The Effect of Nanofluid Volume Fraction to The Rate of Heat Transfer Convection Nanofluid Water-Al2O3 on Shell and Tube Heat Exchanger

by I Made Arsana

Submission date: 30-Mar-2023 08:13PM (UTC+0700)

Submission ID: 2050983933

File name: The_Effect_of_Nanofluid_Volume_Fraction_to_The_Rat.pdf (648.41K)

Word count: 2148

Character count: 11356

Journal of Physics: Conference Series

PAPER • OPEN ACCESS

The Effect of Nanofluid Volume Fraction to The Rate of Heat Transfer Convection Nanofluid Water-Al_2O_3 on Shell and Tube Heat Exchanger

To cite this article: I M Arsana *et al* 2020 *J. Phys.: Conf. Ser.* **1569** 032048

The Effect of Nanofluid Volume Fraction to The Rate of Heat Transfer Convection Nanofluid Water-Al_2O_3 on Shell and Tube Heat Exchanger

I M Arsana[1,2],D R Agista [1] ,A Ansori[1],D H Sutjahjo[1],M Effendy[1]

[1]Department of Mechanical Engineering, Faculty of Engineering, Universitas Negeri Surabaya, East Java, Indonesia.
[2]Corresponding author,email: madearsana@unesa.ac.id , Orcid ID:http://orcid.org/0000-0001-8503-5760

Abstract. *Shell and tube heat exchanger is now widely used in the field of industry and technology. In many applications, the working fluid is still a conventional fluid that still has a low thermal conductivity properties. Nanofluid is one of the ways that can be used to increase the thermal conductivity. The purpose of this research is to identify the influence of volume fraction against the heat transfer rate and effectiveness on shell and tube heat exchanger. The material used is Al_2O_3 with difference fraction volume of 0.5%, 1%, and 1.5% on the cold fluid. The temperature of the fluid used in the heat of 90 °C . The result of this study shows the highest effectiveness in mixed fraction nanofluid volume of 1.5%, which is 42% with the rate of heat transfer of 7061.93 Watts. Then the lowest effectiveness obtained on the State mixture volume fraction without nanofluid, which is 17.7% with the rate of heat transfer of 5666.71 Watts. Thus it can be concluded that when the fraction of nanofluid is getting higher, then the volume will increase the rate of heat transfer convection as well as the effectiveness of the shell and tube heat exchanger.*

Keywords: *shell and tube heat exchanger, heat transfer, nanofluid, aluminum oxide.*

1. Introduction

Heat exchanger is a tool used to exchange heat energy from a flowing fluid to another flowing fluid that can occur through direct or indirect contacts [1,2]. Shell and tube heat exchanger is one of the type of heat exchanger used in various industries. The working fluid used in industries field is conventional fluid that has low thermal conductivity properties. One way to increase the heat transfer is to improve the thermal properties of conventional fluid with nanofluid. Nanofluid is a new innovation from the fluid consisting of a basic fluid and nanoparticles sized (1-100 nm) and it is suspended jointly. There are several types of nanofluid, i.e. Al_2O_3, ZrO_2, SiO2 and TiO2 as oxides nanofluids. Ag and Cu as metal nanofluids, and Teflon as polymer nanofluid.

Aluminum oxide is a chemical compound of aluminum and oxygen with chemical formula (Al_2O_3). Aluminum oxide also widely used in fabrication industries, so it is easy to find.

Concentration factor in nanofluid affects the magnitude of the increasing forced convective heat transfer coefficient ratio. The addition of nanofluid with volume fraction 1% shows a increased coefficient as 31%-48% [3]. One of the nanofluid condition that can be used in cooling nuclear system is having low neutron absorption ans short half-life time. Nowdays, a research about cooling nuclear system using nanofluid only use Al_2O3 and ZrO_2 [4]. Heat transfer rate on annular tube will increase

Journal of Physics: Conference Series **1569** (2020) 032048 doi:10.1088/1742-6596/1569/3/032048

as the increasing of nanoparticles Al_2O_3 concentration ratio [5]. Research on heat transfer of Al_2O_3-water nanofluid volume variations of 0.15%, 0.25% and 0.5% with the experimental method. Obtained the results of an increase in the highest Nusselt number of 40.5% in partiel 0.5% volume variation on Al_2O_3-water nano fluid [6]. The addition of nanoparticle on base fluid in concentric pipe heat exchanger, will increase the rate of heat transfer due to temperature variation and volume fraction variation on nanofluid. The addition 0,5% volume fraction is the highest rate of convective heat transfer [7]. The usage of nanofluid on shell and tube heat exchanger will minimize the cost of optimization on shell and tube heat exchanger as 55,19% [8]. The arrangements of instrumentation system in shell and tube heat exchanger design explains that shell and tube heat exchanger performance test has a heat transfer as 5105,30 watts and effectiveness as 37% [9]. Effect of carboxyl grapherene nanofluid on automobile radiator performance It is observed that addition of carboxyl graphene nanoplatelets increases the Nusselt number and effectiveness of radiator while friction factor is unaltered. The effectiveness of radiator increases by 27.38% and 23.41% for inlet temperatures of 40 □C and 50 □C respectively at 0.02 vol% and 5 LPM flow rate [10]. Enhancing heat transfer rate in a car radiator by using Al_2O_3 nanofluid as coolant. Furthermore, this increase nanoparticle concentration, water velocity and nanofluid velocity and enhances the overall heat transfer coefficient [11].

Based on the existing research related, so this study aims to analyzing the effect of using low concentration of Al_2O_3 nanofluid against the rate of heat transfer convection in shell and tube heat exchanger.

2. Mathematical Formulation

Density

$$\varrho_{nf} = \phi\varrho_p + (1-\phi)\,\varrho_{bf} \qquad (1)$$

Viscocity

$$\mu_{nf} = (1 + 2{,}5\,\phi)\,\mu_{bf} \qquad (2)$$

Heat Capacity

$$(\varrho Cp)_{nf} = \phi\,(\varrho C_p)_p + (1-\phi)\,(\varrho C_p)_{bf} \qquad (3)$$

Thermal Conductivity

$$K_{nf} = \frac{K_p + 2K_b + 2(K_p - K_b)\varphi}{K_p + 2K_b - (K_p - K_b)\varphi} K_{bf} \qquad (4)$$

Volume fraction

$$\varphi = \frac{V_p}{V_l}\; x\; 100\% \qquad (5)$$

$$V_p = \frac{W_p}{\rho_l} \qquad (6)$$

$$W_p = V_p\; x\; \rho_p \qquad (7)$$

3. Experimental Setup

Shell and Tube Heat Exchanger Trainer

Experimental instrument used has the following requirements

Fig 1. Shell and Tube Heat Exchanger Trainer

Shell and Tube Heat Exchanger with following specification:

Shell
Outside diameter (do,s) : 0.17 m
Inside diameter (di,s) : 0.164 m
Length (Ls) : 0.955 m
Thickness (Th,s) : 0.003 m
Conductivity (K) : 15.1 W/m°C
Material : SS 304

Tube
Total of tube : 12
Outside diameter (do,t) : 0.0127 m
Inside diameter (di,t) : 0.0097 m
Length (Lt) : 0.966 m
Tube pitch (Pt) : 0.045 m
Tube clearance (C') : 0.029 m
Thickness (Tht) : 0.0015 m
Conductivity (K) : 385 W/m°C

Baffle
Baffle spacing : 0.04 m
Inside diameter : 0.163 m
Thickness : 0.003 m
Baffle cut : 21%
Material : Aluminium

Materials and Instruments

Materials used in this research are:

- Shell and tube heat exchanger
- Hot fluid pump
- Cold fluid pump
- Heating element
- Thermocouple
- Pipe
- Fluid tank
- Valve
- MCB
- Scale

Substance that used in this research are aluminium oxide Al_2O_3 as nanoparticle and distilled water.
Instrument that used in experiment are:

- Thermocontrol
- Pressure gauge
- Flowmeter

Data Collection

Data collecting was carried out with 4 variations of the volume fraction of nanofluid which are: none of nanofluid mixture, 0.5%, 1%, and 1.5%. Each variation of the volume fraction is treated in 90 ° C. The data obtained is then descriptively analyzed.

4. Results and Discussion

Overall Heat Transfer Coinfisient (U)

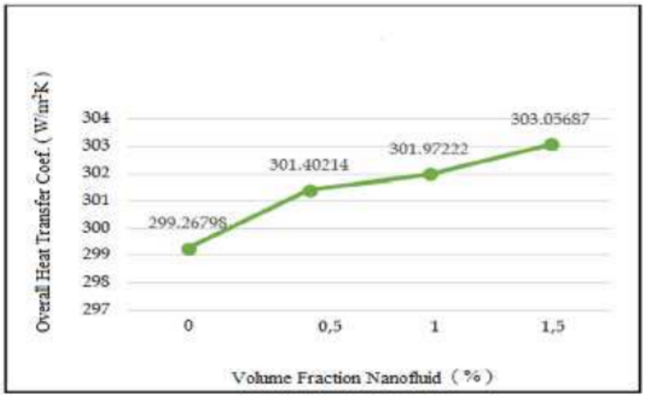

Fig 2. Overall Heat Transfer Coefficient Shell and Tube Heat Exchanger

Based on the fig, it can be seen that the rate of overall heat transfer coefficient is a significant increase. The highest overall heat transfer coefficient obtained when nanofluid volume fraction is 1.5% with 303.05 W/m^{2}K. This is because at a fraction of the volume of 1.5%, a lot of particles movement will also increasing so the nanoparticles with high volume fraction will absorb the heat transmitted by the hot fluid.

Rate of Heat Transfer (q)

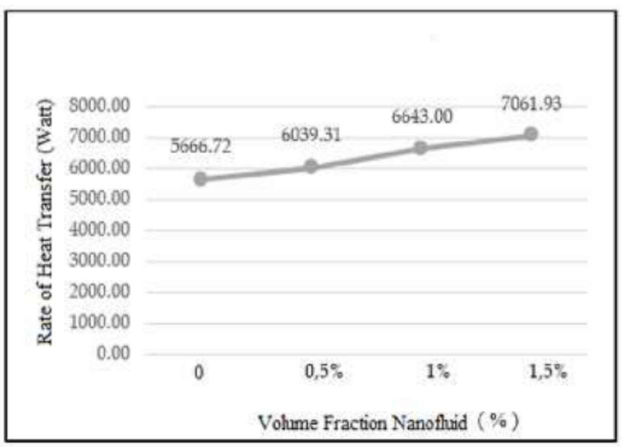

Fig 3. Rate of Heat Transfer (q) on Shell and Tube Heat Exchanger

Based on the graph above, it can be seen that the rate of heat transfer (q) will increase in line with the increasing of nanofluid volume fraction. The highest rate of heat transfer is obtained when the nanofluid volume fraction is 1.5% with 7061.93 watts. This is caused by nanoparticles Al_2O_3 that absorbs heat, the more nanoparticles, the more heat can be absorbed and the rate of heat transfer will also be increased.

The Effectiveness of Shell and Tube Heat Exchanger

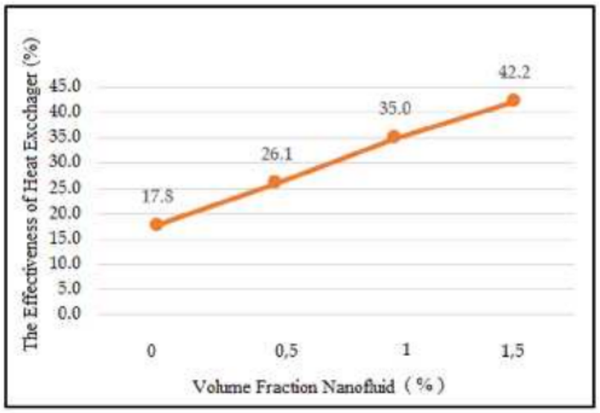

Fig 4. The Effectiveness of Shell and Tube Heat Exchanger

Based on the fig, it can be seen that the effectiveness of shell and tube heat exchanger increase following with the increasing of nanofluid volume fraction. The highest effectiveness is obtained achieving 42.2% at the time of the nanofluid volume fraction of 1.5%. It is because when the rate of heat transfer is increased, then the effectiveness will also be increased automatically. Compared with research on heat transfer of Al_2O_3-water nanofluid volume variations of 0.15%, 0.25% and 0.5% with the experimental method. The results obtained of an increase in the highest Nusselt number of 40.5% in partiel 0.5% volume variation on Al_2O_3-water nanofluid. So the result is the higher the volume fraction of nanofluid, the better the effectiveness of heat exchanger.

5. Conclusions

Experimental test results influence the fraction of volume against the heat transfer convection nanofluid water – Al_2O_3 on the shell and tube heat exchanger can be concluded that convection heat transfer rate increases along with increasing of Al_2O_3 nanofluid volume fraction caused nanoparticles move growing rapidly because it is broken down by high temperatures. A growing number of nanoparticles then will also increasingly absorb the heat of the hot fluid that flows in the side of the tube. Rate of heat transfer and effectiveness of most optimal volume fraction occurs at 1.5% nanofluid with the results of 7061.93 watt and 42.2% respectively.

6. References

[1] Arsana, I Made, Budhikardjono, Kusno, Susianto, Altway, Ali. 2016. *Modeling of The Single Staggered Wire and Tube Heat Exchanger*. International Journal of Applied Engineering Research 11(8):5591-5599.

[2] Arsana, I Made, Susianto, Budhikardjono, Kusno, Altway, Ali. 2016. *Optimization of The Single Staggered Wire and Tube Heat Exchanger*. MATEC Web of Conferences 58, 01017 .

[3] Putra, Nandy, Maulana, Syahrial, Koestoer, R.A, A.S. Danardono. 2005. Measurement of Heat Transfer Convection Nanofluid Water (Al_2O_3)On Finned Tube Heat Exchanger (Pengukuran Koefisien Perpindahan Kalor Konveksi Fluida Air Bersuspensi Nanopartikel (Al_2O_3) Pada Fintube Heat Exchanger). Jurnal Teknologi Edisi No. 2(XIX ISSN 0215-1685):116-125.

[4] Buongiorno, Jacopo, Hu, Lin-Wen, Kim, Sung Joong Hannink, Ryan, Truong, Bao & Forrest, Eric. 2007. Nanofluids for Enhanced Economics and Safety of Nucelar Reactor. Journal Nuclear Technology Volume 162, 2008 - Issue 1 pp 80-91.
[5] Shedid, Mohammed A. 2014. Computational Heat Transfer for Nanofluids through an Annular Tube. Proceedings of the International Conference on Heat Transfer and Fluid Flow paper no. 206.
[6] Sudarmadji, Soeparman, Sudjito, Wahyudi, Slamet, Hamidy, Nurkholis. 2014. Effect of Cooling Process of Al_2O_3-water Nanofluid on Convective Heat Transfer. FME Transactions. 42: 155-161.
[7] Suroso, Bekti, Kamal, Samsul,, Kristiawan, Budi. 2015. The Effect of Temperature and Volume Fraction Against Heat Transfer Convection Nanofluid TiO_2 / Termo-Oil XT32 on Concentric Tube Heat Exchanger (Pengaruh Temperatur dan Fraksi Volume Terhadap Nilai Perpindahan Kalor Konveksi Fluida Nano TiO_2 / Oli Termo XT32 pada Penukar Kalor Pipa Konsentrik). Jurnal Mekanika Volume 13 Nomor 2.
[8] Azad, Abazar Vahdat. 2016. Application of Nanofluids for the Optimal Design of Shell and Tube Heat Exchanger Using Genetic Algoritm. Case Studies in Thermal Engineering Volume 8, September 2016, Pages 198-206.
[9] Putra, Alfian Rizqi Laksana. 2017. The Instrument System Planning on The Design of Shell and Tube Heat Exchanger (Perencanaan Sistem Instrumen pada Rancang Bangun Heat Exchanger type Shell and Tube). JRM Volume 04 Nomor 01 Tahun 2017, hal 1- 6.
[10] Sumanth, S, Rao, P.B, Krishna, V, Seetharam, Seetharamu. K.N. 2018. Effect of carboxyl graphene nanofluid on automobile radiator performance. Heat transfer Asian Research, 2018, pp. 1-15.
[11] Arunkumar, T, Anish, M, Jayaaprabakar, J, Beemkumar, N. 2019. Enhancing Heat Transfer Rate In A Car Radiator By Using Al_2O_3 Nanofluid as a Coolant. Internasional Journal of Ambient Energy, vol. 4, pp. 367-373.

The Effect of Nanofluid Volume Fraction to The Rate of Heat Transfer Convection Nanofluid Water-Al2O3 on Shell and Tube Heat Exchanger

ORIGINALITY REPORT

6%	0%	0%	6%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to University of Surrey Student Paper	6%

Exclude quotes	Off	Exclude matches	< 5%
Exclude bibliography	Off		