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TÍTULO: Modelado numérico de intercambiadores de calor de aletas circulares que utilizan nano-fluido e investigan los efectos de diferentes parámetros en la transferencia de calor y la caída de presión.

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RESUMEN: Los intercambiadores de calor son casi los elementos más aplicables en procesos químicos. En este estudio, los intercambiadores de calor se han estudiado numéricamente utilizando nano-fluido. El efecto de diferentes parámetros en el intercambio de calor y la caída de presión también se ha estudiado y los resultados mostraron que el aumento del espacio entre los tubos y el aumento del número de tubos pueden aumentar la transferencia de calor y la caída de presión. Sin embargo, el aumento del grosor de la aleta puede disminuir la presión como resultado de un mayor intercambio de calor; por lo tanto, puede ser el parámetro más efectivo para mejorar la eficiencia del intercambiador de calor con aletas.

PALABRAS CLAVES: Intercambiadores de calor, nano-fluido, espesor de la aleta, transferencia de calor, caída de presión.

TITLE: Numerical modeling of Circular Finned Heat Exchangers using Nano-Fluid and investigating the effects of different parameters on Heat Transfer and Pressure Drop.

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ABSTRACT: Heat exchangers are almost the most applicable elements in chemical processes. In this study, heat exchangers have been studied numerically using nano-fluid. The effect of different parameters on heat exchange and pressure drop has also been studied and the results showed that the increased space between the tubes and the increase in the number of tubes can increase heat transfer and pressure drop. However, increasing the thickness of the fin may decrease the pressure as a result of increased heat exchange; therefore, it may be the most effective parameter to improve the efficiency of the finned heat exchanger.

KEY WORDS: heat exchangers, nano-fluid, fin thickness, heat transfer, pressure drop.

INTRODUCTION.

The heat exchange process between two fluids with different temperatures separated by solid wall happens in many engineering applications. The machine used for this exchange is heat exchanger. In physical and chemical processes, the applied fluids should be cooled or heated. For heat exchange between two fluids without mixing, heat exchange level is needed.

Today, many factories are active across the world to produce heat exchangers. Many industries are active to design types of exchangers and various fields are also presented at the universities in regard with heat exchangers. The estimations relevant to exchangers can be time consuming and challenging; although it is possible to design that based on different parameters using computer programs. Software including B-jac, Aspen and HFTS can be the most applicable software programs in this filed. Heat exchangers can be classified from different aspects and the classifications are presented in table 1 in summary (Muzaffar-Ur-Rehman et al, 2018; Saraninezhad & Ramezany, 2019; Naderi, 2019; Ahmadi Kamarposhti & Geraeli, 2019; Mirrashid & RakhtAla, 2019).

Components of heat exchangers include:

1- Connections.

2- Tube sheet.

3- Gaskets.

4- Shell head.

5- Mounting.

6- Baffle.

7- Shell.

8- Tube bundle.

Table 1. Classification of heat exchangers.

Classification basis.	Classification subsets.
Based on type of contact of cold and hot fluid.	1- Recuperative heat exchangers. 2- Regenerative heat exchangers. 3- Direct contact heat exchangers (Khanafer & Vafai, 2011).
Based on hot and cold fluid flow.	1- Matched flow heat exchangers. 2- Mismatch flow heat exchangers. 3- Perpendicular heat exchangers.
Based on heat transfer mechanism between cold and hot fluid.	1- Displacement of a phase in both sides. 2- Displacement of a phase in one side and displacement of 2 phases in other side. 3- Displacement of two phases in both sides (Tozer & James, 1998).
Based on mechanical structure and exchanger structure (Taler, et al, 2012).	1- Tube exchangers. 2- Plate exchangers. 3- Finned surface exchangers.

A schematic of a heat exchanger is illustrated in figure 1.

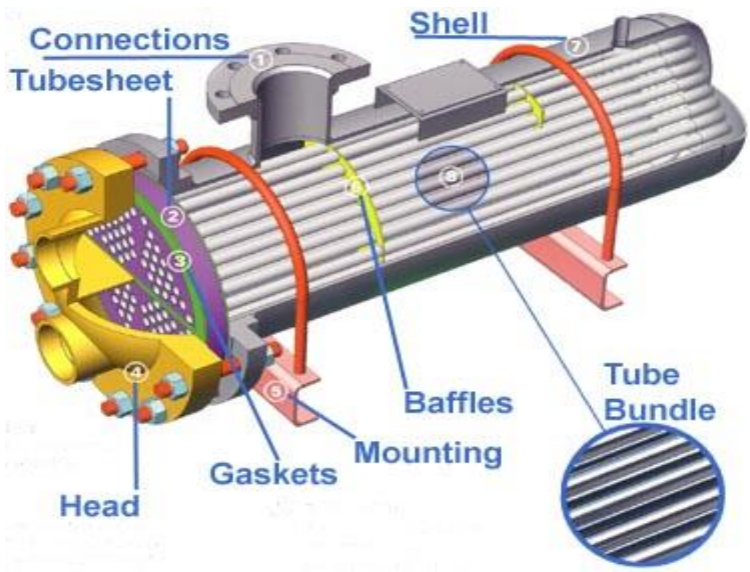

Figure 1: heat exchanger.

Xing et al studied oval tube heat exchanger, which is widely applicable in chemical industries, in terms of flow and heat transfer. In this study, K-e model as used to analyze the correlation of p length with A/B. The results showed that with increase in p and A/B ratio, Nusselt number and total heat transfer and overall performance is increased. The effects of pressure and temperature and speed have been also analyzed in this study (Tan et al, 2013).

Harun et al presented numerical study of circular finned heat exchangers using CFD dynamic model and analyzed the effects of the fin space, fin height, fin thickness and fin type on heat transfer and overall pressure drop for different surfaces of fin tubes. The results showed that with increased height of fin; heat transfer is increased (Bilirgen et al, 2013; Yuvaraj et al, 2019).

Mehet et al studied increased heat transfer and pressure drop in terms of fin angle dependence. Fluent and Gambit software programs were used for numerical simulation and analysis of different parameters and their effect (Tan et al, 2013).

DEVELOPMENT.

Methodology.

To take numerical modeling, Fluent Software has been used. One of the main capabilities of the software is careful use of theories of turbulent flows. Different modes of heat transfer including free mobility, forced and combined mobility can be modeled. Using strong models to simulate combustion and porous environment has changed Fluent software to one of the most powerful CFD software programs.

Two methods have been presented to produce nano-fluid:

1- Single-step preparation method.

2- Two-step preparation method.

In single-step preparation method, the desired particles are prepared and distributed in the fluid directly; for example, to prepare metal nanoparticles in a steam fluid; the metal is directly conducted inside the base fluid to be condensed in form of nanoparticles. The method of preparation of nanoparticles is also known as the bottom-up method (Lotfi et al, 2010; Rasouli et al, 2019; Rahideh & Mazloum, 2019; Bahremand, 2015).

In 2-step method, type of powders with different sizes can be used. This has been always problematic in single-step method. In 2-step method, the desired nanoparticle or nanotube is firstly prepared and is then added to fluid. It seems that the method is more economic than single-step method and is mostly used in industries based on probability of more production and easier production of nanoparticles or nanotubes (Hosseini Naghavi et al, 2019; Mulyono et al., 2018; Ganjali & Teimourpour, 2016; Zare, 2015).

After preparation of nanoparticles, to make than durable and to prevent massification of the particles causing heaviness and acceleration of sedimentation; different methods like change in pH rate or providing ultrasonic turbulent can be used.

Results and discussion.

In this study, numerical analysis of finned heat exchangers is analyzed using nano-fluid. The effect of different parameters on pressure drop and function was studied, and the results are presented in rets of paper. In figure 2, temperature and pressure contours are illustrated in mode of using water as operating fluid.

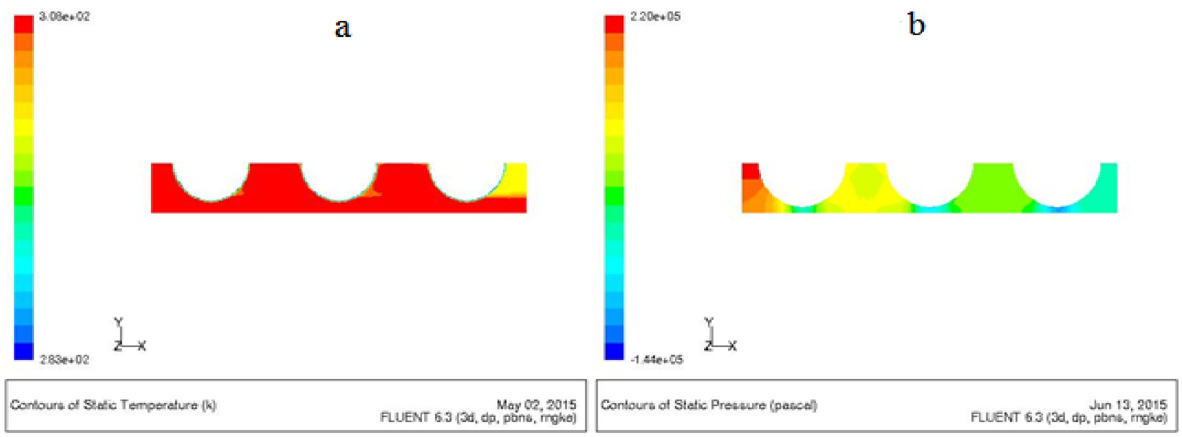

Figure 2. a) Temperature contours in mode of using water as operating fluid. b) Pressure contour in the mode of using water as operating fluid.

Figure 3. Illustrates same contours in the mode of using water nano-fluid and ammonium oxide as operating fluid.

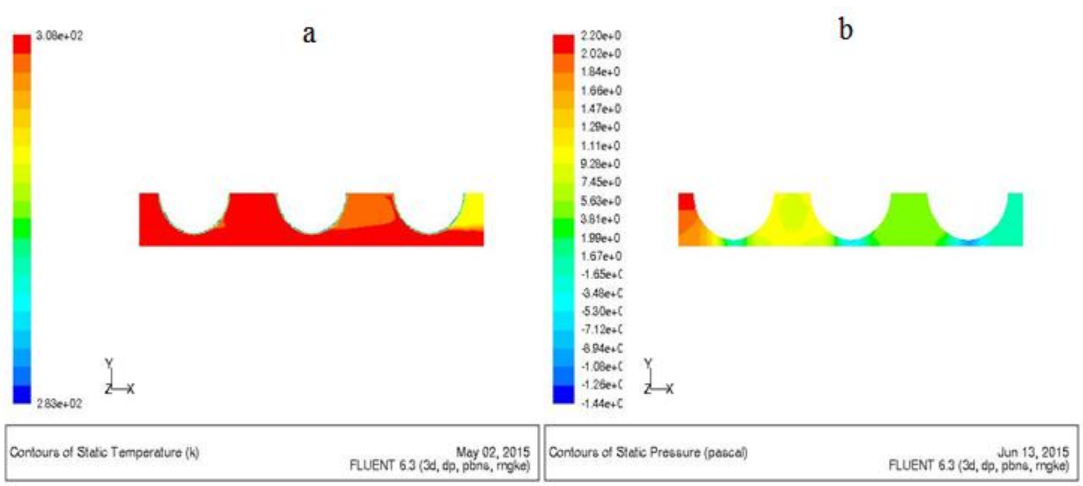

Figure 3. a) Temperature contour in mode of using water nano-fluid and alumina oxide as operating fluid. b) Pressure contour in mode of using water and alumina oxide nano-fluid as operating fluid.

In figure 4, the space between tubes is decreased and pressure and temperature contour is presented in mode of using nano-fluid as operating fluid.

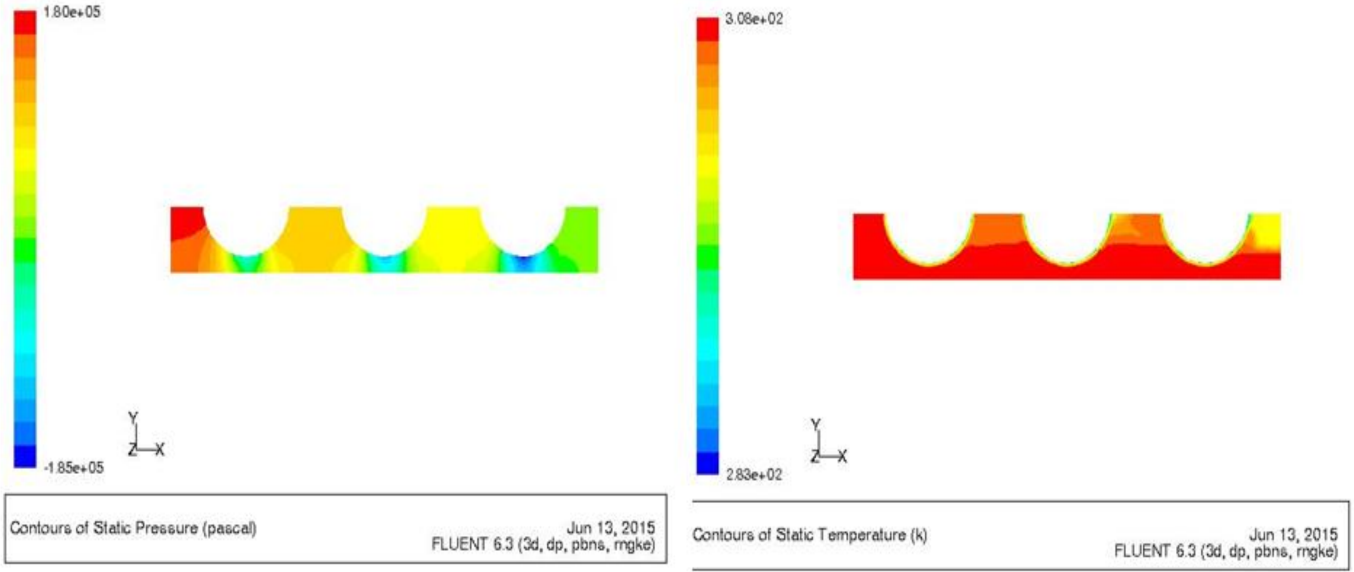

Figure 4. Pressure and temperature contour using nanofluid as operating fluid and with decreased distance of tubes.

Figure 5 is similar to figure 4 with the difference that the distance of tubes is increased this time.

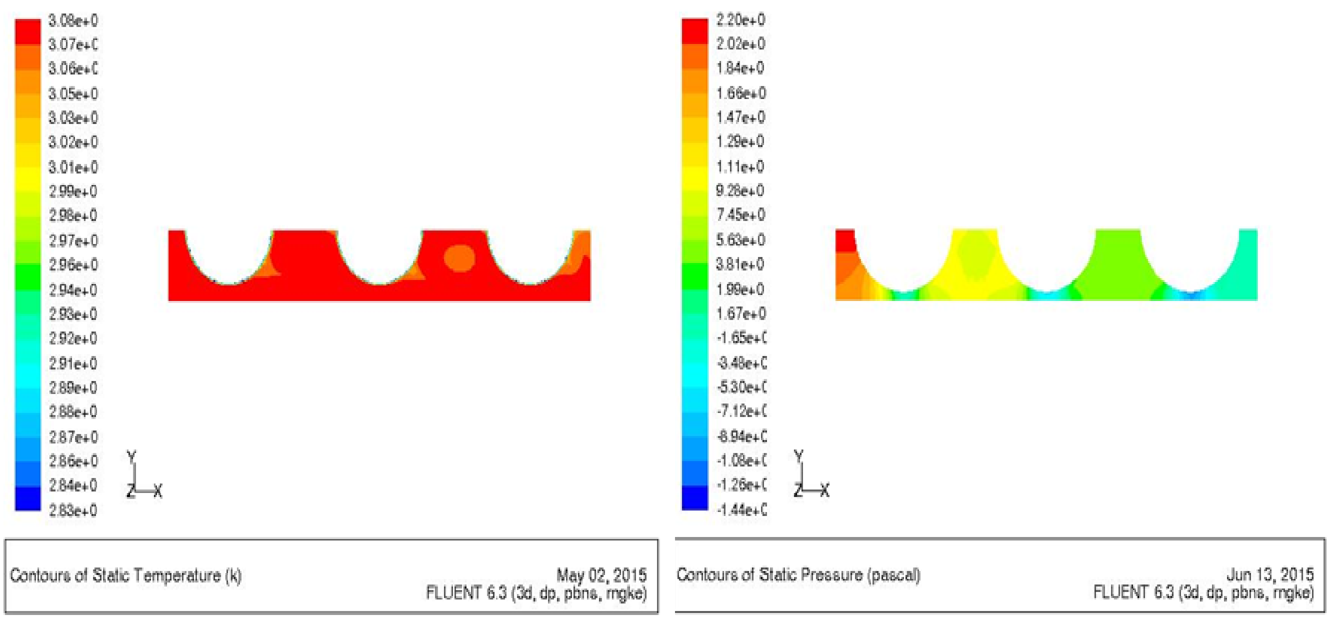

Figure 5. Pressure contour using nanofluid as operating fluid and with increased distance of tubes.

In figures 6 and 7, the effect of parameters of fin thickness on pressure and temperature contour in case of using nanofluid as operating fluid is illustrated. Finally, figures 8 and 9 show the effect of decreased and increased number of tubes on pressure and temperature contour in case of using nanofluid as operating fluid.

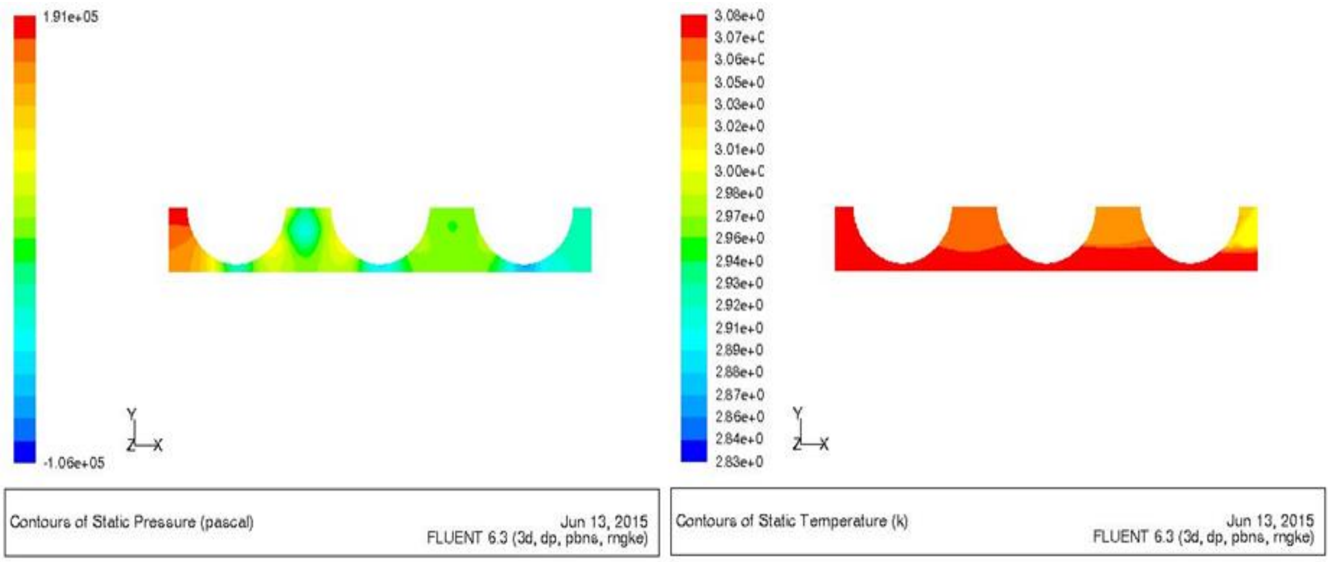

Figure 6. Temperature contour using nanofluid as operating fluid and with increased fin thickness.

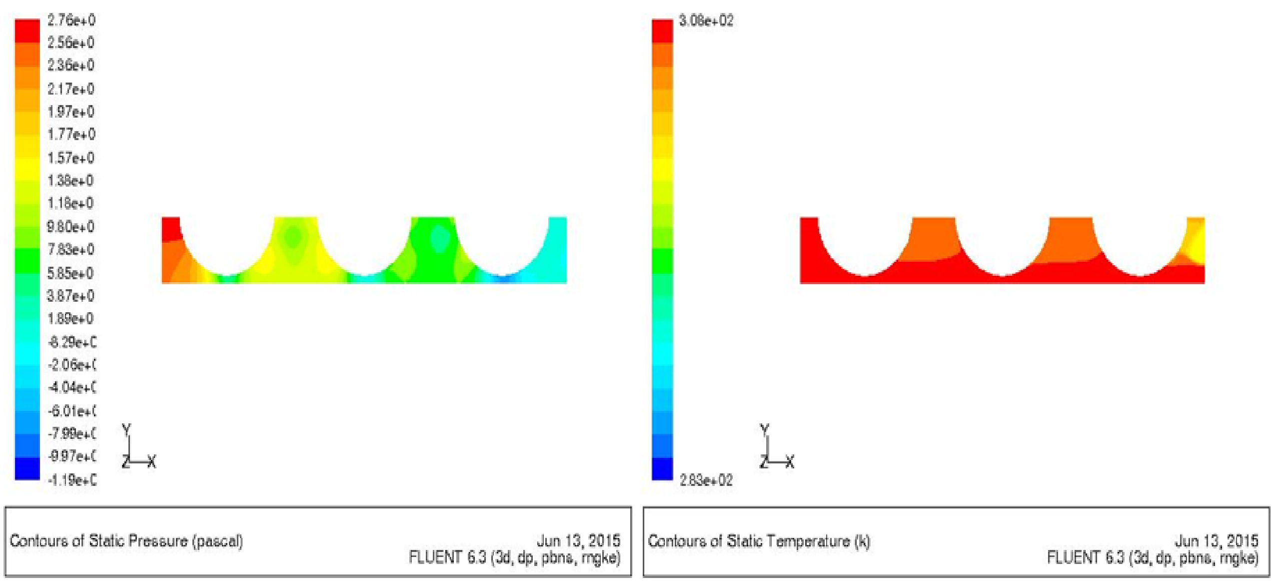

Figure 7. Temperature and pressure contour using nanofluid as operating fluid and with increased fin thickness.

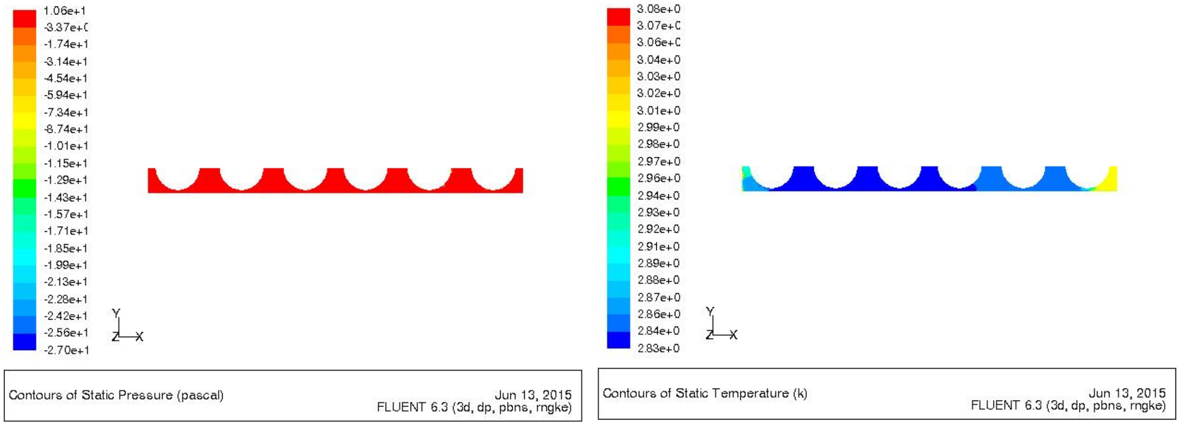

Figure 8. Temperature and pressure contour using nanofluid as operating fluid and with increased number of tubes.

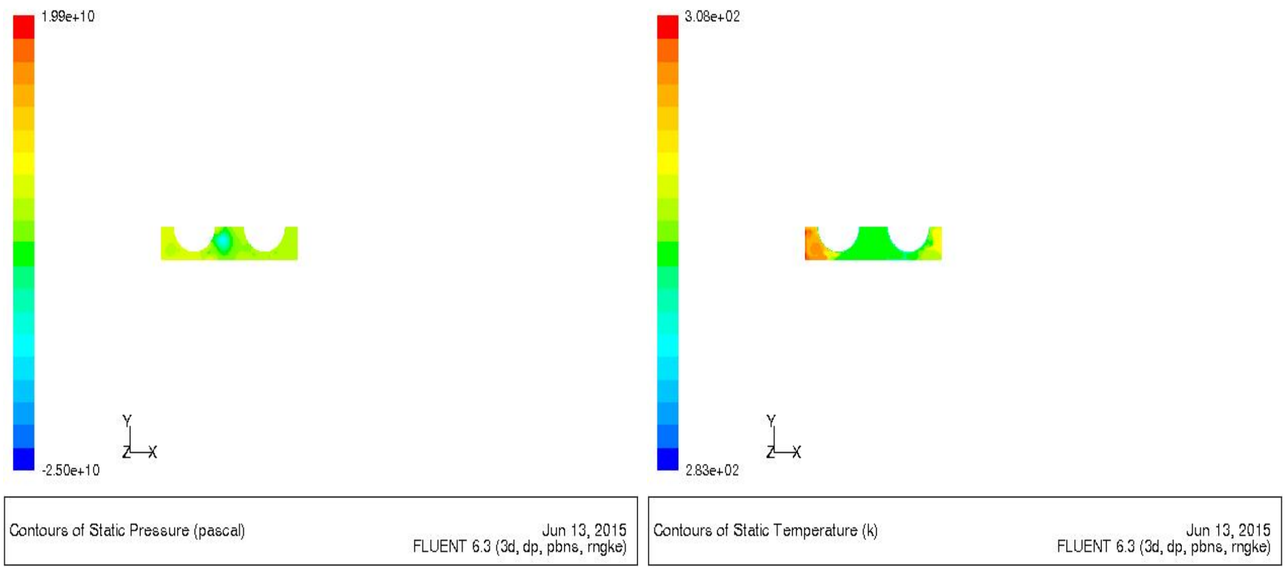

Figure 9. Temperature and pressure contour using nanofluid as operating fluid and with decreased number of tubes.

The diagrams relevant to pressure drop with changed working fluid, change in heat transfer level, pressure drop with change in distances of tubes, changes in fin thickness and changes in number of tubes are presented in the following.

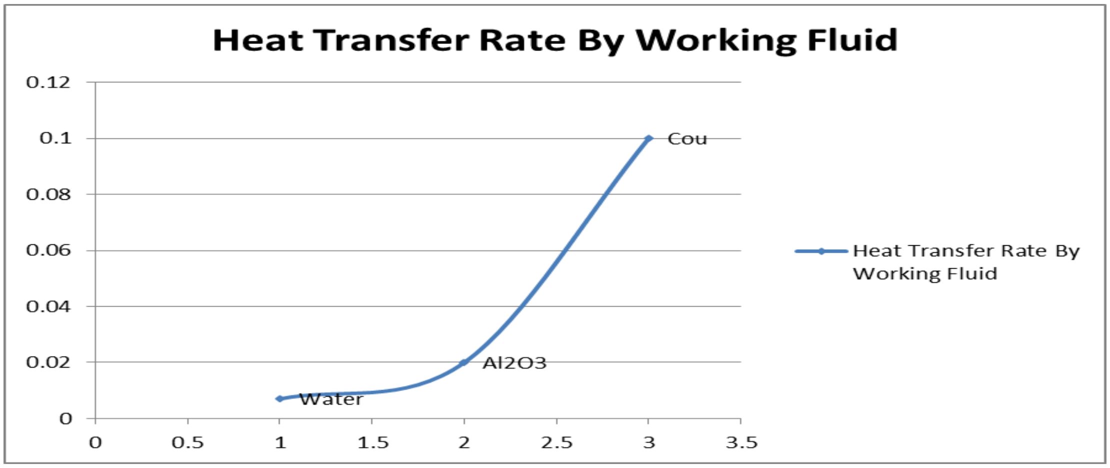

Figure 10. The diagram of pure heat transfer of whole exchanger with variation of working fluid.

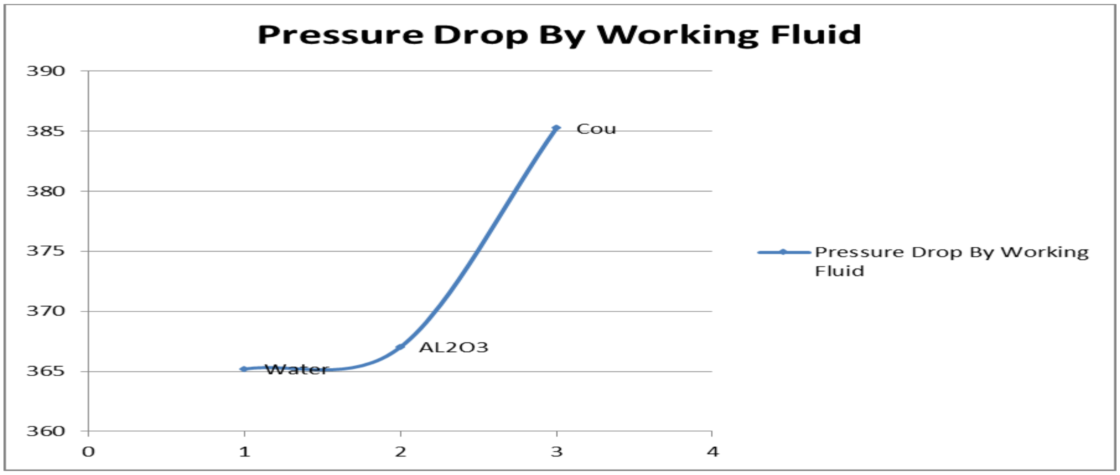

Figure 11. The diagram of pressure drop in whole exchanger with working fluid variations.

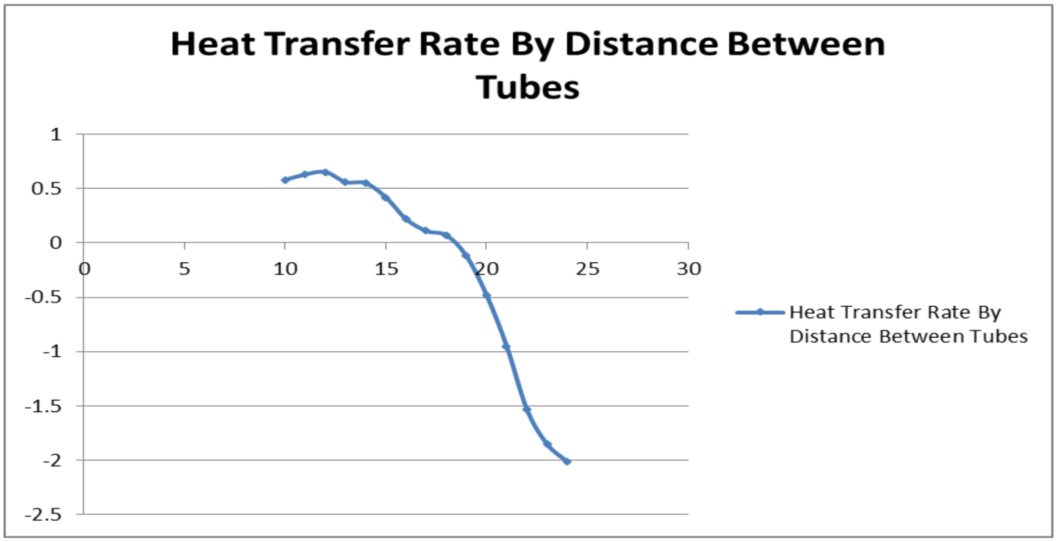

Figure 12. The diagram of changes in heat transfer with change in distance between tubes.

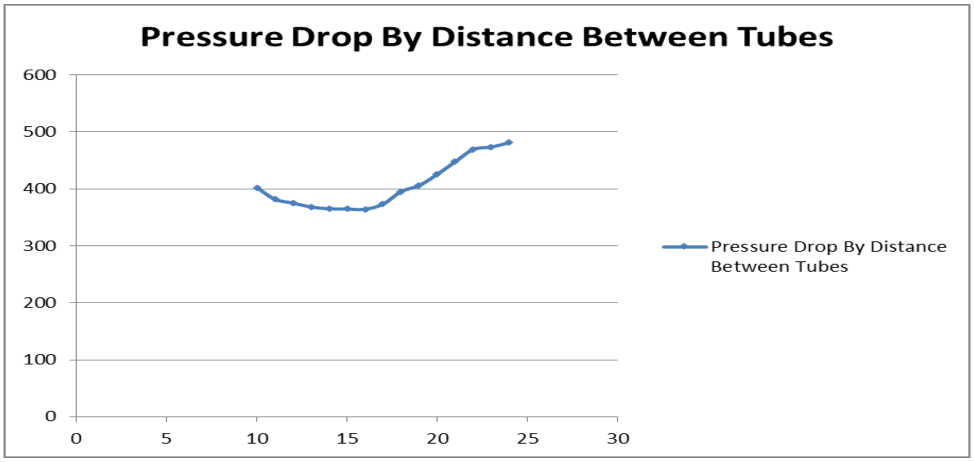

Figure 13. The diagram of pressure drop with variations of distance between tubes.

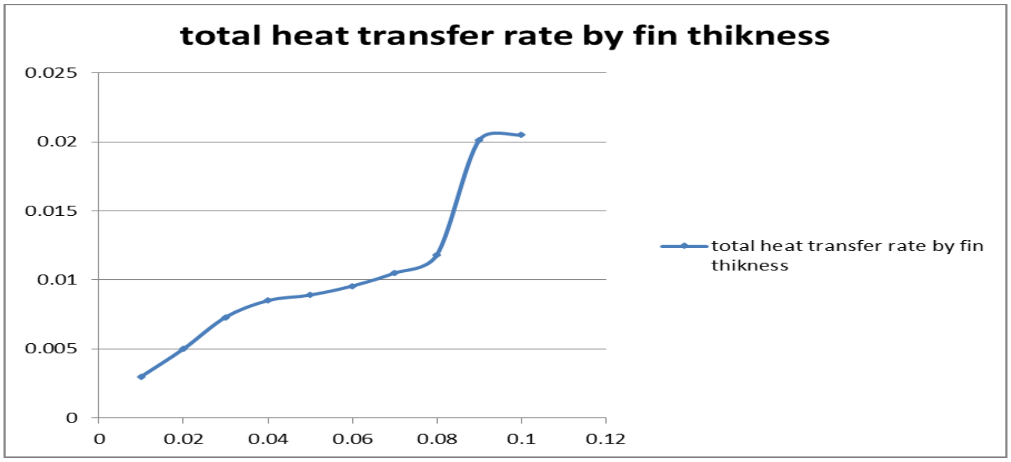

Figure 14. The diagram of heat transfer variations with tin thickness changes.

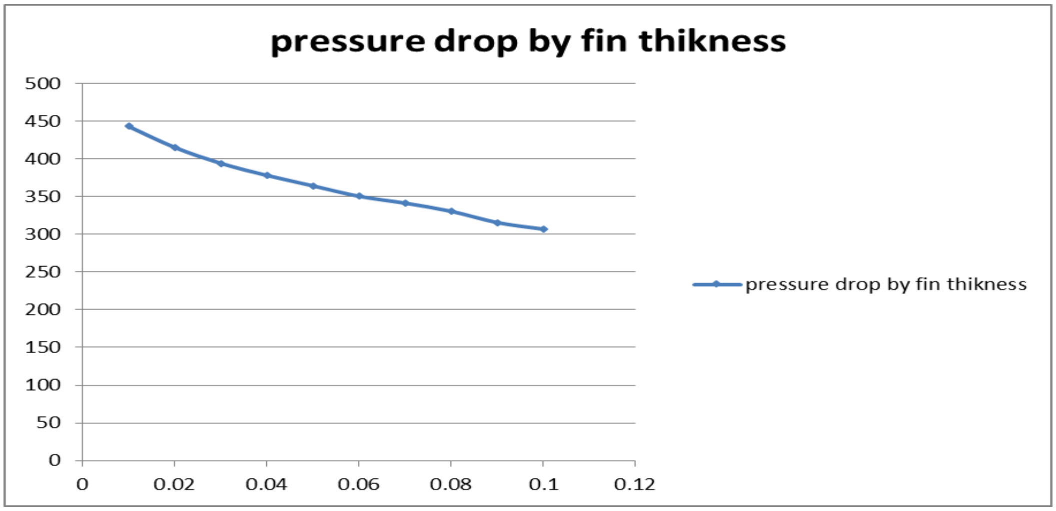

Figure 15. The diagram of pressure drop variations with fin thickness change.

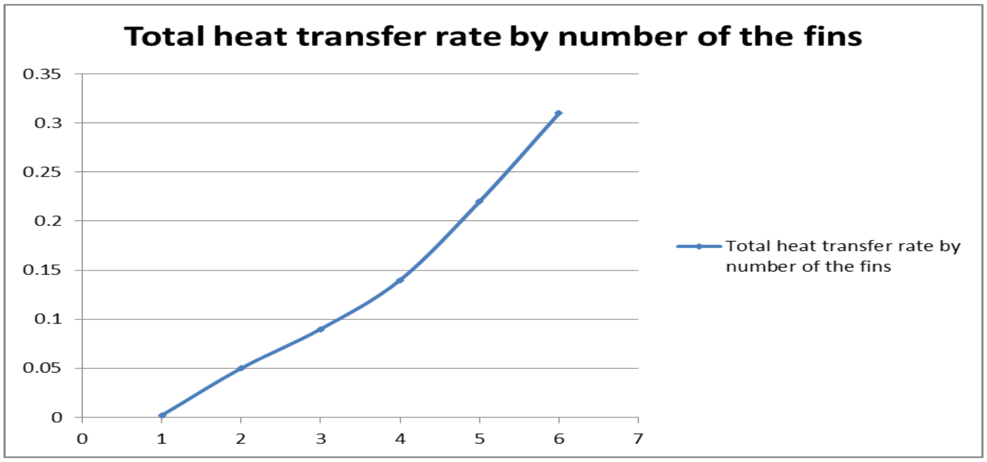

Figure 16. The diagram of heat transfer variations by change in number of fins.

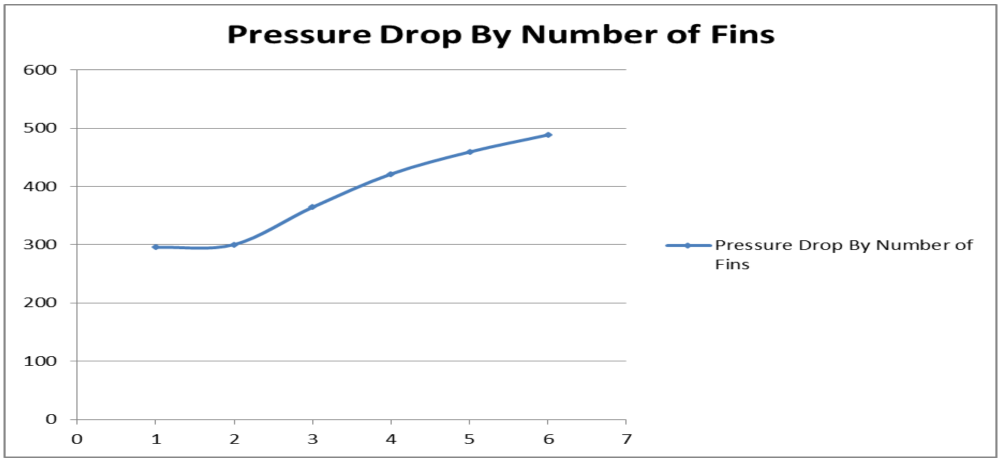

Figure 17. The diagram of pressure drop variations by change in number of fins.

CONCLUSIONS.

Heat exchangers are almost the most applicable elements in chemical processes, and they can be existed in majority of industrial units. They are instruments, which provide the heat transfer between two or more fluids. The operation can be taken in fluid-fluid phase, gas-gas phase or gas-fluid phase. Heat exchangers can be used to cool the hot fluid and to heat the fluid with lower temperature or both of them.

The results obtained from this study are:

1- With increased distance between tubes, total heat transfer is increased; although pressure drop is also increased.

2- With increased fin thickness, heat is increased, and pressure is decreased.

3- With increased number of tubes, the heat transfer is increased, and pressure drop is increased too.

4- Hence, it could be mentioned that the effective parameter to improve heat exchanger efficiency is fin thickness.

Suggestions for future studies:

1- The effect of numerical simulation method of nanofluid on accuracy of different parameters.

2- Effect of diameter of high-pressure nanoparticles.

3- Analysis of the effect of using thermal variable flux in tube.

4- Analysis of using different turbulence models on accuracy of results.

Analysis of the effect of using thermal variable flux in fins.

BIBLIOGRAPHIC REFERENCES.

1. Ahmadi Kamarposhti, M., & Geraeli, F. (2019). Effect of Wind Penetration and Transmission Line Development in order to Reliability and Economic Cost on the Transmission System Connected to The Wind Power Plant. Medbiotech Journal, 03(02), 35-40.

2. Bahremand, A. (2015). The concept of translation in different teaching approaches and methods. UCT Journal of Social Sciences and Humanities Research, 3(1), 5-9.

3. Bilirgen, H., Dunbar, S., & Levy, E. K. (2013). Numerical modeling of finned heat exchangers. Applied Thermal Engineering, 61(2), 278-288.

4. Ganjali, M. & Teimourpour, B. (2016). Identify Valuable Customers of Taavon Insurance in Field of Life Insurance with Data Mining Approach. UCT Journal of Research in Science, Engineering and Technology, 4(1), 1-10.

5. Hosseini Naghavi, A. B., Alishah, O., & Gorji, A. M. (2019). Investigation of the Genetic Diversity of Cultivars and Lines of Tetraploid Cottons by the use of Quantitative Morphologic Properties of Fibers. Medbiotech Journal, 03(02):65-9.
6. Khanafer, K., & Vafai, K. (2011). A critical synthesis of thermophysical characteristics of nanofluids. International journal of heat and mass transfer, 54(19-20), 4410-4428.
7. Lotfi, R., Saboohi, Y., & Rashidi, A. M. (2010). Numerical study of forced convective heat transfer of nanofluids: comparison of different approaches. International Communications in Heat and Mass Transfer, 37(1), 74-78.
8. Md. Muzaffar-Ur-Rehman, Asra Jabeen, Maimanath Mariya (2018). Side reactions in peptide synthesis: An overview. International Journal of Pharmacy Research & Technology, 8 (1), 1-11.
9. Mirrashid, N., & RakhtAla, S. M. (2019). Fuel Cell Systems and Developments in Control Abilities. Medbiotech Journal, 03(02), 41-6.
10. Mulyono, D., Asmawi, M., & Nuriah, T. (2018). The Effect of Reciprocal Teaching, Student Facilitator and Explaining and Learning Independence on Mathematical Learning Results by Controlling the Initial Ability of Students. International Electronic Journal of Mathematics Education, 13(3), 199-205. https://doi.org/10.12973/iejme/3838
11. Naderi, R. (2019). Solving a nonlinear Singular Cauchy Problem of Euler- Poisson-Darboux Equation through Homotopy Perturbation Method. Medbiotech Journal, 03(02):29-34.
12. Rahideh, M., & Mazloum, S. Z. (2019). Combination System Optimization of Solar Collector/ Photovoltaic with Genetic Algorithms. Medbiotech Journal, 03(02), 58-64.
13. Rasouli, R., Mohammadali, A., & Houshmandan, H. (2019). Three-Dimensional Analysis of Permanent Covering Behavior of Gelevard Dam Injection Gallery and Optimal Design of Tunnel Coverage. Medbiotech Journal, 03(02), 47-57.

14. Saraninezhad, M., & Ramezany, M. (2019). Optimal Placement of Wind Turbines for Reducing Losses and Improving Loadability and Voltage Profile in Distribution Networks by Data Clustering and NSGA-II Algorithm. Medbiotech Journal, 03(02), 77-83.
15. Taler, J., Taler, D., Sobota, T., & Cebula, A. (2012). Theoretical and experimental study of flow and heat transfer in a tube bank. Advances in Engineering Research, 1, 1e56.
16. Tan, X. H., Zhu, D. S., Zhou, G. Y., & Yang, L. (2013). 3D numerical simulation on the shell side heat transfer and pressure drop performances of twisted oval tube heat exchanger. International Journal of Heat and Mass Transfer, 65, 244-253.
17. Tozer, R., & James, R. W. (1998). Heat powered refrigeration cycles. Applied Thermal Engineering, 18(9-10), 731-743.
18. Yuvaraj, D., Kumar, G. S., Prasath, J. S., & Kumar, S. S. (2019). Modeling and Tuning of First Order Process with Dead Time. IWRA (India) Journal (Half Yearly Technical Journal of Indian Geographical Committee of IWRA), 8(1), 9-12.
19. Zare, Z. (2015). The benefits of e-business adoption: an empirical study of Iranian SMEs. UCT Journal of Management and Accounting Studies, 3(1), 6-11.

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