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EXPERIMENTAL INVESTIGATION ON SHELL AND TUBE HEAT EXCHANGER

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Abstract*— Heat exchangers are the essential accessories designed to provide highest heat transfer inside the minimal area feasible. Heat exchangers are always regarded important for research in the field of thermal engineering. Nanoparticles like suspensions of ZnO, CuO, Fe3O4, TiO2, and Al2O3 in water is the new revolutionary solution to increase the effectiveness of heat exchangers. There are a lot of exclusive forms of heat exchangers as per the geometric traits. Right here, we have taken shell and tube heat exchanger for our evaluation. Suspention of Al2O3 nanoparticles in water at 0.03 volumetric fractions have been viewed for experimental investigation. It has been observed that use of nanoparticles can simply increse the effectiveness of heat exchanger. It is due to increse in convective co-effective of heat switch. We have got additionally analyzed thermal performance of shell and tube heat exchanger for quite a lot of concentrations of nano particles.

***Keywords*— Shell and Tube Heat Exchanger, Nanoparticles, Experimental Investigation, Effectiveness, Nano Fluid**

I. INTRODUCTION

A heat exchanger is equipment which transfers the vigor from a scorching fluid to a cold fluid with maximum possible rate. Heat exchanger is a gadget which transfers the warmth from hot fluid to cool fluid. In traditional heat exchanger most commonly traditional fluids (related to water, mineral oil and ethylene glycol) are used as a working fluid. For decades, efforts have been performed to increase warmness transfer, curb the heat transfer time, lessen dimension of heat exchanger and subsequently develop the warmness switch and effectivity. These efforts comprise passive and energetic ways equivalent to creating turbulence, growing heat switch subject, increasing thermal conductivity of working fluid, and so forth. On the grounds that stable particles have higher thermal conductivity, when they are dispersed in the fluids, it will effect in higher warmness transfer traits. There are many forms of stable particles such as metal, nonmetallic and polymeric. However as a result of gigantic size, micro and macro-sized particles will face some issues in utilising of these suspensions. To shrink these problems, nano-sized particles are used in these suspensions. These suspensions are referred to as as nano-fluids the place nano-sized particles are suspended in a base fluid. Is gear which transfers the vigor from a hot fluid to a cool fluid with maximum possible rate. Heat exchanger is a gadget which transfers the heat from sizzling fluid to cool fluid. In natural heat exchanger most commonly traditional fluids (corresponding to water, mineral oil and ethylene glycol) are used as a working fluid. For decades, efforts were performed to enhance warmth transfer, decrease the warmness transfer time, curb size of heat exchanger and ultimately develop the warmness switch and efficiency. These efforts incorporate passive and active approaches similar to growing turbulence, growing warmness switch subject, increasing thermal conductivity of working fluid, and so on. Seeing that solid particles have bigger thermal conductivity, when they are dispersed in the fluids, it is going to result in larger warmness transfer characteristics. There are many types of strong particles such as metallic, nonmetallic and polymeric. However due to giant dimension, micro and macro-sized particles will face some problems in making use of those suspensions. To diminish these issues, nano-sized particles are utilized in these suspensions. These suspensions are referred to as as nano-fluids where nano-sized particles are suspended in a base fluid.

II. LITERATURE REVIEW

Many research papers are studied to understand applications of nano fluids in the shell and tube heat exchangers as well as heat transfer process. Past research work of Dr. Nirajkumar Mehta is used as a ready reference. Induction furnace research review is done to study research trends. (Nirajkumar Mehta, May 2012). A review is done on applications of different numerical methods in heat transfer with its applications. (N C Mehta, Vipul B Gondaliya et al, February 2013). Thermal fatigue analysis of induction melting furnace wall is done for silica ramming mass. (N C Mehta, Akash D Raiyani et al, February 2013). A review is done for research on induction heating. (Vimal R Nakum et al, April 2013). A review is done for metal forming analysis using different numerical methods. (N C Mehta et al, May 2013). Transient heat transfer analysis of induction furnace is done by using finite element analysis. (Vipul Gondaliya et al, August 2013). Thermal fatigue analysis of induction furnace wall is done for alumina ramming mass. (N C Mehta et al, October 2013). Thermal analysis of hot wall condenser is done for domestic refrigerator using numerical method for temperature distribution. (Akash D Raiyani et al, July 2014). Optimisation of wall thickness is done for minimum heat loss for induction furnace by finite element analysis. (Dipesh D Shukla et al, December 2014). A review is done on numerical analysis of furnace. (N C Mehta et al, April 2015). Thermal fatigue analysis of induction furnace wall is done for zirconia.

(Nirajkumar Mehta et al, April 2015). Comparison of finite difference method and finite element method is done for 2 D transient heat transfer problem. (Nirajkumar Mehta et al, April 2015). Thermal fatigue analysis of induction furnace wall is done for magnesia ramming mass. (Nirajkumar Mehta et al, June 2015). Advanced mathematical modelling of heat transfer is done for induction furnace wall of zirconia. (Nirajkumar Mehta et al, December 2016). Advanced heat transfer analysis is done for alumina based refractory wall of induction furnace. (Nirajkumar Mehta et al, December 2016).

III. RESEARCH METHODOLOGY

Many investigation papers are studied to appreciate applications of nano fluids in the shell and tube heat exchangers as well as warmth transfer procedure. Earlier study work of Dr. Nirajkumar Mehta is used as a able reference. Induction furnace research overview is finished to learn study developments. (Nirajkumar Mehta, may 2012). An evaluate is completed on functions of one-of-a-kind numerical approaches in heat transfer with its applications. (N C Mehta, Vipul B Gondaliya et al, February 2013). Thermal fatigue analysis of induction melting furnace wall is done for silica ramming mass. (N C Mehta, Akash D Raiyani et al, February 2013). An assessment is done for study on induction heating. (Vimal R Nakum et al, April 2013). An assessment is completed for metal forming analysis making use of special numerical ways. (N C Mehta et al, could 2013). Transient heat transfer evaluation of induction furnace is finished via making use of finite aspect evaluation. (Vipul Gondaliya et al, August 2013). Thermal fatigue analysis of induction furnace wall is completed for alumina ramming mass. (N C Mehta et al, October 2013). Thermal analysis of sizzling wall condenser is done for domestic fridge making use of numerical system for temperature distribution. (Akash D Raiyani et al, July 2014). Optimisation of wall thickness is finished for minimal heat loss for induction furnace by finite aspect evaluation. (Dipesh D Shukla et al, December 2014). An evaluate is done on numerical evaluation of furnace. (N C Mehta et al, April 2015). Thermal fatigue analysis of induction furnace wall is finished for zirconia. (Nirajkumar Mehta et al, April 2015). Evaluation of finite change method and finite detail approach is completed for 2-D transient warmth transfer main issue. (Nirajkumar Mehta et al, April 2015). Thermal fatigue analysis of induction furnace wall is completed for magnesia ramming mass. (Nirajkumar Mehta et al, June 2015). Evolved mathematical modelling of heat transfer is done for induction furnace wall of zirconia. (Nirajkumar Mehta et al, December 2016). Developed warmth switch analysis is done for alumina founded refractory wall of induction furnace. (Nirajkumar Mehta et al, December 2016).

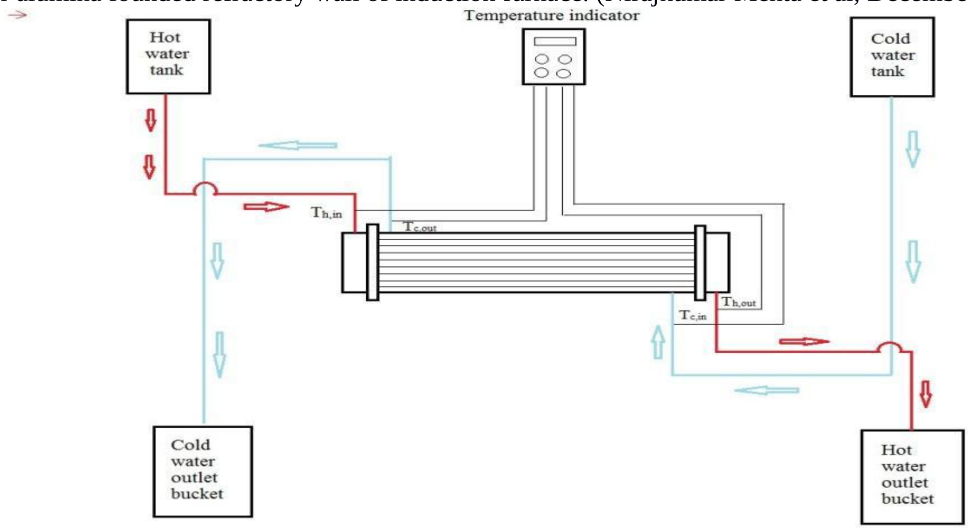

Fig. 1 Experimental Design

Fig. 2 Experimental Set Up

IV. EXPERIMENTAL INVESTIGATION

Fig. 3 Shell and Tube Heat Exchanger Experiment with Nanoparticles

Mass flow rate of Hot(m_h)	Mass flow rate of Cold(m_c)	T_{h1}(hot in)	T_{h2}(Hot out)	T_{c1}(Cold in)	T_{c2}(Cold out)
$6x10^{-5}$	$5.55x10^{-5}$	51.5°C	39.1°C	27.2°C	36.2°C
$6x10^{-5}$	$4.29x10^{-5}$	47.8°C	35.5°C	29.1°C	32.1°C
$6x10^{-5}$	$3.31x10^{-5}$	45.6°C	37.4°C	29.3°C	31.4°C

- **CALCULATION OF EFFECTIVENESS FOR PARALLEL FLOW**

$m_h = 6x10^{-5}$

$m_c = 5.55x10^{-5}$

$T_{h1} = 51.5°C$

$T_{h2} = 39.1°C$

$T_{c1} = 27.2°C$

$Tc_2 = 36.2°C$

- CAPACITY RATIO FOR HOT AND COLD FLUID

$C_h = m_h * c_h = 6x10^{-5} * 4.81$

$= 28.86x10^{-5}$

$C_c = m_c * c_c = 5.55x10^{-5} * 4.81$

$= 26.65x10^{-5}$

- EFFECTIVENESS
- $\varepsilon = Q_{act}/Q_{max}$
- $Q_{act} = m_h * c_h (T_{h1} - T_{h2})$

$= 6x10^{-5} * 4.81(51.5° - 39.1°)$

$= 397.86x10^{-5}$

- $Q_{max} = C_{min}(T_{h1} - T_{c1})$

$= 26.65x10^{-5}(51.5° - 27.2°)$

$= 647.39x10^{-5}$

- $\varepsilon = Q_{act}/Q_{max} = 397.86x10^{-5}/397.86x10^{-5} = 0.55$

Mass flow rate of Hot(m_h)	Mass flow rate of Cold(m_c)	T_{h1}(hot in)	T_{h2}(Hot out)	T_{c1}(Cold in)	T_{c2}(Cold out)
$6x10^{-5}$	$5.55x10^{-5}$	60°C	35.1°C	30.3°C	33.3°C
$6x10^{-5}$	$4.29x10^{-5}$	53°C	33.4°C	30.3°C	31.7°C
$6x10^{-5}$	$3.31x10^{-5}$	47°C	32.3°C	30°C	31.2°C

CALCULATION OF EFFECTIVENESS FOR COUNTER FLOW

$m_h = 6x10^{-5}$

$m_c = 5.55x10^{-5}$

$T_{h1} = 60°C$

$T_{h2} = 35.1°C$

$T_{c1} = 30.3°C$

$Tc_2 = 33.3°C$

- CAPACITY RATIO FOR HOT AND COLD FLUID

$C_h = m_h * c_h = 6x10^{-5} * 4.81$

$= 28.86x10^{-5}$

$C_c = m_c * c_c = 5.55x10^{-5} * 4.81$

$= 26.65x10^{-5}$

- EFFECTIVENESS

$\varepsilon = Q_{act}/Q_{max}$

$Q_{act} = m_h * c_h (T_{h1} - T_{h2})$
$= 6x10^{-5} * 4.81(60° - 35.1°)$

$= 718.6x10^{-5}$

$Q_{max} = C_{min}(T_{h1} - T_{c1})$

$= 26.65x10^{-5}(60° - 30.3°)$

$= 790.02x10^{-5}$

$\varepsilon = Q_{act}/Q_{max=}$ $397.86\text{x}10^{-5}/397.86\text{x}10^{-5} = 0.90$

V. CONCLUSION

Generally, in industrial applications, conventional fluids are used as working fluid in heat exchangers. It is concluded that the heat transfer capacity of nanofluids is higher than that of conventional fluids. Hence, by using nanofluid as working fluid in heat exchangers we can enhance the heat transfer capacity. In this research, initial experiments were done by using water as a working fluid and experimental LMTD, overall heat transfer coefficient, inside heat transfer coefficient, Reynold number and nusselt numbers were calculated. Nano fluids of 2% and 4% vol. concentration Al2O3 were introduced into the heat exchanger and the experimental calculations are estimated. It is observed that Nano fluids showed better performance than that of water. Some concluded points from experiments are as follows. It is observed that Nano fluids shown better performance than that of water. It is concluded that inside heat transfer coefficient is increased by 23% as of water. And it increased with concentration of nanoparticles. LMTD and overall heat transfer coefficient was also increased. Experiments showed a significant increase in experimental nusselt number. It is observed that the enhancement was increased with increased in volume concentration and temperature. Al2O3 with 4% of volume concentration shoved better performance than that of Al2O3 with 2% of volume concentration and water.

VI. FUTURE SCOPE

In the preset work , Al_2O_3 nanoparticles of approximately 50-100 nm sizes are used it can be extended to another nano material like SiC and CNT in various sizes considering thermal conductivity. Other fluid like ethylene glycol, propylene glycol and there mixture with water can be chosen as base fluids and proper suspension can be selected to enhance the heat transfer performance. The present work can be extended to analyse the wear aspects of heat exchanger materials .due to nanoparticles added to the base fluids.

REFERENCES

1) Ningbo Zhao, Jialong Yang, Hui LI, Ziyin Zhang, Shuying Li On this and that. “Numerical investigations of laminar heat transfer and flow performance of Al2O3–water nanofluids in a flat tube” ELSEVIER 0017-9310 (2015)
2) Mehdi Bahiraei, Morteza Hangi, Mahdi Saeedan On this and that. “A novel application for energy efficiency improvement using nanofluid in shell and tube heat exchanger equipped with helical baffles” ELSEVIER 0360-5442 (2015)
3) Shive Dayal Pandey, V.K. Nema On this and that. “Experimental analysis of heat transfer and friction factor of nanofluid as a coolant in a corrugated plate heat exchanger” ELSEVIER 0894-1777 (2012)
4) A.A. Abbasian Arani, J. Amani On this and that.“Experimental study on the effect of TiO2–water nanofluid on heat transfer and pressure drop” ELSEVIER 0894-1777 (2012)
5) R Mondragon, C Segarra, J C Jarque, J E Julia, L Hernandez, R Martinez-Cuenca On this and that. “Characterization of physical properties of nanofluids for heat transfer application” DOI:10.1088/1742-6596/395/1/012017 (2012)
6) Mahmood Ranai, Nahid Nemati On this and that. “Numerical Study of the Effects of Water-Al2O3 Nanofluid on Under Floor Heating System” Vol. 2, No. 1, 2015, pp. 22-31
7) A.E. Kabeel, Mohamed Abdelgaied On this and that. “Overall heat transfer coefficient and pressure drop in a typical tubular exchanger employing alumina nanofluid as the tube side hot fluid” DOI 10.1007/s00231-015-1662-8 (2015)
8) I.M. Shahrul, I.M. Mahbubul, R. Saidur, S.S. Khaleduzzaman On this that. “Performance evaluation of a shell and tube heat exchanger operated with oxide based nanofluids” DOI 10.1007/s00231-015-1664-6 (2015)
9) Nirajkumar Mehta, Dr. C D Shankhavara, “CFD Analysis of Induction Furnace – Review”, International Conference on Emerging Technologies and Applications in Engineering, Technology and Sciences, ISBN No. 978-81-906220-3-5, March 2012.
10) Nirajkumar Mehta, Akash D Raiyani, Vikash R Gondaliya, “Thermal Fatigue Analysis of Induction Melting Furnace for Silica Ramming Mass”, International Journal of Emerging Technology and Advanced Engineering, ISSN No. 2250-2459, Volume 3, Issue 2, pp 357-362, February 2013.
11) Nirajkumar Mehta, Vipul B Gondaliya, Jayesh V Gundania, “Application of Different Numerical Methods in Heat Transfer - A Review”, International Journal of Emerging Technology and Advanced Engineering, ISSN No. 2250-2459, Volume 3, Issue 2, pp 363-368, February 2013.
12) Vimal R Nakum, Kevin M Vyas, Nirajkumar Mehta, “Research on Induction Furnace – Review”, International Journal of Science and Engineering Applications, ISSN No. 2319-7560, Volume 2, Issue 6, pp 141-144, April 2013.
13) Nirajkumar Mehta, Viral V Shiyani, Jemish R Nasit, “Metal Forming Analysis”, International Journal of Emerging Technology and Advanced Engineering, ISSN No. 2250-2459, Volume 3, Issue 5, pp 190-196, May 2013.
14) Vipul Gondaliya, Mehul Pujara, Nirajkumar Mehta, "Transient Heat Transfer Analysis of Induction Furnace by Using Finite Element Analysis", International Journal of Applied Research, ISSN No. 2249-555X, Volume 3, Issue 8, pp 231-234, August 2013.

15) Nirajkumar Mehta, Vasim G Machhar, Ravi K Popat, "Thermal Fatigue Analysis of Induction Furnace Wall for Alumina Ramming Mass", International Journal of Science and Engineering Applications, ISSN No. 2319-7560, Volume 2, Issue 10, pp 186-190, October 2013.
16) Akash D. Raiyani, N. R. Sheth, Nirajkumar Mehta, "Thermal Analysis of Hot Wall Condenser for Domestic Refrigerator", International Journal of Science and Research, ISSN No. 2319-7064, Volume 3, Issue 7, pp 622-626, July 2014.
17) Nirajkumar Mehta, Dipesh D Shukla, Ravi K Popat, "Optimization of Wall Thickness for Minimum Heat Loss for Induction Furnace by FEA", Indian Foundry Journal, ISSN No. 0379-5446, Volume 60, Issue 12, pp 19-25, December 2014.
18) Nirajkumar Mehta, Dr. Dipesh D Shukla, Pragnesh D Kandoliya, “Comparison of Finite Difference Method and Finite Element Method for 2 D Transient Heat Transfer Problem”, National Conference on Recent Research and Development in Core Disciplines of Engineering, Vadodara, Volume: 2, April 2015.
19) Nirajkumar Mehta, Dr. Dipesh D Shukla, Vishvash B Rajyaguru, “Numerical Analysis of Furnace: Review”, National Conference on Recent Research and Development in Core Disciplines of Engineering, Vadodara, Volume: 2, April 2015.
20) Nirajkumar Mehta, Dr. Dipesh D Shukla, Vishvash B Rajyaguru, “Thermal Fatigue Analysis of Induction Furnace Wall for Zirconia”, National Conference on Recent Research and Development in Core Disciplines of Engineering, Vadodara, Volume: 2, April 2015.
21) Nirajkumar Mehta, Dr. Dipesh D Shukla, “Thermal Fatigue Analysis of Induction Furnace Wall for Magnesia Ramming Mass”, ASME 2015 Applied Mechanics and Materials Conference, At Seattle, Washington, United States of America, June 2015.
22) Nirajkumar Mehta, Dr. Dipesh D Shukla, Pragnesh D Kundalia, “Advanced Mathematical Modeling of Heat Transfer in Induction Furnace Wall of Zirconia”, International Journal of Engineering Research & Technology, ISSN No. 2278-0181, Volume 5, Issue 12, pp 176-181, December 2016.
23) Nirajkumar Mehta, Dr. Dipesh D Shukla, Pragnesh D Kundalia, “Advanced Heat Transfer Analysis of Alumina Based Refractory Wall of Induction Furnace”, National Conference on "Emerging Trends in Engineering", ISBN No. 978-93-84659-91-2, At Tolani Polytechnic, Adipur, Volume: 1, December 2016.
24) Nirajkumar Mehta, Dr. Dipesh D Shukla, “Prediction of Life Cycle of Induction Furnace Wall for Silica Ramming Mass”, International Journal of Thermal Technologies, ISSN No. 2277-4114, Volume 6 Issue 4, pp 364-372, December 2016.
25) Nirajkumar Mehta, Dr. Dipesh D Shukla, “Finite Difference Analysis of Induction Furnace Wall for Magnesia Ramming Mass”, SSRG International Journal of Thermal Engineering, ISSN No. 2395-0250, Volume 3, Issue 1, pp 1-7, January 2017.
26) Nirajkumar Mehta, Dr. Dipesh D Shukla, “Computational Investigation of Furnace Wall for Silica Ramming Mass with FDM”, International Journal of Advanced Engineering Research and Science, ISSN No. 2456-1908, Volume 4, Issue 2, pp 133-139, February 2017.
27) Nirajkumar Mehta, Dr. Dipesh D Shukla, “Stress Life Analysis of Induction Furnace Wall for Magnesia Ramming Mass”, IOSR Journal of Mechanical and Civil Engineering, e-ISSN: 2278-1684, p-ISSN: 2320-334X, Volume 14, Issue 1, pp 60-70, February 2017.
28) Kaushik Parmar, Osama Gora, Kashyap Desai, Nirajkumar Mehta, “A Practical Attempt to Improve Performance of Heat Exchanger”, International Journal of Advance Research and Innovative Ideas in Education, ISSN 2395-4396, Volume 3, Issue 1, March 2017.
29) Achyut Chauhan, Heval Saxena, Nirajkumar Mehta, A Review on FEA of Connecting Rod of I.C. Engine, International Journal of Innovative Research in Science, Engineering and Technology, ISSN(Online): 2319-8753, ISSN (Print): 2347-6710, Volume 6, Issue 3, March 2017.
30) Nirajkumar Mehta, Dr. Dipesh D Shukla, “Mathematical Modelling for Life Cycle Forecasting of Zirconia Based Furnace Wall”, International Journal of Advance Research and Innovative Ideas in Education, ISSN 2395-4396, Volume 3, Issue 4, April 2017.
31) Nirajkumar Mehta, Dr. Dipesh D Shukla, Comparison of Life Cycle for Various Refractory Materials of Induction Melting Furnace Wall under Thermal Fatigue Loading Conditions”, International Journal of Advance Engineering and Research Development, e-ISSN (O): 2348-4470, p-ISSN (P): 2348-6406, Volume 5, Issue 01, January -2018.
32) Patil Kaushal, Makwana Arjunsinh, Arab Mohammadazhar, Nirajkumar Mehta, “Mathematically Advanced Computational Heat Transfer Analysis of Cylindrical and Spherical Induction Furnaces: Review”, International Journal of Advance Engineering and Research Development, e-ISSN (O): 2348-4470, p-ISSN (P): 2348-6406, Volume 5, Issue 02, February -2018.
33) Rahul Waghela, Shreyas Parmar, Susmit Vasava, Dr. Nirajkumar Mehta, “Review of Refractory Materials for Innovative Investigation and Testing”, International Journal of Advance Engineering and Research Development, e-ISSN (O): 2348-4470, p-ISSN (P): 2348-6406, Volume 5, Issue 03, March -2018.