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Thermal Analysis of a Ferro Fluid Interrupted and Continuously Twisted Tape Heat Exchanger

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Abstract: We looked at the convective heat transmission of a water-based Ferro fluid in a pipe. The laminar convective heat transfer of water-based Ferro fluid moving through a pipe was explored and analysed in the presence and absence of an external magnetic field. Fe3O4-Water is the working fluid. Simulation and analysis was carried out using Ans. 2019 R3. A single-tube configuration was simulated. In this tube, Ferro fluid is pumped. The outside diameter of the tube, do, is 28 millimetres, while the inner diameter, di, is 25 millimetres. The length of the tube, L= 700 mm, was taken into account. ICEM CFD for Fluent 2019 R3 was used to create the mesh. A mesh report with 158776 nodes and 145000 elements was used for meshing. Fluent was used to create this design. The MHD module in the fluent add-on model was used to apply a magnetic field. In order to provide an external magnetic field with electric potential, a conductor was supplied. There were measurements of local convective heat transfer in both the presence and absence of magnetic fields. Heat transfer augmentation was explored in the Reynolds number range of 250-800. B=500 G was used to maintain a steady external magnetic field strength. To boost the heat transfer rate, the flow pattern must be disrupted and flow redirected. Ferro fluid was shown to react to external magnetic fields. The rupture of the thermal boundary layer and the velocity boundary layer occurs when a constant magnetic field is applied. This increases the heat transfer rate. Flow recirculation happens when a magnetic field is constantly applied. The rupture of the thermal boundary layer and the enhanced mixing of the flow imply a considerable improvement in the heat transfer rate..

Keywords: Ferro fluid

I. INTRODUCTION

There are several applications for heat exchangers, from power plants to transportation vehicles to heating systems to electronic devices to spacecraft. All of these applications might save money, space, and resources by increasing the efficiency of heat exchangers. As a consequence, many studies have been conducted in the past to discover ways to increase the efficiency of heat exchangers. These analyses take into account the thermal conductivity, flow arrangement, and high-effective heat transfer surfaces made from high-conductivity materials. For both single-phase and two-phase heat transfer, effective heat transfer procedures have been established. This work is the only one to look at single-phase forced convection techniques. Scientific papers and reports are published in a range of bibliographic reports, reviews, monographs and edited texts every year. Passive and active methods are the most prevalent ways to organise the heat transfer improvement strategies documented in the literature. Tubes play an important role in a wide range of heat transfer applications, from cooling gas turbine blades in power plants to electronic components in computers and, most recently, hot water in central heating boilers. For a long time, tubes have been utilised for this purpose. As a consequence, twisted tape flow studies have attracted a wide range of scientists and engineers. It is possible to improve the efficiency of a heat transfer system by using the heat transfer enhancement strategy. As the price of energy and materials has risen in recent years, more and more work has been put into developing heat exchange equipment that is more efficient. Building a heat transfer is the most critical step in reducing the amount of energy needed to pump the heat. An increasing focus is being placed on heat exchanger heat transfer growth in the design process. Enhancement techniques boost convective heat transmission by decreasing the heat exchanger's thermal resistance. There are a variety of ways to increase heat transfer. Passive, active, and compound are the three sorts of methods. Passive Inserts and additional devices, which modify the flow channel's surface or geometry, are prevalent in technique. A spike in fluid pressure drop is caused by the use of these techniques, which do not need external power sources but instead pull power from inside the system. A larger heat transfer coefficient may be achieved by altering or disrupting the flow behaviour. Passive heat transfer enhancement methods include treating surfaces, roughening them up, expanding them, and adding inserts. Mechanical assistance, surface vibration, fluid vibration, electrostatic fields, suction, and jet impingement are examples of active heat transfer methods. It is possible to produce a greater increase in heat transfer when two or more methods are used in combination, rather than one method alone.

Heat Transfer Mechanism.

When we mention "heat," we're referring to the ability of temperature variations across systems to transfer energy. Work and other kinds of energy may be utilised to determine how much heat energy is transferred throughout the system, according to the first law of thermodynamics. Research in heat transfer focuses on determining the rate at which heat energy moves. Heat may be transferred by any of these three mechanisms: conduction, convection, or radiation. All routes of heat transmission need a temperature differential, and all modes are from a hot medium to a cold one. Detailed descriptions of each modality are provided below.

Explanation: Conduction occurs when a single portion of an object gets heated. The rate at which heat is transferred from the heated to the unheated region depends on the material's temperature difference and thermal conductivity (k). Electricity can flow through all types of matter. Accidental collisions and diffusion are the result of molecular mobility in gases and liquids, and these processes are what lead to conduction. Molecule motions and free electron energy transfer are responsible for the occurrence in a lattice.

One of the most popular methods of transferring heat energy is by convection. Convective heat transmission in a system is caused by both molecular mobility and bulk fluid motion. It is possible to classify convective heat transfer into free or spontaneous convection and forced convection. In natural convection, buoyant forces generated by temperature variations cause the movement of a fluid. Consider the free convection heat transport in a vertical array of circuit boards. Parts become heated and lose density as the air comes into contact with them. Forces from the outside world are used to produce flow. Via a fan to cool hot electrical components on printed circuit boards using forced convection air is an excellent example of this kind of technology. Convectional heat transfer is described by Newton's law of cooling.

II. OBJECTIVES

The following goals will be used to carry out the project.

• Using an in-tube system to investigate heat transfer coefficients and pressure drops Ferro fluid heat exchanger. Ferro fluid heat transfer rate in the presence of a magnetic field is being investigated.to investigate the influence of twisted tape and magnetic fluid on the rate of heat transfer in the presence of a magnetic field When a magnetic field is varied, the pressure decrease may be studied. Inflow circumstances typified by a Reynolds number of 700-1000 will be explored in these setups. Water will be delivered at a steady temperature during this research by using an inner tube. Computational fluid dynamics (CFD) will be used as well as an experimental method in the study.

III. LITERATURE REVIEW

In a ferro fluid, ferromagnetic nanoparticles are suspended in a non-magnetic liquid that is non-magnetic. It has been studied since the 1930s, but in the 1960s and 1970s, when magnetic fluids became commercially viable, the research into their magnetic characteristics really took off (Elmore 1938). (Bashtovoy & Vislovich 1988). For example, Rosensweig (1979), Bashtovoy & Vislovich (1988), Blums et al. (1989), and references thereto, exist today on the characteristics of Ferro fluids. There is no net magnetization in Ferro fluids if the magnetic moments of individual particles in the fluids are not aligned. Consequently, they are commonly referred to as "super paramagnets" instead of "Ferro magnets" (Albrecht et al. 1997). A magnetic field causes them to align themselves along that field, and this results in the fluid being magnetised. The intensity of the applied field, as well as the surrounding temperature and concentration of magnetic particles, all influence the degree of magnetization. A magnetised fluid will flow toward areas with a greater magnetic field under the influence of the increasing Kelvin force. Only the thermal and magnetic fields will be evaluated in this research since the concentration of magnetic phase is anticipated to stay constant. The Soret effect or solid particle thermophoresis-induced magnetic fluid segregation might support such an assumption if the typical timeframe of interest convection flows is substantially shorter than the magnetic fluid segregation (Shliomis & Smorodin 2002). As a result, we may conclude that the magnetic susceptibility of the fluid, which is the ratio of fluid magnetization to the applied magnetic field, has no effect on the Ferro fluid magnetization. Ferro fluids are paramagnetic, therefore they follow Curie's rule and become less charged at increasing temperatures, as Curie's law dictates. A Ferro fluid's magnetic buoyant force is triggered by temperature variation, resulting in fluid movement known as convection. Convection is a key mechanism of mass transmission in fluids, as well as a major sort of heat transfer. Thermodynamics of convection Using a linear stability analysis of the Naiver- Stokes equations complemented with Maxwell's equations and taking into account the magnetic body force, Huang et al. (1997) investigated the thermos convective instability of an unbounded no conducting horizontal layer of paramagnetic fluid heated from below under a uniform oblique magnetic field. When the axes of the convective rolls are aligned parallel to a horizontal component of the magnetic field, convective instability is triggered. In the case of high critical wave numbers, Russell et al. (1999) studied the structure of two-dimensional vortices in a thin layer of a magnetised ferromagnetic fluid heated from the top. Belyaev and Smorodin (2010) studied the linear stability of a convective flow in a flat vertical layer of ferrimagnetic fluid under a transverse temperature gradient in a uniform magnetic field perpendicular to the plates, and presented a nonlinear asymptotic description of the vortex pattern that occurs directly above the critical point in the parametric space where instability first sets in. This study examined three-dimensional disturbances and their effects on the stability of flow. The stationary and two wave modes originally described by Suslov et al. were verified by the authors (2008). Thermomagnetic waves may occur across a broad range of values of the magnetic susceptibility, Prandtl number, and Langevin parameter. This huge wavenumber was discovered by Suslov et al. (2008), and the top and lower borders of the Prandtl number interval were identified. Thermal convection patterns in a vertical differentially heated layer of no conducting ferromagnetic fluid under an external uniform transverse magnetic field have been studied theoretically and empirically by Suslov et al. (2012). Suslov et al. predicted oblique thermomagnetic waves, which the authors studied experimentally and found to be true (2008). There are three main kinds of instability that are caused by thermos-gravitational and magnetic processes. To help guide future experiments, the physical nature of all three modes is examined in great depth, and the most conspicuous aspects are highlighted. Detected convection patterns' wavenumbers were found to be strongly affected by the magnetic field and the layer's temperature differential. Quantitative criteria were proposed to identify when thermomagnetism and thermogravitational processes take the lead in causing a flow instability, using the disturbance energy balance analysis. Grashof and magnetic reconnection were discovered to cause such a transformation. Similar in size as Grashof numbers

Inquiry into Experiments

The air generated by the high-velocity fan will be directed via the cylinder, which will be situated within the duct. It is planned to introduce a stream of low-temperature, high-pressure air into the chamber by way of the holes in the surface. As a direct consequence of this, the flow path heater has been switched on in order to provide the required thermal energy. Monitoring the temperature data will be done in order to determine the conditions that constitute the steady state (Ts, Tc, Ti). • Once the conditions have returned to their normal state, the relevant measurements will be recorded. If any more modifications are made to the temperature of the fluid or the flow velocity of the fluid, STEP iv will need to be repeated. Analyses and comparisons of the outcomes. Experimentation and computational fluid dynamics (CFD) data will be used to study the heat transfer away from a cylinder's surface. Because of the thermal qualities that ferro fluids possess, they have been proposed as a new kind of working fluid for use in industrial applications. Convective heat transport in Fe3O4-Ferofluid 66 was the topic of investigation in this paper. In order to evaluate ferro fluid in a magnetic field ranging from 0 to 500 G, CFD is used. The ferro fluid in varied volume fractions (1-4 percent) and the ferro fluid 66 make up the operating fluids for a parabolic trough solar collector (the base fluid). Following the application of theoretical discoveries to the evaluation of numerical analysis, a further in-depth examination is carried out to identify the influence that the magnetic field has on a variety of factors. By adding a magnetic field to the collector tube, it was discovered that it was possible to produce an increase in the collector output temperature, as well as an increase in the heat transfer coefficient and thermal efficiency. It was also shown that increasing the magnetic field strength and the nanoparticle volume % in the base fluid improved collector performance. Examples of include hydropower, solar power, and wind power.

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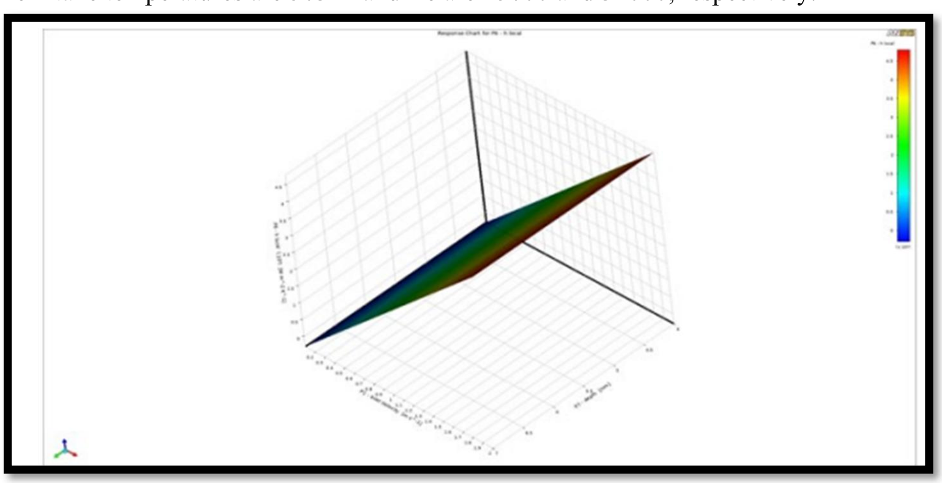
The Scientific Process of Experimentation

A total of six unique tube designs were manufactured and put through their paces for each of the five various Reynolds values. A U-tube manometer was attached to the inlet and outlet of the test section so that the difference in pressure that was experienced at the inlet and exit could be measured. The difference in the head of the U-tube manometer is what is utilised to determine the decrease in pressure. The data taken with the manometer were used in the calculation of the pressure drop for each Reynolds number of tubes. The data provide the basis for an estimate of the mean temperature of the fluid (i.e., surface temperature and fluid temperature). Two examples of water attributes are the density and the thermal conductivity of the water. We are able to calculate the dynamic viscosity of the fluid by using the average temperature of the fluid. The final calculations were completed by utilising the observations of the pressure drop and the heat transfer coefficient.

IV. RESULTS AS WELL AS COMMENTS ON THEM

In order to solve the governing equations, ANSYS Fluent is used. In order to investigate the effect that a magnetic field has on the hydrothermal characteristics of a fluid, a model with a single phase is utilised. The modelling of the heat transfer inside the receiver tube makes use of a three-dimensional steady state turbulent k– RNG model as well as standard wall functions. Excellent predictions may be obtained for a pipe using the RNG-derived k-model when non-equilibrium wall functions are used. The SIMPLEC solution technique and the k– RNG turbulence model have both been changed as a direct consequence of this so that they may be used with the parabolic trough receiver setup. In order to solve equations involving motion and energy, the upwind second-order differencing method is used. When solving equations involving motion and mass, the convergence limit is set at 103, whereas when solving equations involving energy, it is set at 106. The Ferro fluid properties and the magnetic field effects are added to the simulation with the help of a user-defined function code that was created in the C programming language. In this step, the mesh sensitivity of the receiver tube is analysed, and the thermal efficiency of the solar collector is calculated for a number of different meshes. Table 2 presents the results of a study of the mesh's sensitivity performed with a smooth absorber and an input temperature of 2300 degrees Celsius. It has been determined that a discretization with around 4.5 million cells is suitable for use. As was said before, the ferro fluid is used as the working fluid in volume fractions of 1 percent, 2 percent, and 4 percent respectively. A wire that carries an electric current and is located close to the collecting tube may be used to magnetise nanoparticles. The base fluid, Therminol 66, has the temperature and velocity illustrated in Figure 4 for its departure when the intake temperatures are 503 K and Re are 15000 and 31000, respectively.



Comparison of heat transfer coefficient

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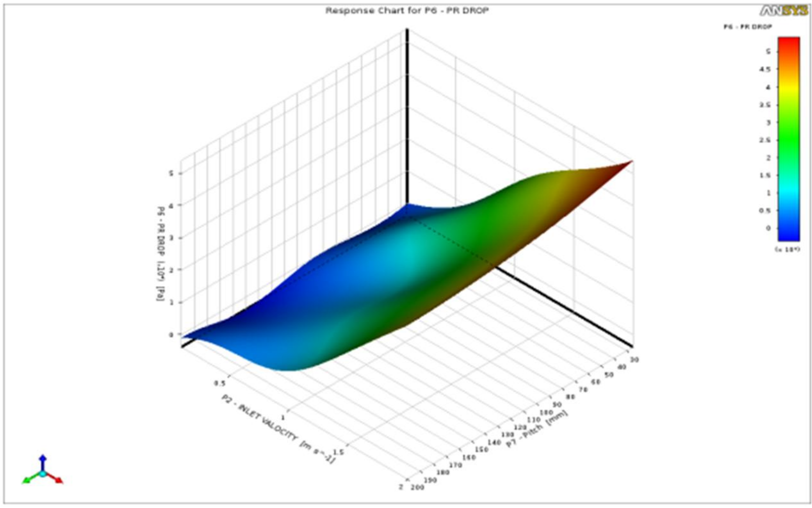
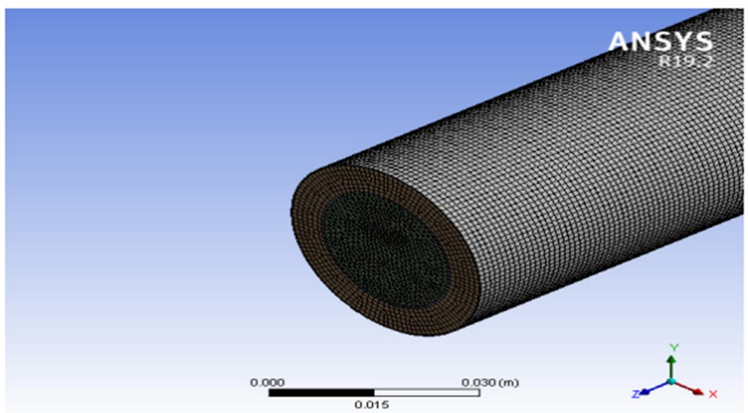


Comparison of Pressure drop different flow rate



V. CONCLUSION

This study studied how the performance of a heat exchanger is impacted by the presence of Ferro fluid and magnetic fields. The investigation was carried out by numerical simulations in ANSYS FLUENT. The working fluid consisted of varying volume percentages of the base fluid, which was called Fe3O4- Ferro fluid. In order to validate our hypothesis further, we gathered data in conditions in which the magnetic field of the collecting tube was present as well as under conditions in which it was not. Extensive research has been carried out on how the presence of a magnetic field affects the rate of convective heat transfer, the thermal efficiency, and the performance of collectors. The results suggest that increasing the number of buried nanoparticles in the base fluid might increase the heat transfer coefficient (HTC) of heat exchangers. There is a possibility that the HTC might be raised by simultaneously raising the volume proportion of nanoparticles. A recent research shown that the application of a magnetic field results in an increase in the local heating capacity (HTC), output temperature, and thermal efficiency of the collector tube. When a magnetic field of 500 G was applied, the best results were obtained by utilising ferro fluid at a concentration of 4% volume percent; this finding demonstrates the significance of ferro fluid as well as magnetic field in enhancing collector performance. In the absence of a magnetic field, the flow pressure drop and friction factor have their lowest values for Ferro fluid with a volume percent of 1 vol percent. These results are equivalent to those that were found in the literature.

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REFERENCES

[1]. Khosravi, R. N. N. Koury, L. Machado, and J. J. G. Pabon, “Energy, exergy and economic analysis of a hybrid renewable energy with hydrogen storage system,” Energy, vol. 148, no. C, pp. 1087–1102, 2018.

[2]. Khosravi, R. N. N. Koury, L. Machado, and J. J. G. Pabon, “Prediction of hourly solar radiation in AbuMusa Island using machine learning algorithms,” J. Clean. Prod., vol. 176, no. C, pp. 63–75, 2018.

[3]. Khosravi, L. Machado, and R. N. Oliviera, “Time-series prediction of wind speed using machine learning algorithms: A case study Osorio wind farm, Brazil,” Appl. Energy, vol. 224, no. C, pp. 550–566, 2018.

[4]. M. Faizal, R. Saidur, S. Mekhilef, and M. Alim, “Energy, economic and environmental analysis of metal oxides nanofluid for flat-plate solar collector,” Energy Convers Manag, vol. 76, pp. 162–168, 2013.

[5]. U.S. Energy Information Administration Office of Integrated Analysis and Forecasting, “International Energy Outlook,” 2016.

[6]. Fernandez-Garcia, E. Zarza, L. Valenzuela, and P. M. Erez, “Parabolic-trough solar collectors and their application,” Renew Sustain Energy Rev, vol. 14, no. 7, pp. 1695– 1721, 2010.

[7]. E. Kaloudis, E. Papanicolaou, and V. Belessiotis, “Numerical simulations of a parabolic trough solar collector with nanofluid using a two-phase model,” Renew. Energy, vol. 97, pp. 218–229, 2016.

[8]. S. Kalogirou, “The potential of solar industrial process heat applications,” Appl. Energy, vol. 76, no. 4, pp. 318 337–361, 2003. 319

[9] V. V. Wadekar, “Ionic liquids as heat transfer fluids – an assessment using industrial exchanger geometries,” Appl. Therm. Eng., vol. 111, pp. 1581–1587, 2017.