Review of Computational Fluid Dynamics Using ANSYS with Turbulence Equations-Viscosity and Reynolds Stresses

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Abstract

In a computational fluid dynamic, trails have been conducted on the heat transfer and nusselt no. for a helical coil tube heat exchanger. In the CFD investigation, it was assured that the two types of nanofluids were considered with water also to determine overall heat transfer rate and nusselt no., for heat transfer. This investigation was carried out on a different mass flow rate ranging between 0.00418 to 0.0167 Kg/s. When the observations were compared between water and other nanofluids it was concluded that: The CuO as a nano fluid could not transfer the desired heat and so it was not practically prepared and the nano fluid as Fe2O3 is efficient enough to transfer heat but water has a huge complexity in design, whereas the Fe2O3 as a nano fluid have overcome this problem.

Keywords: - ***CFD Analysis, FLUENT, Helical coil tube heat exchanger, Nusselt no., and overall heat transfer coefficient.***

INTRODUCTION

Heat transfer fluids have many industrial and civil applications, including electronic cooling, transport, energy and air-conditioning system. Traditional fluids such as water, oil and glycols have poor thermal performance due to their low thermal conductivities [1-2]. Re-search and development has been carried out to improve the thermal performance of fluid. Solid metallic materials and non-metallic materials have much higher thermal conductivity than based fluid. The suspension of nano-sized metallic/non-metallic particle smaller than 100 nm into the base fluid termed as “Nanofluid”. Nanofluids are attracting a great intension with their vast potential to provide enhanced performance properties, especially with the respect to heat transfer [5].

Second laws of thermodynamics explain that energy transformation direction is moving from high quality energy to low quality energy. Quality of energy during a process also considers the quantitative measurement of exergy, potential work and entropy, and non-potential work. Quality energy during a process and energy transformation direction was described in the Second law of thermodynamics. The measurement of irreversibility magnitudes during a process is called as entropy generation rate. Researchers have carried out the irreversibility analysis of different systems and have showed that irreversibility or entropy generation analysis is a powerful tool to decide which installation or process is efficient. Shuja et al. [5] studied the entropy generation under convective heat transfer. Bejan derived the equations for entropy generation under forced convective heat transfer for various geometries like round tube, boundary layer over a flat plate and single cylinder in cross-flow[5]. In section II. discuss the related work and in section III discuss Computational Fluid Dynamic. In section IV discuss approach with ANSYS 15.0 and finally discuss conclusion and future work in section V.

II. RELATED WORK

Gabriela Huminic and Angel Huminic Et al. [1] In this work, a three-dimensional analysis is used to study the heat transfer and entropy generation inside a helically coiled tube-in-tube heat exchanger in laminar flow regime using two different types of nanofluids. The present contribution is a companion paper of Huminic and Huminic. The numerical results reveal that the use of nano-fluids in a helically coiled tube-in-tube heat exchanger improves the heat transfer performances. Thus, the maximum effectiveness was 91% for 2% CuO nan-oparticles and 80% for 2% TiO2 nanoparticles.

M.A. Khairul, R. Saidur, M.M. Rahman, M.A. Alim, A. Hossain and Z. Abdin Et al. [2] This paper presents the thermodynamic second law analysis of a helical coil heat exchanger using three different types of nanofluids. During the analyses, the entropy generation rate was expressed in terms of four parameters: particle volume concentration, heat exchanger duty parameter, coil to tube diameter ratio and Dean number. Amongst the three nanofluids, CuO/water nanofluid, the heat transfer enhancement and reduction of entropy generation rate were obtained about 7.14% and 6.14% respectively.

Mohammad Mehrali, Emad Sadeghinezhad, MarcA. Rosenc, Amir Reza Akhiania, Sara Tahan Latibari, Mehdi Mehrali and Hendrik Simon Cornelis Metselaar Et al. [3] The impact of the dispersed nanoparticles concentration on thermal properties, convective heat transfer coefficient, thermal performance factor and entropy generation is investigated. An enhancement in thermal conductivity for GNP of between 12% and 28% is observed relative to the case without nanoparticles. Finally, it is demonstrated that a GNP nanofluid with a concentration between 0.075 wt.% and 0.1 wt.% is more energy efficient than for other concentrations. It appears that GNP nanofluids can function as working fluids in heat transfer applications and provide good alternatives to conventional working fluids in the thermal fluid systems.

M.A. Khairul,M.A.Alima, I.M. Mahbubul, R.Saidura, A. Hepbasli and A.Hossain Et al. [4] This study examined the effects of water and CuO/water nanofluids (as coolants) on heat transfer coefficient, heat transfer rate, frictional loss, pressure drop, pumping power and exergy destruction in the corrugated plate heat exchanger. The heat transfer coefficient of CuO/water nanofluids increased about 18.50 to 27.20% with the enhancement of nano-particles volume concentration from 0.50 to 1.50% compared to water. The study also remarked that the increment of particle volume fraction and volume flow rate of nanofluids could enhance the friction factor which will result in a higher pressure drop and pumping power.

M.R. Sohel, R. Saidur, N.H. Hassan, M.M. Elias, S.S. Khaleduzzaman and I.M. Mahbubul Et al. [5] In this analysis, the entropy generation of a turbulent flow through the circular microchannel and mini-channel heat exchanger is comparatively discussed using two different base fluid and nanofluid at various volume fraction. According to the analysis, the principle findings are pointed below: Entropy generation decreased by the increasing of volume fraction of both type of nanoparticle dispersed in H_2O and EG.The entropy generation rate ratio in microchannel was lower than the unity and it decreased by the increasing of volume fraction. At 6% volume fraction, the maximum decreasing rate was 36% using Cu–H_2O nanofluid and it was only 16% using Al_2O_3–H_2O nanofluid.

Abhinav Gupta, Ravi Kumar and Akhilesh Gupta Et al. [6] This article presents an experimental investigation of heat transfer and pressure drop characteristics of R-134a condensing inside a horizontal helical coil tube with the cooling water flowing in the shell in counter flow direction. The experimental two-phase flow regime is plotted on Taitel and Dukler flow map and mass flux versus vapor quality flow map. Martinelli parameter is used to indicate the transition from intermit-tent to annular flow, which is vtt = 0.65. The transition from stratified-wavy to intermittent or annular flow is identified in mass flux versus vapor quality flow map.The average heat transfer coefficient and pressure drop of helical coil tube increase with increasing average vapor quality and mass flux.

M. Farzaneh-Gord , H. Ameri and A. Arabkoohsar Et al. [7] Defining the dimensionless expression of curvature ratio for both of the inner tube (d1) and the annulus (d2), it was found out that the geometry of the heat exchanger affects its performance significantly and one could find optimal curvature ratios for both of the inner tube and the annulus to minimize the demotion of thermal energy and viscous dispersion of mechanical energy in the heat exchanger. Finally, taking the results of the numerical simulation implemented into account, the optimal geometry (d1 and d2) and flow characteristics (Re number, De number) that optimize the performance of this type of heat exchanger based on the lowest rate of entropy generation were determined.

Hamed Sadighi Dizaji, Samad Jafarmadar and Mehran Hashemian Et al. [8] This work presents experimental investigations on the effects of flow, thermodynamic and geometrical characteristics on exergy loss in shell and coiled tubes heat exchangers. This paper experimentally investigates the effect of flow, thermodynamic and geometric parameters on exergetic characteristics in shell and coiled tube heat exchangers. The key findings from the experimental study are described as below.Exergy loss increases with the increase of shell or coil side flowrate. Dimensionless exergy loss can increase or decrease withthe increase of flow rates. It depends on Cmin. Both of the exergy loss and dimensionless exergy loss increasewith the increase of coil side inlet temperature and decrease ofshell side inlet temperature.

R. Ellahi, M. Hassan and A. Zeeshan Et al. [9] In this paper, a mathematical model is analyzed in order to study the natural convection boundary layer flow along an inverted cone. The shape of nano-size particles on entropy generation with based fluid is considered. Simultaneous effects of porous medium, magneto hydrodynamics, radiation and power law index effects are also taken into account. Hamilton–Crosser model is used for the effective thermal conductivity. The calculations are performed for different governing parameters such as Prandtl number, Rayleigh number, power law index, porosity parameter, radiation parameter and magnetic parameter. The physical interpretations of obtained results are illustrated by graphs and tables. In addition, correlation of Nusselt number and skin friction corresponding to active parameters are also analyzed in this investigation.

Lorenzo Santini, Andrea Cioncolini, Matthew T. Butel and Marco E. Ricotti Et al. [10] The heat transfer coefficient during flow boiling of water in an electrically heated, full-scale helical coil steam generator tube was measured, covering operating pressures in the range of 2–6 MPa, mass fluxes from 200 to 800 kg m^(-2) s^(-1) and heat fluxes from 40 to 230 kW m2, conditions which are of interest for the design and operation of compact steam generators in nuclear power applications. Overall, 1575 peripherally averaged and axially local heat transfer coefficient measurements were collected, with an experimental uncertainty within 5–20%. The heat transfer coefficient was found to depend on the mass flux and the heat flux, indicating that both nucleate boiling and convection are contributing to the heat transfer.

Bharathwaj V, Markan A, Atrey M, Neumann H and Ramalingam R Et al. [11] In this paper, the principle, design and installation of sensors are explained and the initial experiments are carried out to demonstrate the measurement technique. The experimentally measured temperature distribution was found to be agreeable with the simulated values with minor deviations. This could be due to the fact that the simulation assumes the heat exchange to be perfect whereas there may be certain inefficiencies in the system. The heat transfer characteristics of the heat exchanger are analyzed to further scrutinize the performance of the heat exchanger. From the results obtained, it can be inferred that the use of FBG sensors could provide researchers with a unique method for temperature measurement in a TIT heat exchanger.

Zan Wu, Lei Wang, Bengt Sundénand Lars Wadsö Et al. [12] This work experimentally investigated the hydraulic and thermal performance of aqueous multi-walled carbon nanotube (MWCNT) nanofluids in a double-pipe helically coiled heat exchanger. A transient plane source method was adopted to measure thermal conductivity. The in-crease in viscosity of the nanofluids is much larger than the thermal conductivity enhancement. For example, the relative thermal conductivity is only 1.04 while the relative viscosity is 9.56 for a 1.0 wt%MWCNT/water nano-fluid. Pressure drop and heat transfer characteristics were experimentally studied for aqueous MWCNT nanofluids of weight concentrations 0.02 wt%, 0.05 wt% and 0.1 wt% inside the helical heat exchanger.

III. COMPUTATIONAL FLUID DYNAMIC

The purpose of this dissertation is to use simulate temperature distribution and wind velocity stream lines in greenhouse dryer heat and validate the simulation with an actual Base paper result result. Different solvers and turbulence models are used to try to determine the most accurate CFD method. Computational fluid dynamics (CFD) may be a computer-based simulation methodology for analysing fluid flow, heat transfer, and connected phenomena like chemical reactions. This thesis uses CFD for analysis of temperature and wind velocity[11-13].

It may be advantageous to use CFD over traditional Base paper result-based analyses, since experiments have a cost directly proportional to the number of configurations desired for testing, unlike with CFD, where massive amounts of results may be created at practically no added expense [7-8]. During this method, parametric studies to optimize instrumentation are terribly inexpensive with CFD in comparison to Base paper result.

This section shortly describes the overall concepts and theory associated with using CFD to analyses fluid flow and heat transfer, as relevant to this thesis. It begins with a review of the tools required for carrying out the CFD analyses and the processes needed.

IV. APPROACH USED

Geometry was modelled in ANSYS 15.0 and then generated to ANSYS workbench 15.0 where meshing was done, then the mesh was generated to FLUENT. The boundary conditions, material properties and encompassing properties were set through parameterized case files. FLUENT solves the problem until either the convergence limit is met or the amounts of iterations specified by the user are complete[9-10].

The procedure for resolving any problem is[4-7]:

- Create the geometry.
- Meshing of the domain.
- Set the material properties and boundary conditions.
- Obtaining the solution.

After modelling the geometry in ANSYS, it was generated to ANSYS workbench design modular for its discretization. Meshing is dividing the complete geometry of interest into small parts. Mesh density varies based upon the assigned refinement factor. Mesh is the key part of a high quality convergence[1-2]. There are 3 types of meshing. These are Hexahedral Cartesian, Hexahedral Unstructured and Tetrahedral meshes. Hexahedral Cartesian mesher generates totally structured meshes. It’s appropriate for free kind of geometries. But inappropriate for models where curved surfaces exist.

V. CONCLUSION & FUTURE WORK

Computational model has been developed in ANSYS 15.0 and analysis has been done in Fluent 15.0. Numerical results are in good agreement with Base paper result results. The internal consistency of the results confirms the validity of the CFD model. From results expectation, higher value of temperature, overall heat transfer coefficient, and nusselt is found out for ferrous oxide nano fluid than water and CuO.

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