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CFD Analysis for the Variation of Velocity inside Different Types of Ribs

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Abstract: Heat exchanger is used to accomplish the industrial demand. Heat Exchanger are necessary for nuclear reactors and in chemical engineering, for of large quantity of heat is conveying in a slight space with high heat transmission rates and slight habitation time distributions even it suffers through a disadvantage of larger pressure drop. From my analysis, it is found that the uses of ribs inside the solar heat exchanger increase the heat transfer with increase in Reynolds number. Through analysis, it is also found that the value of heat transfer coefficient increases with increase in Reynolds number, heat transfer coefficient is maximum for rectangular shape rib in both the cases that are during using water and nano fluid as a working fluid. The average heat transfer coefficient ratio graph shows that rib used in the solar heat exchanger with nano fluid flow shows more heat transfer enhancement as compared to a solar heat exchanger with simple water flow. Overall it is found that rectangular shape ribs show more heat transfer coefficient as compared to other rib.
Keywords: Heat Exchanger, Ribs, Velocity vector, Reynolds Number, Solar, CFD.

I. INTRODUCTION

Over the past decade, experiments have been commonly performed and analyzed to confirm the importance of nutrients. It is clear that Nano Vento-based minerals are much more effective than traditional collectors. So it's clear that you can improve your regular collector just by adding Nano fluid. This is also observed in digital simulations, where increasing the nanoparticle fraction and tube length increases the average temperature and decreases it at a decreasing rate.

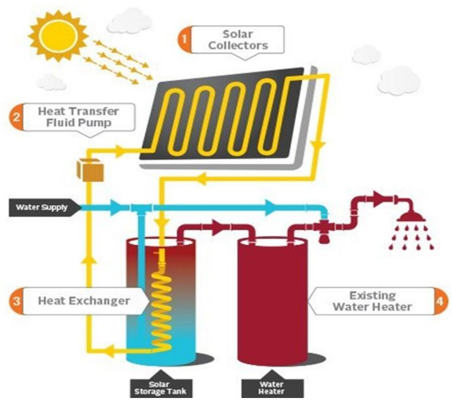

Fig.1 solar heat exchanger system

A. Benefits of Use of Nanofluids in Solar Collectors

Nanofluids make the accompanying benefits over regular fluid, making them reasonable for use in sunlight based gatherers: Sun oriented energy utilization will increment by reshaping the state of the mass and the amount of nanoparticles. The nanoparticles, which are suspended, increment the surface region, yet diminish the warm limit of the solids because of the little molecule size. Postponed nanoparticles increment the warming proficiency of the intensity move framework. The attributes of the fluid can be changed by changing the grouping of nanoparticles. Minuscule size of nanoparticles in a perfect world permits them to go through siphons. Nanofluid can be settled on utilizing optical (daylight retention and bringing down in infrared stream). The primary contrast between the customary gatherer and the Nano fluorine authority is standing out water is warmed. In the primary case, daylight is consumed from the surface, wherein case, daylight is straightforwardly consumed by working liquids (by sending radiation). While drawing closer, daylight communicates energy to nanofluid.

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B. Heat Exchanger and its Types

In order to discuss the various types of heat exchangers we need a basis for categorization. For this, generally two approaches are followed. The first one is based on the type of flow pattern within the heat exchanger, while the second is based on the type of construction of heat exchanger equipment. Both are considered here.

Classification According to Type of Flow

On the basis of type of flow configurations, these are of following types:

1) Counter Flow
2) Parallel Flow
3) Cross flow
4) Hybrids such as Cross Counter flow and Multi Pass Flow

Figure illustrates the mechanism of flow in counter current flow. This is because it can transfer most of the heat from the medium per unit mass. This type of flow pattern is considered as default for numerical problem formulation and calculations.

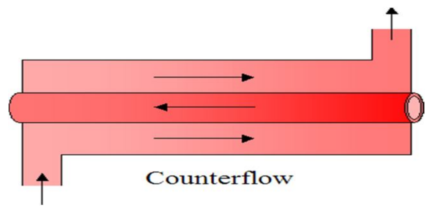

Figure 2 Counter flow.

In co current or parallel flow heat exchangers, both the streams flow parallel to each other and in the same direction as shown in figure. Though it is less efficient than counter current flow but it gives uniform average temperature differences.

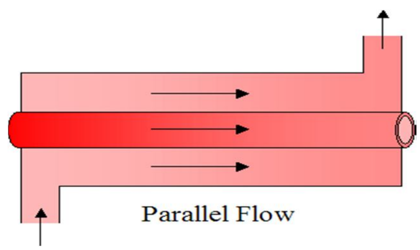

Figure 3 Parallel Flow.

In Cross flow heat exchangers, the streams flow perpendicular to each other as shown in Figure. Their efficiency lies roughly in between of the Parallel and counte flow heat exchangers.

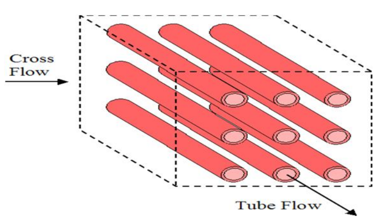

Figure 4 Cross Flow

Figure illustrates the hybrids of the above mentioned flow types. These are often found in industrial heat exchangers. Examples of these are combined cross flow heat exchangers and multi pass flow heat exchangers.

II.LITERATURE REVIEW

1) Omar Bait et.al (2021) In this paper, they had introduced an extensive outline of the job of nanofluids in many fields, particularly in sun based innovation by utilizing Pyramid sun oriented still. Advantages of utilizing nanofluids had been featured about their beneficial outcomes on working on the warm execution of sun based stills (direct sun oriented refining)

with OK difficulties. Without a doubt, this study showed that Nano liquids have important qualities in working on warm conductivity in correlation with base liquids which are liberated from any extra metal or metal oxide Nano-sized particles. An exploratory examination was conveyed by utilizing the numerical models and noticed the outcomes acquired by utilizing test. The results of result showed that there was areas of strength for in the middle between Nano grain sizes particles and expanded warm conductivity. Furthermore, this concentrate additionally researched the impacts of nanoparticle size, measure of nanoparticles, nanofluid solidness, and scattering methodology.

2) Andrey Yasinskiy et.al (2018) In this work, they had showed an examination of the properties of nanofluids in view of TiO2, for example, actual dependability and their intensity move coefficients. Nanofluids were ready with eutectic combinations of diphenyl oxides and biphenyls by adding nanoparticles of TiO2 and 1-octadecanethiol (ODT) nanoparticles, which were utilized as surfactants. Nanofluids were tried for their warm and actual properties like security, thickness and mass. The presentation of TiO2 nanoparticles, joined by an equivalent measure of ODT, showed an emotional expansion in the properties of fundamental intensity exchanger in a sun oriented power plant (CSP). There was a slight expansion in the thickness and vulnerability, which was something like 0.12% and 4.85%, separately. The warm properties improved essentially to 52.7% for isobaric explicit intensity and for warm conductivity up to 25.8%. So nanofluids in light of nanoparticles TiO2 had all the earmarks of being an effective option in contrast to HTFs at CSP processing plants.
3) Ahmed Kadhim Hussein et.al (2017) In this examination work, they had shown an outline of the most recent advances in the utilization of Nano-fluid in the intensity pipe sun powered gatherers. Here, Nanoparticles had distributed in essential liquid to increment daylight assimilation and to expand the productivity of sun oriented gatherer. It is prescribed to utilize carbon Nano horns (CNHs) as nanoparticles to upgrade optical properties of HPC (Intensity Line sun powered gatherer). This is because of their huge region and an enormous number of depressions. The consequences of inspected paper showed that the general act of HPC is the capability of the properties of nanofluids and other framework properties.
4) Ehsan Ebrahimnia-Bajestan et.al (2016) In this work, they had shown an imaginative way to deal with further developing the intensity move properties of the planetary group is the utilization of nanofluids as an intensity medium. In this review, the intensity move of the TiO2 fume of nanofluid water in view of the gas pipeline was researched through analyses and tests. So some alterations were brought into the twofold standard model, generally to get more exact appraisals of the qualities of the change in nanofluid heat. This altered model analyzed the impacts of convergences of particles, widths, iotas, and particles and fundamental solids on the intensity move paces of various quantities of Reynolds. The outcomes proposed that the single-stage strategy, even temperature-subordinate, relies upon temperature-subordinate temperatures, assessment of the exchange attributes of the intensity move of nanofluids. Moreover, two-stage electronic models neglected to foresee the precision of intensity move. The review inferred that the coefficient of intensity trade of nanofluids was higher than that of the primary liquids. Also, Reynolds numbers and particles fixations.
5) Alibakhsh Kasaeian et.al (2015) In this work, they had uncovered that the antagonistic impacts of human exercises on the climate stand out, particularly in worldwide temperatures. To battle environmental change, perfect and feasible wellsprings of energy should be grown quickly. Concentrates on in the space proposed that the utilization of nanofluids in the planetary group offers the main benefit over regular fluid. This article portrayed the utilization of nanofluids on different sorts of sun powered gatherers, sunlight powered chargers and nearby planet groups. Notwithstanding the colossal energy trade, the endeavors made on the ESS have been evaluated. In view of education, the better warming of nanofluid is the main reality, or to increment proficiency in the planetary group, however high hardness doesn't necessarily in every case increment productivity. The assimilation of nanofluids in measures of sun powered authorities diminishes the intensity obstruction of the connection point and lessens the distinction among temperature and intensity medium. Hence, high effectiveness is normal. The utilization of nanofluids in the nearby planet group is harmless to the ecosystem, for example, lessening CO2 outflows by expanding effectiveness and diminishing emanations during the time spent delivering nanofluid gatherers.

III. METHODOLOGY AND MATHEMATICAL MODEL USED

A. *Step to be Followed*

To accomplish the target of this work following step were occurred
1) Investigation of sunlight based heat move framework.
2) Investigation of various cycle boundaries of sun based heat exchanger on which the presentation of the intensity exchanger depends.
3) Advancement of CFD model of sun powered heat exchanger based on trial investigation of sun oriented heat exchanger .

4) Advancement of strong model of sun powered heat exchanger based on mathematical boundaries considered during the trial examination acted in base paper.
5) Computing the impact of progress in Reynolds number on heat move coefficient of intensity exchanger.
6) Computing the impact of various sorts of ribs utilized in sun oriented heat exchanger to increment heat move rate when water is utilized as a functioning liquid.
7) For examining the impact of various sorts of ribs utilized in heat exchanger here it considered five distinct kinds of ribs that is roundabout, three-sided, rectangular, circular and square shape ribs.
8) Additionally ascertaining the impact of Nano liquid utilized in heat exchanger to build the intensity move rate.
9) Contrasting the worth of intensity move coefficient for various Reynolds number for various kinds of ribs utilized in sun based heat exchanger during water streaming.
10) Looking at the worth of intensity move coefficient for various Reynolds number for various kinds of ribs utilized in sunlight based heat exchanger during Nano liquid stream.
11) Report planning.

B. *Objectives*

1) Playing out the CFD investigation of sun based heat exchanger and examining the impact of various cycle boundaries.
2) Finding the impact of various kinds of ribs utilized inside the sun based heat exchanger when water is utilized as a functioning liquid to increment disturbance inside the line.
3) Tracking down the impact of progress in speed on the presentation of intensity exchanger.
4) Tracking down the impact of purpose of ribs inside the intensity exchanger, when Nano liquid is streaming inside the cylinder.

C. *Development of Solid model of solar heat exchanger heat*

Solid model of solar heat exchanger depends on the geometric condition as considered in base paper the geometric parameters were shown in the below table

Parameter	Value
Tube inner diameter	7.8 mm
Tube outer diameter	9.6 mm
Tube length	2000 mm

Table 1 Shows value of geometric parameter of solar heat exchanger

On the basis of above mention geometric parameters of solar heat exchanger here we have developed the solid model of heat exchanger. The solid model f heat exchanger is shown in the below fig

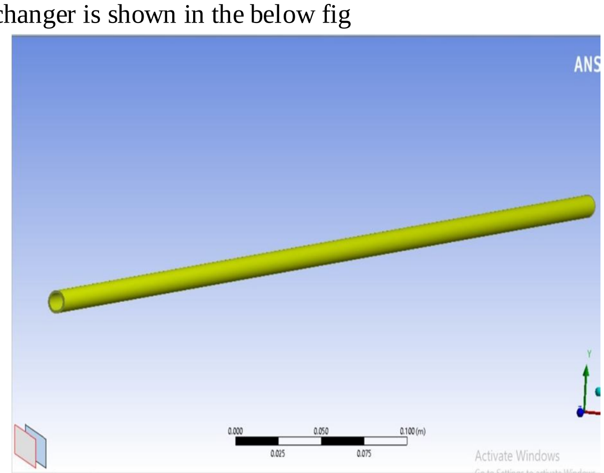

Figure 5 solid model of solar heat exchanger

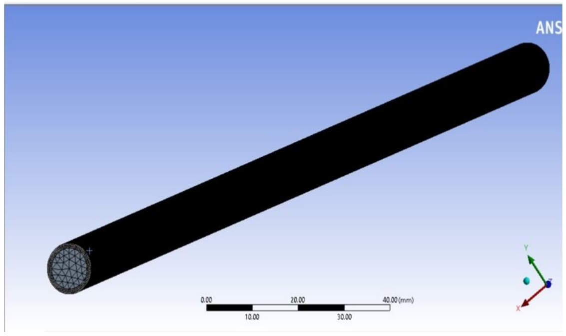

Fig.6 mesh of the tube heat exchanger

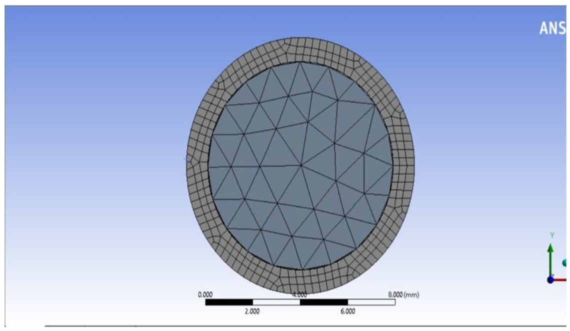

Fig.7 cross sectional view of mesh

IV. RESULT

After validating the CFD model of solar heat exchanger here we have considered five different geometry of solar heat exchanger that is solar heat exchanger having different shapes of ribs inside the pipe to increase the heat transfer rate. Here in this work we have analyzed the effect of different shapes of ribs inside the heat exchanger at different Reynolds number for water and nano fluid both. For analyzing the effect of shapes of ribs on heat transfer here we have considered circular, square, rectangular, elliptical and triangular shapes of ribs having same cross sectional area. Here we have also analyzed the effect of ribs on heat transfer during nano fluid flow.

A. For Water as a Working Fluid

Here in this case water is used as a working fluid inside the solar heat exchange here we have calculated the value of heat transfer coefficient for different geometry of solar heat exchanger as different Reynolds number.

1) For Circular Ribs

Here in this case circular shape ribs is used to increase the heat transfer from solar heat exchanger, here we have considered 2 mm diameter cylindrical with 1 mm height is placed inside the pipe to increase heat transfer. The solid model of solar heat exchanger having circular ribs inside the heat exchanger is shown in the below fig. during the analysis we have considered nine circular ribs inside the pipe having same diameter with pitch distant 0.2.

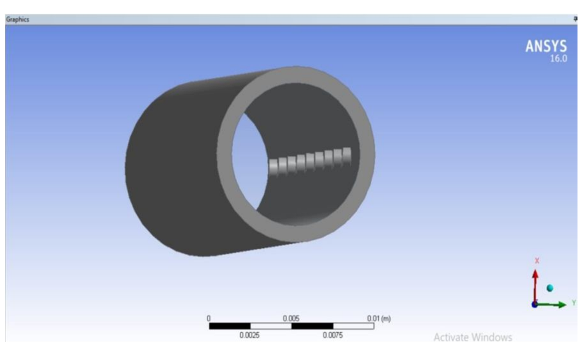

Fig.8 solid model of solar heat exchanger having circular ribs

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The value of heat transfer coefficient for Reynolds number 500 of geometry having circular ribs is shown in the below fig.

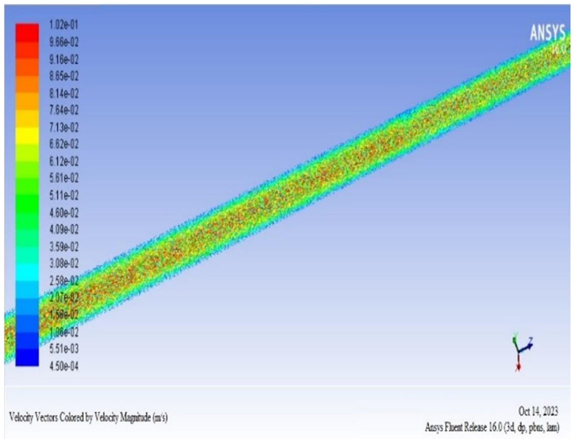

Fig.9 variation of velocity inside the solar heat exchanger

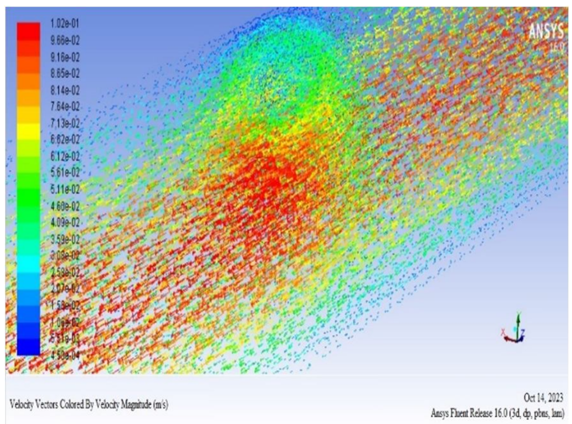

Fig.10 velocity vectors throughout the heat exchanger having circular ribs

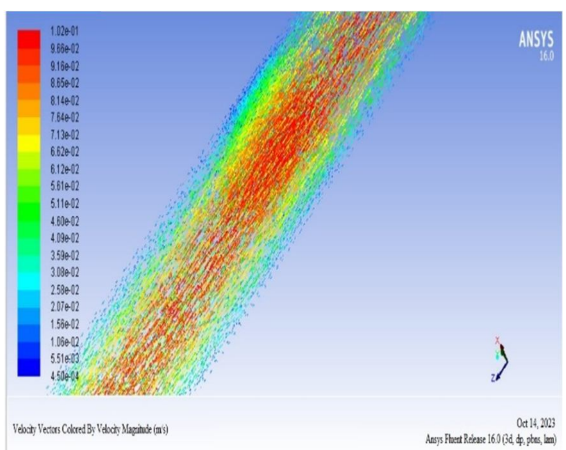

Fig.11 velocity vectors at the circular rib inside the heat exchanger

The above graph shows the variation of velocity inside the heat exchanger due to presence of rib inside the tube. Based on the analysis as considered during 500 Re number, it is further carried out for the different Reynolds number and calculate the value of heat transfer coefficient. Likewise the above analysis we have calculated the value of heat transfer coefficient for different Re number. Value of heat transfer coefficient for different Reynolds number is shown in the below table.

Table 2 Value of Heat transfer coefficient for solar heat exchanger having circular ribs

S. No.	Reynolds Number	Heat transfer coefficient (W/m^2K)
1	500	502
2	900	557
3	1300	617
4	1700	670

From the above analysis it is found that the value of heat transfer for circular ribs is higher for all Reynolds number as compared to solar heat exchanger without rib.

2) For Square Ribs

Here in this case a square shape ribs is used to increase the heat transfer from solar heat exchanger, here we have considered 1.77 mm side square with 1 mm height is placed inside the pipe to increase heat transfer. The solid model of solar heat exchanger having square ribs inside the heat exchanger is shown in the below fig. during the analysis we have considered nine square ribs inside the pipe having same diameter with pitch distant 0.2 m as considered during the analysis of circular ribs.

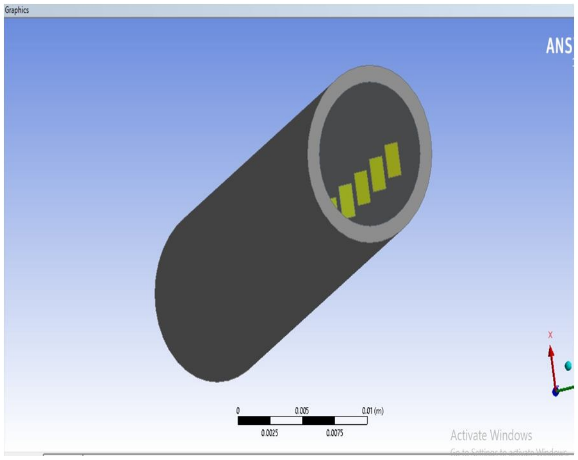

Figure 12 solid model of solar heat exchanger having square ribs

The value of heat transfer coefficient for different Reynolds number for solar heat exchanger having square ribs. Likewise the above analysis we have calculated the value of heat transfer coefficient for different Reynolds number.

Table.3 Value of Heat transfer coefficient for solar heat exchanger having square ribs

S. No.	Reynolds Number	Heat transfer coefficient (W/m^2K)
1	500	601
2	900	649
3	1300	696
4	1700	731

3) For Rectangular Ribs

Here in this case a rectangular shape ribs is used to increase the heat transfer from solar heat exchanger, here we have considered 1.34 mm length and 1.23 mm width of rectangular rib having 1 mm height is placed inside the pipe to increase heat transfer. The solid model of solar heat exchanger having square ribs inside the heat exchanger is shown in the below fig.

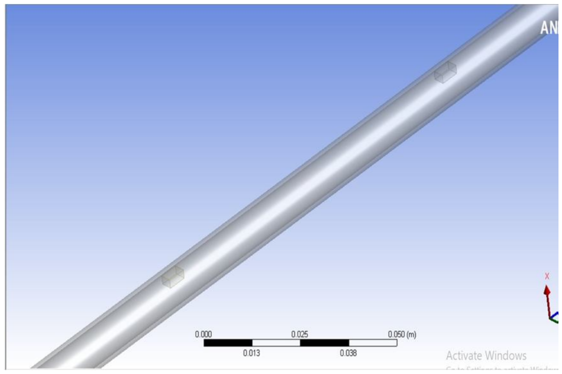

Fig.13 solar heat exchanger having rectangular ribs

The value of heat transfer for different Re number for heat exchanger with rectangular ribs is shown in the below table.

Table.4 Value of Heat transfer coefficient for solar heat exchanger having rectangular ribs

S. No.	Reynolds Number	Heat transfer coefficient (W/m^2K)
1	500	610
2	900	661
3	1300	707
4	1700	743

4) For Triangular Ribs

Here in this case a triangular shape ribs is used to increase the heat transfer from solar heat exchanger, here we have considered 2.69 mm side equilateral triangle with 1 mm height is placed inside the pipe to increase heat transfer. The solid model of solar heat exchanger having triangular ribs inside the heat exchanger is shown in the below fig. during the analysis we have considered nine triangular rids inside the pipe having same cross sectional area with pitch distant 0.2 m as considered during the analysis of circular ribs

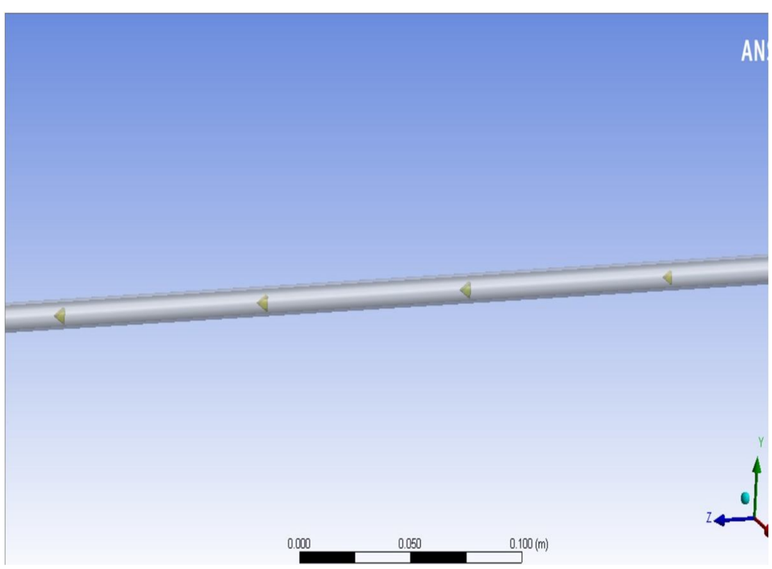

Fig.14 solid model of heat exchanger having triangular shape ribs

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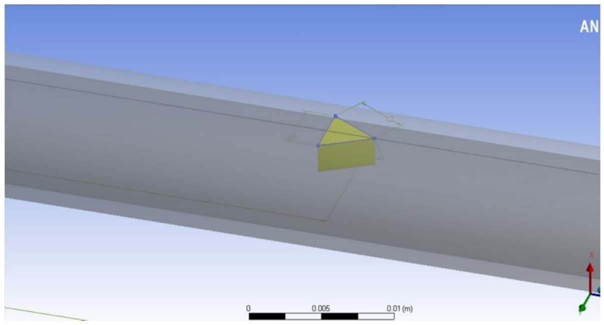

Fig.15 shows the top view of pipe having triangular ribs

The value of heat transfer coefficient for different Reynolds number for solar heat exchanger having triangular ribs. Likewise the above analysis we have calculated the value of heat transfer coefficient for different Reynolds number.

Table.5 Value of Heat transfer coefficient for solar heat exchanger having triangular ribs

S. No.	Reynolds Number	Heat transfer coefficient (W/m^2K)
1	500	478
2	900	528
3	1300	582
4	1700	637

5) For Elliptical ribs

Here in this case a elliptical shape ribs is used to increase the heat transfer from solar heat exchanger, here we have considered 1 mm height of ribs inside the pipe to increase heat transfer. The solid model of solar heat exchanger having elliptical ribs inside the heat exchanger is shown in the below fig.

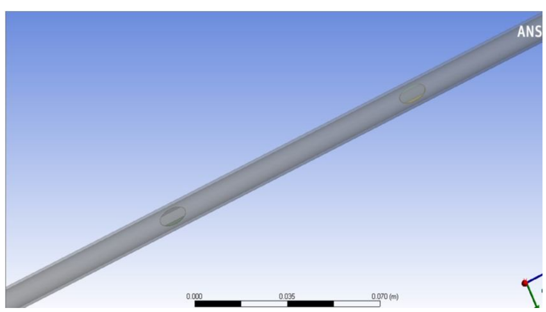

Fig.14 solar heat exchanger with elliptical ribs

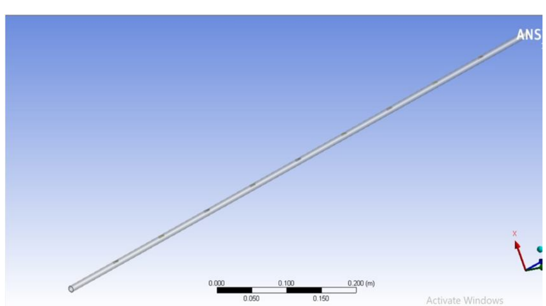

Fig.16 complete solar heat exchanger with elliptical ribs

Value of heat transfer coefficient for different Reynolds number is shown in the below table

Table.6 Value of Heat transfer coefficient for solar heat exchanger having triangular ribs

S. No.	Reynolds Number	Heat transfer coefficient (W/m^2K)
1	500	496
2	900	548
3	1300	609
4	1700	655

V. CONCLUSION

1) From above analysis, it is found that the uses of ribs inside the solar heat exchanger increase the heat transfer with increase in Reynolds number.
2) Through analysis, it is also found that the value of heat transfer coefficient increases with increase in Reynolds number, heat transfer coefficient is maximum for rectangular shape rib in both the cases that are during using water and nano fluid as a working fluid.
3) The average heat transfer coefficient ratio graph shows that rib used in the solar heat exchanger with nano fluid flow shows more heat transfer enhancement as compared to a solar heat exchanger with simple water flow.
4) Overall it is found that rectangular shape ribs show more heat transfer coefficient as compared to other rib.
5) So to increase the heat transfer from solar heat exchanger ribs can be used inside the heat exchanger.

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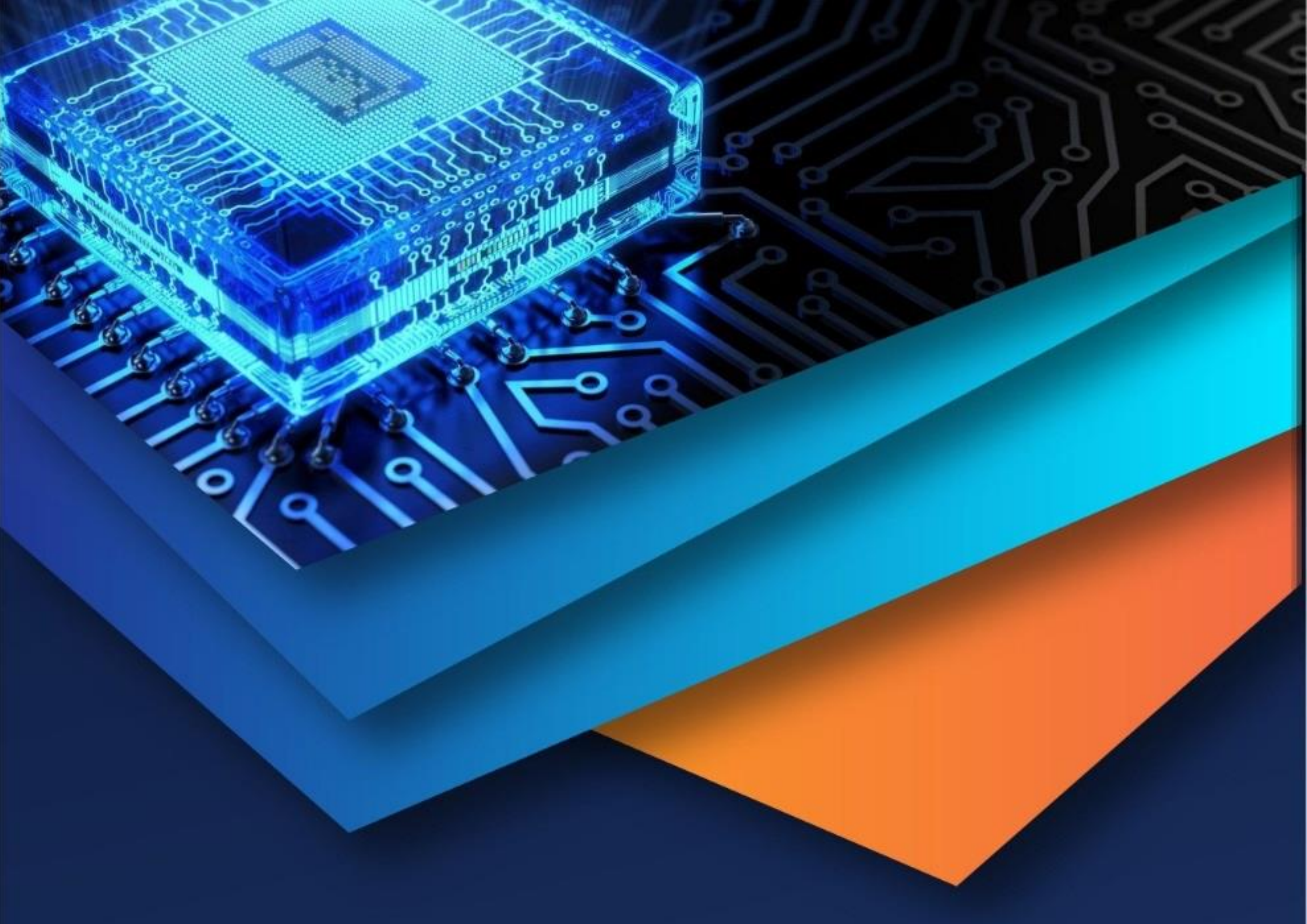

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