Optimization of Heat Transfer Rate of Cooler Using Nanofluid: A Review

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Abstract: It has been essential to study about cooling system because it is applied in many applications nowadays. It is necessary in exchanging and absorbing heat energy. The heat exchanging ability of radiator can be increased by increasing the coefficient of heat transfer of coolant used. The coefficient of heat transfer of working fluid can be raised by improving the various factors i.e. Thermal and physical properties of working fluid used in the system. Because of easy availability of water, previously it was used as coolant. Also, the blend of water & ethylene glycol later introduced as a coolant. Further, the blend of H_2O and $C_2H_6O_2$ was used as coolant because $C_2H_6O_2$ has good coefficient of heat energy transfer. It had some limited benefits and few drawbacks. With the growing technology at Nano-scale. The scientists came with result that thermal conductivity of nanoparticles is very high. When these particles were blended with base fluid like H_2O or $C_2H_6O_2$ they observed that the coefficient of heat transfer of this blend was more than that of conventionally. This fluid is known as nanofluid. The presented review paper interacts with the using new method of improving the cooling capacity of conventional cooler. To increase the cooling ability of cooler, the radiator is introduced in this system through which the nanofluid is allowed to pass.

Keywords: Heat Transfer Enhancement, Multiwalled Carbon Nanotubes, Nanofluid and Nanoparticles.

Introduction:

All over the industrial facility, the heat handling i.e. heat added, removing is important parameter. The heat can be transmitted from one steam to another and it has important duty for process industry. The heat transfer process provides the energy recovery as well as the process of heating / cooling of fluid. The optimization of heat transfer rate of fluid to heating and cooling in process industry may make preserving in energy, process time is reduced, increase thermal capability and durability of working equipment. Due to good heat transfer the processes perform affected qualitatively. In daily life the advancement is done in heat transfer, so that the use of high performance thermal system is increases. To understand performance of heat transfer in system for their physical operation, a number of efforts has been performed. To improve the heat flow rate in the system, some significant technology is developed. To increases the heat transfer efficiency there are many methods are used. There are many methods is used i.e. extended surface, micro channel. Heat transfer rate is depending upon thermal conductivity of fluid. Ethylene glycol, water and engine oil is commonly used as heat transfer fluid. But the thermal conductivity of this fluid is relatively low as compare to the solid. Solid have high thermal conductivity. Hence solid particle is added in working fluid to increase the heat transfer rate of fluid. The workability of such suspensions of solid particles with size in millimeter or micrometer, usually a size of particle in order of 2 micrometer. This particle is investigated by considerable analysis and the consecutive important defect were observed (Das and Choi 2006)

1. The density of solid particle is higher than fluid, the particle settles down briskly and forming the layer on the surface, hence reduces thermal capacity.

2. For reduction of sedimentation, there is the increases the circulation of fluid but the attrition of the heat transfer system increases immediately.

3. The working fluid contain particle of large size, this particle flow through narrow channel. Because of large size of particle tend to block the flow channel.

4. There is increases in pressure drop of fluid.

5. The conductivity of fluid is depending upon the particle concentration (i.e. If particle volume fraction is increases, than the enhancement and problem also increases.). Thus, heat transfer rate is increases, but the problem is occurs due to lager size of suspended particle . However, the evolution of modern technology is used to reduces the size of particle.

Nanoparticle used:

There are various types of nanoparticles i.e. metallic, non-metallic nanoparticles and multiwall carbon nanotubes (MWCNT). This nanoparticle combines with base fluid to optimize the heat transfer rate of fluid. It is used to enhance the thermal performance of cooling system. example: MgO_2, Al_2O_3, TiO_2, CuO are nanoparticles and water, ethylene glycol and oil are uses as base fluid.

Nanofluid Preparation Methods:

There are two methods which are use to preparation of nanofluid:

1: Single-Step Method: As a name suggest, preparation of nanofluid synthesized in only one step. It consists of simultaneously combining and intersperse of nanoparticles in the base fluid. By using this method, more stable nanofluid is prepared. But it has some limitations of high cost process, small range production.

2: Two-Step Method: In this method, first step is to make nanoparticles by any physical and chemical techniques. Then prepared nanoparticles are interspersing in the base fluid by using ultrasonication, magnetic stirrer, etc. In second step, Nano-particles have tendency to aggregate because of high surface area. Hence stability of nanoparticles is affected by aggregation. Because of many companies used Nano powder synthesis technique, this method is economically beneficial. In this study, two step methods are used.

Radiator as Cooling Device:

In automobile industry, the radiator is part of the cooling system of the engine. Automobile radiators used to increase the heat transfer rate. In radiator particularly, a cross flow heat exchanger is used. Generally, the working fluid are air and coolant. As the coolant is entered into the radiator, air drawn by the fan makes that coolant cool. Nanofluid is use as coolant. The main aim of the air is to remove heat from the coolant, which causes the coolant to exit the radiator at a lower temperature compared to its entry temperature.

Literature Survey:

Using turbulent flow, heat transfer characteristics of tiO2 in water and ɤ-Al203 in water was studied by B. Farajollahi et.al. [1]. On comparison, it was found that, heat transfer characteristics of TiO2 in water was greater than those of ɤ-Al203 in water and at higher concentration ɤ-Al203 in H2O represents greater heat exchanging capacity. Baoguo et.al. [2]. Worked for cooling purpose in fusion reactor, and the experiments were carried out using Al203 in water. the temperature at four different positions on root of fins at any particular instant were noticed using temperature sensors. E. Shekarian et.al. [3] Presents different methods of preparation, its uses and also various factors responsible for change in heat transfer rate. The different factors analyzed were nanofluid concentration, type, temperature and also nanoparticle size, shape etc.it was found that all these parameters were accountable in variation of heat transfer rate of nanofluid. Golakiya et.al. [4] Made use of water as coolant in radiator. It was found that the absorbed heat by using nanofluid was more than that of water. Jaafaret.al. [5] Studied force convection heat transfer using nanofluid made of Al2O3 (30nm) nanoparticles with base fluid as water. The results were analyzed by varying the concentration of nanofluid from 0.3 to 2 percent in shell and tube heat exchanger. It was noticed that the heat transfer rate was higher than the water. Johnathan et.al. [6] Gave introduction on enhancement in heat transfer rate of nanofluid. The results were obtained by adding various quantities of nanoparticles. Kailash et. al. [7] Found that by increasing probe sonication duration, the heat transfer rate of nanofluid also increases. The experiment was done by using CuO based nanofluid. Kaufui et. al. [8] Gave the introduction about use of nanofluid in different fields including real time and future applications. It can be applied in various fields like industries, nuclear power plant, automobiles, electronical devices and biomedical. Kazem et. al. [9] Focused on effect on viscosity by varying the different factors of nanofluid. The factors included were method of preparation of nanofluid, base fluid, particle size, shape and volume concentration of nanofluid. Kedar et. al. [10]: In the paper analytical model was built. In this model heat transfer rate of nanofluid was analyzed by using different shapes of nanoparticles. In this experiment heat transfer rate of nanofluid was also taken into account because of Brownian's motion. M. Rao et.al. [11] Prepared emulsions of biodiesel in this experiment by using surfactants which is capable of reducing surface tension of fluid and it was checked on the engine. Emulsions of biodiesel being most effective way to lessen the nitrogen oxide level, (AlO(OH)) particles were used. It results into considerable degradation in pollution level. Majid et. al. [12] Expressed the cause of solid volume fraction of nanoparticle used on heat transfer characteristics of particular selected nanofluid by him. He used CuO as nanoparticle and H_2O as base fluid. In the results obtained, it was observed that the CuO-H_2O have more heat transfer characteristics as compared to the H_2O. As well it was noticed that the heat exchange ability and Nu improves with concentration of nanofluid. Mohammad et. al. [13] Studied the heat transfer improvement of ferrous oxide-water nanofluid in various flow conditions in the shell and tube type of heat exchanger. The experiments are performed in the paper by using various types of flows using different heat flux. Laminar, transient and turbulent type of flows were used in this experiment. Nishant et. al. [14] They used H_2O and $C_2H_6O_2$ as bade fluid and copper oxide and titanium oxide as nanoparticles. The flow rate was varied and also the volume fraction was varied from 0.02 to 0.06 percent. The improvement was observed in the heat transfer rate by considering various parameters like concentration, probe sonification time, temperature etc. Purnachandra et. al. [15] In this presented paper the effects of various factor on nanofluid heat exchange ability was investigated by changing various parameters. The parameters included were viscosity, temperature, probe sonification time of fluid and shape, size concentration of nanoparticles in nanofluid to check its performance in different conditions. This paper also gives review on both theoretical as well as the experimental works done on heat transfer coefficient of nanofluids as it is applicable in various fields. Ravi et. al. [16]: In this presented paper the heat transfer rate of CuO nanoparticles mixed with distilled water used as base fluid was investigated at certain concentration. It was found that the heat transfer capacity of this mixture was very good and it was changing with volume fraction of. It was also noticed that the heat transfer ability of the mixture formed by mixing CuO and distilled water is proportional to the volume fraction up to certain limit. Radrigo et.al. [17] In this paper they have represented in very well manner that how does the nanoparticles, Brownian motion of the particles and also the cluster formation affects the heat exchanging ability of nanoparticle and base fluid mixture. They gave the techniques to increase the heat transfer ability of the nanofluid by changing some factors. R. J. Bhatt et.al. [18] The nanofluid was used as a coolant in radiator of the vehicle. It was used to improve the efficiency of vehicle. Because of high heat absorption capacity of nanofluid, it was used in radiator. It results into reduced size of the radiator, increased efficiency of radiator. It also helps in reducing the weight of the automobile. But the only drawback of using it was its sedimentation under nonworking condition. Sadegh et. al. [19] In this the different techniques of formation of nanofluid and methods of keeping it stable are discussed. The heat transfer rate by convection when the fluid is allowed to flow through curve pipes is also discussed. S. S. Abhishek et.al. [20] The paper gives the brief exposure about the new technology that can be used in thermal field namely nanofluids. The various methods of formation and thermal properties, characteristics of it are also introduced in it. Its characteristics are also discussed in this paper. T. Coumaressin et. al. [21] HFC is responsible for ozone layer deflection. Still it is used widely in different countries as refrigerant for cooling purpose. Mostly it is used in air conditioning and refrigeration equipment. nanofluid can be used in place of it which is not responsible for depletion of ozone layer. Yimin et. al. [22] In this presented paper the methods of preparation of nanofluid which is mainly the mixture of suspended nanoparticles and the base fluid was explained. The variety of mixtures were created by using the explained techniques. In the experiment performed, the thermal conductivity of the nanofluid was registered by using the hot tube apparatus technique. Zena et. al. [23] The research was done in the presented paper to improve the heat exchanging capacity of heat exchanger by using. The nanofluid made of MgO was allowed to flow through the cross-flow heat exchanger to exchange the heat energy. In result it was observed that the heat transfer characteristics of heat exchanger is increased by using emulsion of MgO and H_2O in place of conventionally using fluid. B. Farajollahi, S.G. Etemad, M. Hojjat [24] In this presented paper, two nanofluids were prepared and their heat exchanging capacity was checked by varying the dimensionless number that is peclet number. It was observed that the heat transfer is higher for both the fluids at their optimum volume fractions. At same dimensionless number the heat exchanging capacity of nanofluid was more than that of base fluid. K. Bashirnezhad, S. Bazri, M. R. Safaei, M. Goodarzi, M. Dahari, O. Mahian, A. S. Dalk., S. Wongwises [25] The practical study of viscosity of mixture of Nano size particles and base fluid was done by varying the different parameters.it was noticed that the viscosity of the fluid was highly influenced by changing the temperature of entering fluid and the volume fraction of the particles. For acquiring the higher accuracy in future applications some other factors were suggested like probe sonification time, pH, base fluid etc. Liu Yang and Yuhan Hu [26] Came to a final decision that even if nanoparticle loading have shown comparably better result with heat transfer of nanofluids, results of other distinguishing features operates as an entity. Also for a nanoparticle loading effect, the rate of improvement in heat exchanging capacity varies greatly for various nanofluids. Titanium dioxide particle nanofluid has given better use in energy transfer area. Although, uncertainty of large interval uses for nanofluids as well as equipment where it has to be used and also rise in pressure drop has to check for preceding uses.

Conclusion:

1. The heat dissipation ability and effectiveness of mixture of base fluid and nanoparticle is greater than the ordinary fluid used as a coolant. The heat exchanging capacity of titanium oxide emulsion in base fluid is greater than that of aluminium oxide emulsion in base fluid. The heat exchanging ability of such fluid is directly depend on its flow rate.

2. The ability of heat absorption and its effectiveness is relies on the mass flow rate of both air and coolant formed by making emulsion of nanoparticles and base fluid. by decreasing the inlet temperature of the nanofluid, the heat energy exchanging ability increases and vice a versa.

3.The nanofluid shows higher heat exchanging ability than that of the ordinary coolant used for cooling purpose in various applications like industrial, air conditioning, power etc.

4. The heat exchanging ability of nanofluid is greatly relies on the concentration of the metallic oxides in the base fluid.

5. There are more chances of corrosion if the water is used as coolant alone. If the mixture of water and ethylene glycol is made in same ratio by adding corrosion inhibitors, the corrosion can be reduced.

6. The heat exchanging ability is influenced by the nanoparticle shape, size and its concentration. It is also influenced by the base fluid type, its inlet temperature and its volume flow rate.

7. It do not contribute in global warming. Hence it can be used in place of of chlorofluorocarbon in few areas of application.

Future Scope:

Since cooling systems are too bulky and refrigeration has very high energy requirement, we can shift to use of nanofluids as a coolant which can act as a medium of refrigeration by using effective base fluids. Also use of nanofluids is harmless and environment friendly it can be brought to a wide usage. Since preparation of nanofluids is costly and time consuming, a large-scale production and usage may result in reduction of cost of usage thereby increasing its usability.

REFERENCES:

[1] B. Farajollahi, S. Gh. Etemad , M. Hojjat, "Heat Transfer Of Nanofluids In A Shell And Tube Heat Exchanger";International Journal of Heat and Mass Transfer Volume 53, Issues 1–3, 15 January 2010, Pages 12–17

[2] Baoguo Pan, Weihua Wanga, Delin Chu, Luoqin Mei, Qianghua Zhang, "Experimental Investigation Of Hypervapotron Heat Transfer Enhancement With Alumina–Water Nanofluids"; International Volume, July 2016, Pages 738–745

[3] E. Shekarian, A.H. Tarighaleslami, and F. Khodaverdi, "Review of Effective Parameters on The Nanofluid Thermal Conductivity"; Journal of Middle East Applied Science and Technology (JMEAST)

[4] Golakiya Satyamkumar, Sarvaiya Brijrajsinh, Makwana Sulay, Thumar Ankur, Rathwa Manoj, "Analysis of Radiator with Different Types of Nano Fluids"; Journal of Engineering Research and Studies, , Vol. VI, Issue I, Jan.-March, 2015, p.p 01-02

[5] Johnathan J. Vadasz, Saneshan Govender, Peter Vadasz, "Heat Transfer Enhancement In Nano-Fluids Suspensions: Possible Mechanisms And Explanations"; International Journal of Heat and Mass Transfer Volume 48, Issue 13, June 2005, Pages 2673–2683

[6] Jaafar Albadr, Satinder Tayal, Mushtaq Alasadi, "Heat Transfer Through Heat Exchanger Using Al2O3 Nanofluid At Different Concentrations"; Case Studies in Thermal EngineeringVolume 1, Issue 1, October 2013, Pages 38–44

[7] Kailash Nemade, SandeepWaghuley, "A Novel Approach For Enhancement Of Thermal Conductivity Of Cuo/H2O Based Nanofluids"; Applied Thermal Engineering Volume 95, 25 February 2016, Pages 271–274

[8] Kaufui Vincent Wong, Omar De Leon, "Applications of Nanofluids: Current and Future"; Advances in Mechanical Engineering 2 · January 2010

[9] Kazem Bashirnezhad, Shahab Bazri, Mohammad Reza Safaei, Marjan Goodarzi, Mahidzal Dahari, Omid Mahian, Ahmet SelimDalkiliça, Somchai Wongwises, "Viscosity of Nanofluids: A Review of Recent Experimental Studies"; Transfer Volume, April 2016, Pages 114–123

[10] Kedar N. Shukla, Thomas M. Koller, Michael H. Rausch, Andreas P. Fröba, "Effective Thermal Conductivity Of Nanofluids – A New Model Taking Into Consideration Brownian Motion"; International Journal of Heat and Mass Transfer Volume 99, August 2016, Pages 532–540

[11] Majid Zarringhalam, Arash Karimipour, Davood Toghraie, "Experimental Study Of The Effect Of Solid Volume Fraction And Reynolds Number On Heat Transfer Coefficient And Pressure Drop Of Cuo–Water Nanofluid"; Experimental Volume, September 2016, Pages 342–351

[12] Mohammad Hossein Aghabozorg, Alimorad Rashidi, Saber Mohammad, "Experimental Investigation of Heat Transfer Enhancement of Fe2O3-CNT/Water Magnetic Nanofluids Under Laminar, Transient and Turbulent Flow Inside a Horizontal Shell and Tube Heat Exchanger"; Science Volume, April 2016, Pages 182–189

[13] M. Srinivasa Rao, R.B. Anand, "Performance and Emission Characteristics Improvement Studies on A Biodiesel Fuelled DICI Engine Using Water And AlO(OH) Nanoparticles"; Engineering Volume, 5 April 2016, Pages 636–645

[14] Nishant Kumar, Shriram S. Sonawane, "Experimental Study Of Thermal Conductivity And Convective Heat Transfer Enhancement Using CuO And TiO_2 Nanoparticles"; Transfer Volume, August 2016, Pages 98–107

[15] Purna Chandra Mishra, Santosh Kumar Nayak, Sayantan Mukherjee, "Thermal Conductivity of Nanofluids-An Extensive

Literature Review"; International Journal of Engineering Research & Technology (IJERT) IJERT ISSN: 2278-0181 IJERTV2IS90352 www.ijert.org Vol. 2 Issue 9, September – 2013

[16] Ravi Agarwal, Kamalesh Verma, Narendra Kumar Agrawal, Rajendra Kumar Duchaniya, Ramvir Singh, "Synthesis, Characterization, Thermal Conductivity and Sensitivity of CuO Nanofluids"; Applied Volume, 5 June 2016, Pages 1024–1036

[17] Rodrigo Vidonscky Pinto, Flávio Augusto Sanzovo Fiorelli, "Review of The Mechanisms Responsible for Heat Transfer Enhancement Using Nanofluids"; Engineering Volume, 5 September 2016, Pages 720–739

[18] R J Bhatt, H J Patel, O G Vashi, "Nanofluids: A New Generation Coolant"; IJRMET Vol. 4, Issue 2, May - October 2014

[19] Sadegh Aberoumand, Amin Jafarimoghaddam, "Mixed Convection Heat Transfer of Nanofluids Inside Curved Tubes: An Experimental Study"; Applied Thermal Engineering, Volume 108, 5 September 2016, Pages 967-979

[20] S.S. Abhishek, M.Y. Yuthica, P.G.V. Vishal, G.S. Sanika, "Introduction To Nanofluids"; Journal of Applied Fluid Mechanics, Vol. 9, No. 2, pp. 593-604, 2016.

[21] T. Coumaressin, K. Palaniradja, "Performance Analysis of a Refrigeration System Using Nano Fluid"; International Journal of Advanced Mechanical Engineering. ISSN 2250-3234 Volume 4, Number 4 (2014), pp. 459-470

[22] Yimin Xuan, Qiang Li, "Heat Transfer Enhancement Of Nanofluids"; International Journal of Heat and Fluid Flow Volume 21, Issue 1, February 2000, Pages 58–64

[23] Zena K. Kadhim, Muna S. Kassim, Adel Y. Abdul Hassan, "Effect Of (MgO) Nanofluid On Heat Transfer Characteristics for Integral Finned Tube Heat Exchanger"; International Journal of Mechanical Engineering and Technology (IJMET) Volume 7, Issue 2, March-April 2016, pp. 11-24, Article ID: IJMET_07_02_002

[24] B. Farajollahi, S. Gh. Etemad*, M. Hojjat, "Heat transfer

of nanofluids in a shell and tube heat exchanger", International journal of heat and mass transfer Volume 53, issues 1-3, 15 January 2010, Pages 12-17

[25] Kazem Bashirnezhad, Shahab Bazri, Mohammad Reza Safaei, Marjan Goodarzi, Mahidzal Dahari, Omid Mahian, Ahmet Selim Dalkılıça, Somchai Wongwises," Viscosity of nanofluids: A review of recent experimental studies" International journal of heat and mass transfer Volume 73, April 2016, Pages 114-123

[26] Liu Yang and Yuhan Hu" Toward TiO2 Nanofluids—Part 2: Applications and Challenges" Yang and Hu Nanoscale Research Letters (2017)