step method – which is more economic, involves the preparation of nanoparticles throughout different ways and after that, their dispersion in the base fluid.

Should be also mentioned the fact that Nano fluids require important costs of production, being advised the recycling of added particles from industrial wastes [5].

As a traditional working fluid in several industry sectors, water shows poor heat transfer behavior, translated into low performance and big sizes of the equipment; by adding Al_2O_3 nanoparticles in water will be obtain water-Al_2O_3 Nano fluid which will be expected to have better thermo-physical properties than water [6].

According to Hasan et al (2018), water-Al_2O_3 Nano fluid shows enhanced thermal conductivity values than water (see Table 1) [7].

Table 1. Thermal conductivity of water-Al_2O_3 Nano fluid, diameter = 20 nm

Al_2O_3	32 W/mK
water	0.6215 W/mK
Nano fluid 5%	0.62238 W/mK
Nano fluid 15%	0.62414 W/mK
Nano fluid 20%	0.62502 W/mK
Nano fluid 30%	0.62679 W/mK

Since specific heat capacity influences heat transfer processes, this property is estimated throughout available models and corrections [8].

This paper deals with the assessment of specific heat capacity (SHC) of water-Al_2O_3 Nano fluid by the use of Zhou et al model.

Will be found the influence of the concentration on SHC and also the effect of temperature variation on SHC.

2. METHODS AND MATERIALS

SHC of the nanofluid means the capacity of this new working fluid to absorb heat without changing its phase.

According to the selected model, SHC of the nanofluid is assessed by the use of the following formula [9]:

$$SHC_{nf} = \frac{\varphi(\rho SHC)_{np} + (1-\varphi)(\rho SHC)_{bf}}{\varphi\rho_{np} + (1-\varphi)\rho_{bf}} \quad , \quad (1)$$

where subscripts:
np – nanoparticle
bf – base fluid
nf – nanofluid
and where
ρ – density
φ – solid volume fraction

The volume fraction of Al_2O_3 nanoparticles is obtained by using the below equation [10]:

$$\varphi = \frac{m_{np}/\rho_{np}}{m_{np}/\rho_{np} + m_{water}/\rho_{water}} \quad , \quad (2)$$

where:
m – mass.

3. RESULTS AND DISCUSSIONS

In Figures 1 and 2 it is provided the effect of volume concentration (φ) on the specific heat capacity of the nanofluid (SHC). In the first figure, nanoparticle diameter (d) is 60 nm, while in the second one, diameter is 30. In both cases, temperature of nanofluid is 30°C.

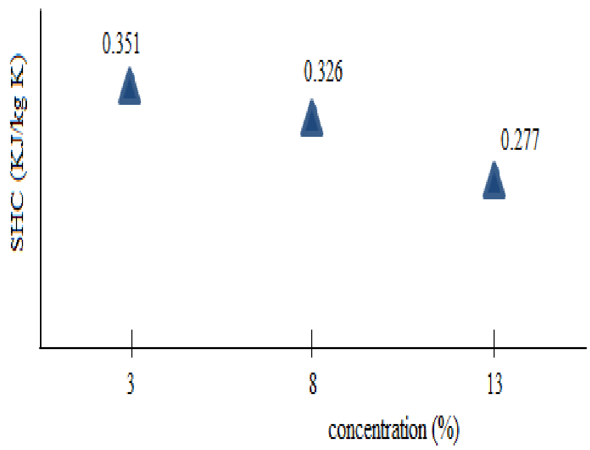

Figure 1 Effect of φ on SHC, d = 60 nm

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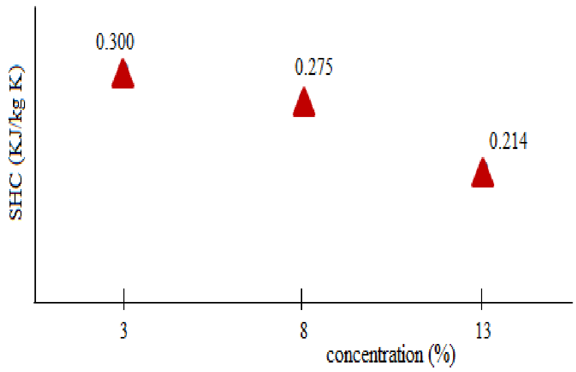

Figure 2 Effect of φ on SHC, d = 300 nm

In both cases, it is observed that the increase of concentration will lead to lower specific heat capacities. Better values for SHC are found when nanoparticles diameter is higher.

In the given case, the increase of SHC with decrease of φ is 27% - when d=60 nm, respectively 40% - when d=30 nm.

The influence of temperature (t) on Nano fluid SHC, for the above mentioned concentration is provided in Figure 3.

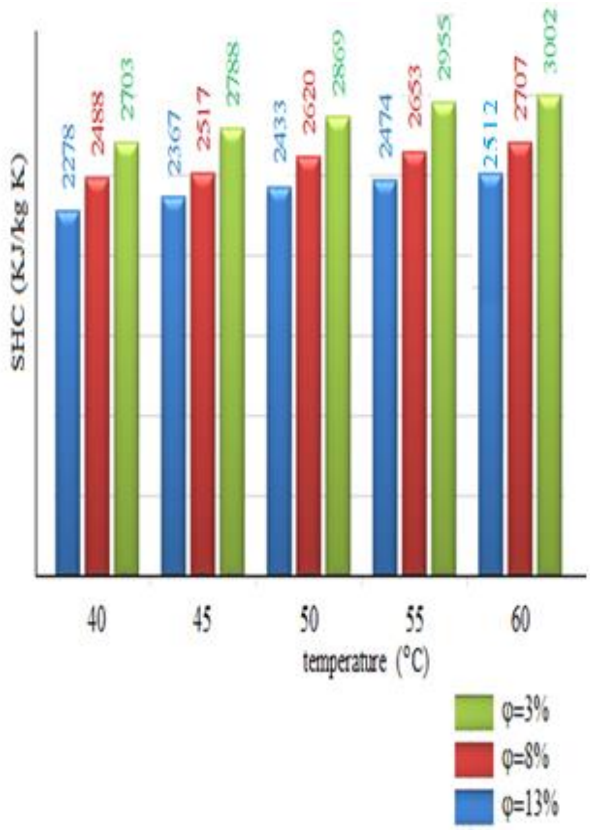

Figure 3 Effect of t on SHC

As known for classic working fluids, the temperature increase will reveal better values of Nano fluid SHC.

For high values of temperature correlated with low values of concentration, results enhanced values for Nano fluid SHC.

The gain around 19%, considering the maximum and the minimum concentrations.

4. CONLUSIONS

Water based nanofluids are recommended to be use instead of water in heat transfer processes.

The prediction of heat transfer capacity values is important in design of heat exchangers.

By the help of models, heat transfer capacity can be estimated for different concentrations of nanofluids.

In the present study, the variation of concentration in the range (3 – 13)% of water- Al_2O_3 nanofluid resulted to decrease together with the increase of the concentration.

This trend is observed for two types of nanoparticles diameter.

Specific heat transfer capacity increases with temperature increase and with concentration decrease.

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