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Biosynthesized zinc nano fluid for helically coiled heat exchanger at constant heat flux

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Abstract

Spinach fresh leaves have been utilized in the biosynthesis of zinc nanoparticles, just as the arrangement of nano fluid. The biosynthesized nanofluid in a helical loop heat exchanger was studied for heat transfer rate and discussed the effects of Nusselt number, heat transfer coefficient and friction factor at research facility of NIT, Raichur. The di-ionized fluid flowing through the helical coil is kept at constant temperature of 60°C and biosynthesized zinc nanofluid flows through the shell side and the inlet temperature is maintained at 32°C. A dean number in the range of 1000–3000 for laminar flow and 3000–8000 for turbulent flow was set to lead investigate at shell side. A heat transfer examination has been done considering stream rate, heat transfer coefficient, and thermal performance factor. The results of di-ionized fluid and biosynthesized nanofluid has been compared and validated with the equations proposed by other researcher.

Introduction

Energy is important to do our day to day activities, 70–80% of energy that we are utilizing are delivered form of heat energy. Hence heat exchanger assumes a fundamental part for heat transfer among liquid and liquid or liquid and solids. Various kinds of heat exchanger are accessible where heat transfer takes place with or without direct contact of liquid. In most heat transfer applications, optimizing the heat transfer capacity is basic challenges. The heat exchangers have gained major concentration on working principle and there is consistent advancement in further enhancing heat transfer rate. In earlier heat exchangers the lower heat transfer coefficient liquids were utilized in these frameworks. An answer for conquer this issue is replacing the regular liquids with nano liquid. As the concentration of nanoparticles to working fluid increases, the heat transfer properties of the working fluid is found to be enhanced. In view of issues with Nano size molecule suspension, Nano particles have been utilized relying upon their heat transfer capacity. In numerous modern frameworks, heat should be transferred either to into a framework [1]. Numerous endeavors have been made to upgrade heat transfer rate of heat exchanger. These endeavors usually incorporate active and passive strategies like making rough surface, increasing the contact surface area or the utilization of a fluid with higher thermal conductivity properties [2]. As one of the passive method to upgrade heat transfer techniques is helical cylinders and have been broadly utilized in many fields such as synthetic industry, power transformation, food processing industry, pharmaceutical industry, squander heat recuperation, cooling, and refrigeration. Dean [3] was the primary scientist who worked on helical coil heat exchanger. He presented a dimensionless boundary named Dean

number, which could describes the stream in helical coil heat exchanger. Dravid et al mathematically researched the impact of auxiliary stream on laminar stream heat transfer in helically coiled tubes both in the completely evolved area and in the warm passage one. They introduced a connection for the asymptotic Nusselt number. Manlapaz and Churchill [6] proposed two dependable relationships for the friction factor and the Nusselt number for the completely evolved laminar convection in the helical coil with the consistent heat transfer. Liu et al. [7] conducted experiments on helical coil heat exchanger and provided mathematical correlation (Nusselt number) for heat flow through the test section. Huttl et al. [8] study on the impact of helical coil for an incompressible fluid flow using Navier stroke equation. Thermal conductivity is high in this combination, helpless suspension steadiness, erosion, clotting, and slight enhancement in friction factor, pressure drop are some of the burdens of this framework [10]. Adding nano particles to liquid was first proposed by Choi [11]. Contrasted with ordinary suspension, nanofluids show better thermophysical, rheological properties, higher thermal conductivity, and no considerable pressure drop [12]. Akbarinia and Behzadmehr [17] laminar flow convective heat transfer using nanofluid in helical coil heat exchanger showes the positive heat transfer upgrade. Hashemi [19] characterized new boundary execution list to assess the general presentation of the two improved heat transfer techniques with CuO nanoparticles and oil. Akbaridoust et al. [20] researched Pressure drop and the convective heat transfer conduct of nanofluid in helically coiled tubes under consistent divider temperature utilizing both mathematical and trial systems. They utilized both homogeneous and dispersion models for their mathematical methodology. Bahremand et al. [22] considered the laminar and turbulent flow inside the helical coil under consistent heat transition. Derived the correlation for Nusselt number both mathematically and experimentally (see Tables 1 and 2).

As it was surveyed, pressure drop and the convective heat transfer conduct for bio synthesized nanofluid in helical coil heat exchanger at a steady heat motion were not examined. Convective heat transfer of water–zinc nanofluid in helical cylinders, under constant heat flux condition, with different volume concentration is examined.

Helical looped tubes have been demonstrated to be better than straight cylinders in a couple of studies. Bended cylinders have been proposed as a technique for further developing heat transfer and are generally utilized in various heat transfer applications. We utilized a helical coil heat exchanger for this examination. Nano fluids are colloids comprised of nano-scale particles and a base fluid. They were considered in view of their upgrades in base-fluid heat transfer capacity properties. It showed that adding a limited quantity of nanoparticles (under 5% by volume) to standard fluid enhances the thermal conductivity of the fluid by around multiple times. The utilization of bio Nano liquid would be a stage toward eco-friendly (see Figs. 1 and 2).

Section snippets

Broth extraction

Take spinach fresh leaf, the fresh leaves are thoroughly rinse with deionized water and cut into small pieces. Then the chopped leaves are dried in solar tunnel. The dried leaves are further reduced to power form using pulveriser. Using sieves the diameter of the particle is in the range of 20–40 nano meters. Then the 5 g of uniformly sized power is taken into a beaker along with 100 ml of ethanol and kept the solution for 24 h. The obtained solution is filtered with double filtration (Whatman…

Validation

The experimental setup is validated with David & Roger equation for heat transfer study. Experiment was conduct with DI-water under laminar and turbulent flow condition i.e. Dean Number is in the range of 500–8000. The experimental results were compared with the theoretical values given by David & Roger equation it was found that they were in good agreement. Comparison of experimental values with David & Roger equation is shown in Figs. 8 and 9.

Experiments were conducted using nanofluid i.e.…

Conclusion

An experimental investigation has been carried out to study the heat transfer and Friction Factor characteristics of Zn/DI water nanofluid in a helical coil heat exchanger by using varied range of particle volume concentration (0.01–0.05%).

The use of zinc nanoparticles has increased the heat transfer rate without significant increase in pressure drop.

The Nusselt number increases with increase in Reynolds number and nanoparticles concentration. This is due to the thinning of the boundary layer…

CRediT authorship contribution statement

H. Ravi Kulkarni: Methodology, Validation, Formal analysis, Investigation, Writing – original draft. **C. Dhanasekaran:** Project administration, Supervision. **P. Rathnakumar:** Project administration. **S. Mohamed Iqbal:** . **S. Sivaganesan:** Project administration.…

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.…

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Upgrading the performance of shell and helically coiled heat exchangers with new flow path by using TiO<inf>2</inf>/water and CuO–TiO<inf>2</inf>/water nanofluids

2022, International Journal of Thermal Sciences

> *Citation Excerpt :*
> …Sepehr et al. [80] simulated overall characteristics of a fin integrated SHCHE and calculated mean Nusselt number as 125. Kulkarni et al. [76] utilized biosynthesized zinc nanofluid in a SHCHE at different working conditions and Nusselt number obtained approximately between the range of 25–240. In addition, Noorbakhsh et al. [81] designed a new geometry for coil side of a SHCHE and achieved Nusselt number approximately between 30 and 70.…

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