CFD Simulation With Ansys Effect Of Twisted Tape Ratio On Nusselt Number and Reynold Number Solar Collector

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Abstract— Solar collector is one of the tools used to harness solar power and then convert it into heat which is used to heat water. The solar collector used is a flat plate type solar collector, the drawback of this solar collector is its low efficiency value. One method that can be used to increase its efficiency is to add twisted tape. Twisted tape serves to increase the value of the nusselt number and reynold number, where the increasing nusselt number and reynold number means the efficiency will increase, the Twisted Tape Ratio is the ratio between the distance of two peaks (H) and the width of the pipe (D). In this study using three variations of the tape ratio, namely 5,4, and 3, at Y = 5 the highest nusselt value and the Reynold number 4000 and Nuselt Number 24 were used, this is because the Twisted Tape ratio is 4 and 3 forms of twisted tape inhibit the flow. which causes a decrease in the value of the nusselt number and reynold number.

Keywords— Nusselt Number, Reynold number, Solar Collector, Twisted Tape, Twisted Tape Ratio

I. Introduction

The increasing world population causes high energy needs, but the availability of energy from time to time is running low which causes the earth to be in an energy crisis. We can handle this energy crisis, one of which is by utilizing what is available around us as energy that will not run out or commonly called renewable energy, one of the renewable energies is sunlight or solar energy. In some countries, especially countries that receive sunlight throughout the year, have begun to use solar energy as renewable energy. This solar energy is usually utilized by converting solar energy into electrical energy and heat energy, one of the uses of solar energy is a solar collector or solar collector. [7]

Solar collector is a tool that utilizes solar power as a water heater by absorbing radiation from the sun and distributing it in a liquid fluid. Stationary system solar collectors are permanent or fixed in position and do not track the sun. There are three main types that fall into the category of collectors, the first Flat-plate collector (FPC), the second Stationary compound parabolic collector (CPC) and the third Evacuated tube collector (ETC). It consists of a wide glass plate and a tube filled with fluid that circulates to transfer the heat absorbed by the glass plate to the outlet. For example, it is used to heat water [1]. The heat transfer fluid can be water or another non-freezing fluid if the FPSC is used in cold areas. The liquid used must have a very low freezing point so as not to freeze in the system if the FPSC is used in cold regions. The amount of heat that is not bound to the fluid causes the low outlet temperature of this pipe to be one of the drawbacks of this device. [4] The method used to increase the rate of heat transfer in solar collectors, one of which uses nanofluids [5] magnetic field phase change materials, turbulators, and twisted tape [13-15].

Improved heat transfer efficiency by using the integration of the twisted tape inside the tube and the FPSC riser creates a vortex flow inside the tube, which increases the circulation of the heat transfer fluid between the tube wall and the center of the tube [8], increased flow path of the fluid through the pipe, which accelerates the rate of heat transfer [10] reduction of the thermal boundary layer near the tube wall the thickness of the thermal boundary is inversely proportional to the rate of heat transfer, the provision of this Twisted tape aims to increase the value of the heat transfer rate [7] and fins in a cross section perpendicular to the direction of the tube length affect the rate of heat transfer on the flat plate [11].

FPSC The desired optimal conditions to get the highest Nusselt value, maximum thermal, and solar efficiency at the lowest friction factor value in the geometric design of the Twisted tape must be maximized. therefore for the heat transfer coefficient (h) using Newton's law of cooling. [6] :

$$h = \frac{Q}{A(T_s - T_b)} \qquad (1)$$

Where Q is the convective warmness switch coefficient, A is the floor vicinity over which warmness switch occurs, Tb is the majority temperature of the fluid, the common temperature among the inlet and outlet fluid temperatures, and Ts is the common floor temperature of the fluid. The Nusselt variety is decided by [**3**]:

$$Nu = \frac{hD}{k} \qquad (2)$$

where k is the thermal conductivity of the fluid flow and D is the hydraulic diameter of the channel. Note that the pressure through the heat exchanger drops through operation. The apply of heat transfer enhancers and heat transfer methodology can increase pressure drop and friction coefficients, effect with higher heat transfer coefficients. The coefficient of friction, which describes the pressure drop across the sample of fluid flow in one channel, is given by:

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$$f = \frac{\Delta P}{(L/_D)x(\frac{\rho U^2}{2})} \quad (3)$$

where ΔP is the line pressure drop, U is the average velocity and density of the liquid flow, and L is the line spacing. The efficiency of a solar module can be determined using the Hottel-Willier-Bliss equation. [12], This helps in designing, developing and testing the performance of flat plate collectors. The collector efficiency takes into account the following factors: the flat glass component, the temperature difference between the input medium (Ti) and the environment (Ta), and the total solar radiation available to the collector. [7]:

$$\eta = F_R\tau\alpha - F_R U_L \frac{(T_1 - T_a)}{G_T} \quad (4)$$

Where F_R is the heat dissipation coefficient, U_L is the total solar collector heat loss coefficient, and G_T is the total solar radiation and absorption transmission coefficient. Ignoring the second term in the equation, we arrive at the efficiency of the solar collector.

Thermal Power Factor The simultaneous use of an intensifier and a turbulator increases the heat transfer coefficient, increases pumping capacity and pressure loss. The thermal figure of merit parameter shown below quantifies the increase in heat transfer coefficient with respect to pressure drop due to secondary flow and turbulent region [2]:

$$\xi = \frac{Nu/Nu^{\circ}}{(f/f^{\circ})^{1/3}} \quad (5)$$

where Nu∘ and f∘ are the Nusselt number and the coefficient of friction, respectively, for an unflexed ligament system. Nusselt number, coefficient of friction, and efficiency of solar panels are very sensitive to various parameters, including geometric properties and fluid flow parameters. Powerful simulations are required for a deep understanding of the behavior of energy systems.

II. METHODS

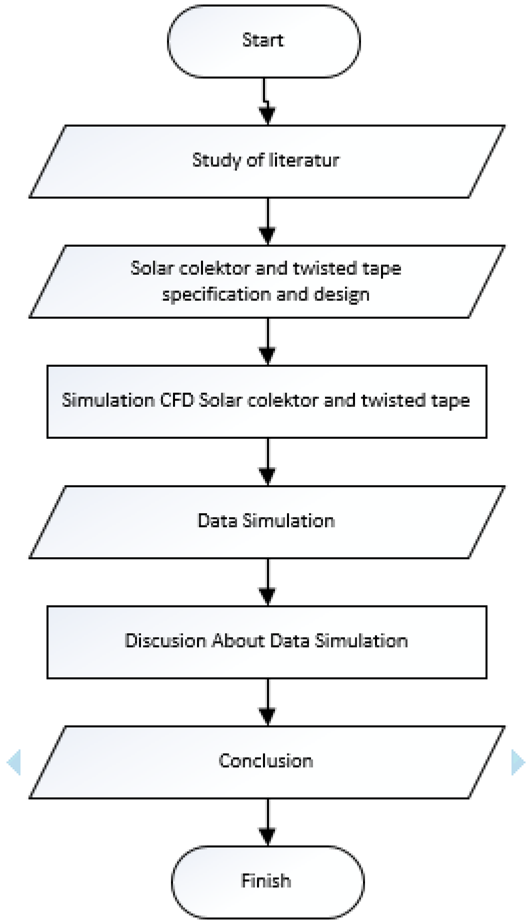

Fig.1. Reserch Flowchart Simulation CFD flat plate with Twisted Tape

In this study, we aim to evaluate the thermal performance of an aluminum flat plate collector in a water flow configuration, given twisted bands with varying band ratios, by CFD simulations. His FPSC computational geometry of the latter design provides multiple passages for the air ducts between the absorber plate and the bottom of the collector. This is intended to increase the heating time of the working medium in the collector and thus ensure maximum heat transfer from the absorber. plate. A flow test is performed to analyze the type of flow formed for a simulation application.

The system considered in this study is a flat plate solar collector model with a flat plate solar collector structural scheme. Solar collectors are applicable with curved strip inject to increase the heat transfer rate within the tubes. The aluminum insert is 1mm thick and 9mm wide. A free space of 1 mm is built into the measuring section so that the insert can be insert into the tube. Three flexible band ratios (Y): 5, 2.5, and 1 are designed in ANSY software. The collector is insulated with rock wool pads on the sides and bottom.

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III. Results and Discussion

The results of the CFD simulation using ANSYS software produce a flow simulation where there is a nusselt number and a Rynold number where the variable used is twisted tape ratio (Y), where the twisted tape ratio used is Y=5, Y=4, and Y=3 . And the results obtained from the CFD simulation are as follows:

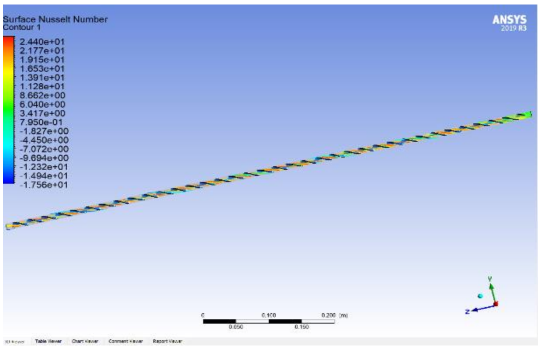

Fig.2. Nusselt Number Y=5

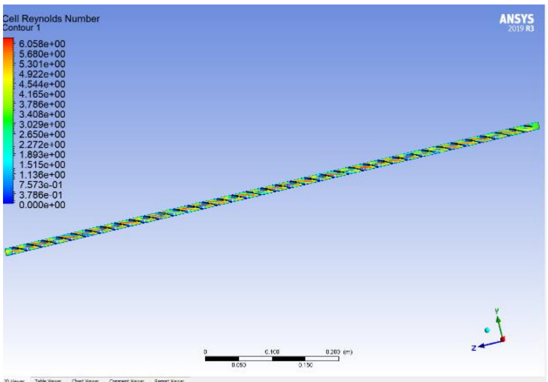

Fig.3. Renold Number pada Y=5

Fig. 2 and Fig.3. that the Reynolds Number at Y=5 is with the highest value of 6000, for Nusselt Number it is at 24 at the highest value while for the simulation with a tape ratio of Y=4 as follows

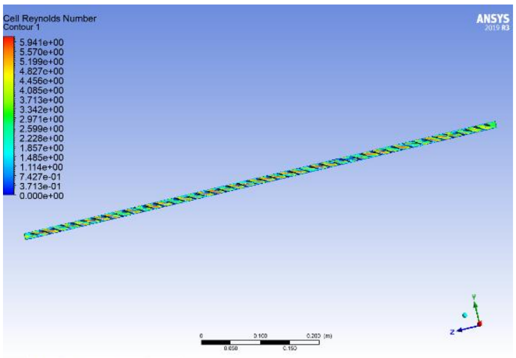

Fig.4. Nusselt Number Y=4

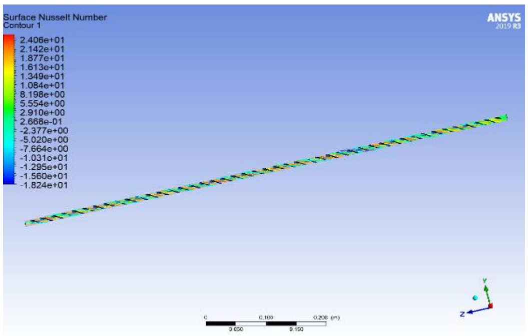

Fig.5. Renold Number pada Y=4

Fig.4 and Fig.5. that the Reynolds Number at Y=4 is with the highest value of 4000, while the Nusselt Number is 16 at the highest value. This value is smaller than Y=5, for simulations with a tape ratio of Y=4 as follows:

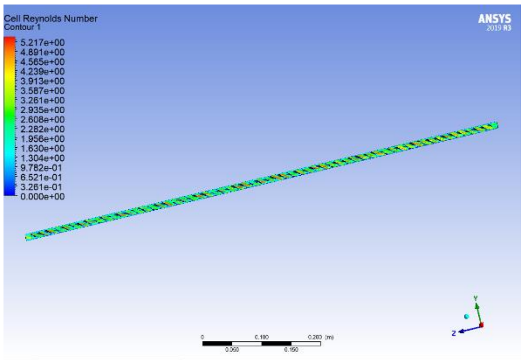

Fig.6. Renold Number pada Y=3

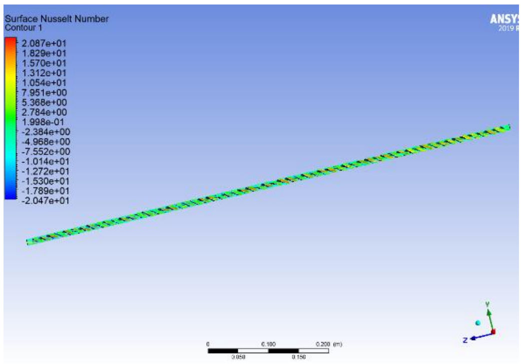

Fig.7. Renold Number pada Y=3

Fig.6 and Fig.7, it can be seen that the Reynolds Number at Y=4 is the highest value of 2900, while the Nusselt Number is 12 at the highest value. This value is smaller than Y = 5, we can know from the simulation results using ANSYS that the highest Nusselt Number and Renold Number values are found in the Twited Tape Ratio of 5.

IV. Conclusion

The application of twisted tape on a solar collector falt plate is able to increase the value of the nusselt number and Reynold number, this increase is highest at the Twited tape ratio (Y) value of 5, this is because the increase in flow velocity that occurs due to the addition of twisted tape this

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increase also results in increase in solar collector efficiency. at Y= 5 it produces the highest nusselt value and reynold number 4000 and nuselt number 24 where this is because the Twisted Tape ratio is worth 4 and 3 forms of twisted tape inhibit the flow which causes a decrease in the value of nusselt number and reynold number. However, pressure drop and friction coefficient are at fairly low degree, while leverage to provide an all around optimization characterized by high Nusselt number, high solar efficiency, high thermal power factor and large temperature difference. There are still many factors.. So in the next research, it is expected to add other variables such as the thickness of the pipe and the type of material used by the pipe to determine the increase that can be generated from the addition of twited tape.

REFERENCES

[1] Alawi, O. A., et al. (2021). "Nanofluids for flat plate solar collectors: Fundamentals and applications." Journal of Cleaner Production 291: 125725.

[2] Bezaatpour, M. and M. Goharkhah (2020). "Convective heat transfer enhancement in a double pipe mini heat exchanger by magnetic field induced swirling flow." Applied Thermal Engineering 167: 114801.

[3] Bezaatpour, M. and H. Rostamzadeh (2020). "Heat transfer enhancement of a fin-and-tube compact heat exchanger by employing magnetite ferrofluid flow and an external magnetic field." Applied Thermal Engineering 164: 114462.

[4] Bezaatpour, M. and H. Rostamzadeh (2021). "Simultaneous energy storage enhancement and pressure drop reduction in flat plate solar collectors using rotary pipes with nanofluid." Energy and Buildings 239: 110855.

[5] Bezaatpour, M., et al. (2021). "Hybridization of rotary absorber tube and magnetic field inducer with nanofluid for performance enhancement of parabolic trough solar collector." Journal of Cleaner Production 283: 124565.

[6] Brahim, T. and A. Jemni (2021). "Parametric study of photovoltaic/thermal wickless heat pipe solar collector." Energy Conversion and Management 239.

[7] Mohseni-Gharyehsafa, B., et al. (2021). "Soft computing analysis of thermohydraulic enhancement using twisted tapes in a flat-plate solar collector: Sensitivity analysis and multi-objective optimization." Journal of Cleaner Production 314.

[8] Nakhchi, M. E. and J. A. Esfahani (2019). "Performance intensification of turbulent flow through heat exchanger tube using double V-cut twisted tape inserts." Chemical Engineering and Processing - Process Intensification 141.

[9] Nakhchi, M. E. and J. A. Esfahani (2020). "Numerical investigation of turbulent CuO–water nanofluid inside heat exchanger enhanced with double V-cut twisted tapes." [10]Journal of Thermal Analysis and Calorimetry 145(5): 2535-2545.

[10] Pourfattah, F., et al. (2021). "On the optimization of a vertical twisted tape arrangement in a channel subjected to MWCNT–water nanofluid by coupling numerical simulation and genetic algorithm." Journal of Thermal Analysis and Calorimetry 144(1): 189-201.

[11] Rezaei Miandoab, A., et al. (2022). "Numerical study of the effects of twisted-tape inserts on heat transfer parameters and pressure drop across a tube carrying Graphene Oxide nanofluid: An optimization by implementation of Artificial Neural Network and Genetic Algorithm." Engineering Analysis with Boundary Elements 140: 1-11.

[12] Sharafeldin, M. and G. Gróf (2018). "Experimental investigation of flat plate solar collector using CeO2-water nanofluid." Energy Conversion and Management 155: 32-41.

[13] Vengadesan, E. and R. Senthil (2020). "A review on recent development of thermal performance enhancement methods of flat plate solar water heater." Solar Energy 206: 935-961.

[14] A. J. Gannon and T. W. Von Backstro, "Solar Chimney Cycle Analysis With System Loss and Solar Collector Performance," J. Sol. Energy Eng., vol. 122, no. August, pp. 133–137, 2000.

[15] P. K. Nagarajan, J. Subramani, S. Suyambazhahan, and R. Sathyamurthy, "Nanofluids for solar collector applications: A review," Energy Procedia, vol. 61, pp. 2416–2434, 2014, doi: 10.1016/j.egypro.2014.12.017.

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