RESEARCH ARTICLE OPEN ACCESS

CFD Analysis of Solar Water Heater with Helix Inserts

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Abstract:

Heat exchangers are used as a piece of different methods reaching out from change, utilize and recovery of warm essentialness in various present day, business and nearby applications. Some ordinary delineation join steam age and development in charge and cogeneration plants; sensible heating and cooling in warm treatment of engineered, pharmaceutical and agrarian things; fluid heating in amassing and waste heat recovery et cetera. Augmentation in Heat exchanger's execution can provoke more mild diagram of heat exchanger which can make imperativeness, material and cost reserves related to a heat exchange process. The solar water heaters are widely used in the Daily life application so far numerous projects are done to improve the flow pattern and heat transfer efficiency to improvise the heating ration of the water in the tube our current project deals with the Solar air heater with twisted tape insert to Produce higher heating where the twisted tape is assembled in side a tube top end of the Surface is subjected to the Solar heating the pressure Velocity and Temperature distribution is determined changing the twist tape y=(l/w) ratio to optimize the Length and width of the twist tape for optimum twist angle.

Keywords — **Cfd , Solar water Heater , Twist Tape.**

1. INTRODUCTION

Heat exchangers are used as a piece of different methods reaching out from change, utilize and recovery of warm essentialness in various present day, business and nearby applications. Some ordinary delineation join steam age and development in charge and cogeneration plants; sensible heating and cooling in warm treatment of engineered, pharmaceutical and agrarian things; fluid heating in amassing and waste heat recovery et cetera. Augmentation in Heat exchanger's execution can provoke more mild diagram of heat exchanger which can make imperativeness, material and cost reserves related to a heat exchange process.

The need to fabricate the warm execution of heat exchangers, subsequently influencing imperativeness, material and cost venture stores have provoked headway and use of various strategies named as Heat trade broadening. These frameworks are furthermore insinuated as Heat trade.

Nowadays, twisted tape inserts have extensively been associated for redesigning the convective heat move in various organizations, in light of their feasibility, negligible exertion and basic setting up. Imperativeness and material saving idea, and furthermore judicious, have incited the undertakings to make more capable heat-exchanger equipment. Along these lines, if the warm imperativeness is safeguarded, the moderate treatment of warm essentialness through heat-exchanger will be possible.

The headway of prevalent warm structures has enabled eagerness for procedures to upgrade heat trade. The goal of enhanced heat trade is to help or oblige high heat advances. The heat trade systems enables heat exchanger to work at more diminutive speed, yet in the meantime finish the same or significantly higher heat trade coefficient. This suggests an abatement of weight drop, contrasting with less working cost. Heat trade development systems suggest different strategies used to construct rate of heat trade without affecting much the general execution of the structure. These methodologies are used as a piece of heat exchangers. A part of the uses of heat exchangers are-in process organizations, warm Power plants, cooling equipment's, fridges, radiators for space vehicles, autos et cetera. These techniques widely are of three sorts viz. disconnected, dynamic and compound systems.

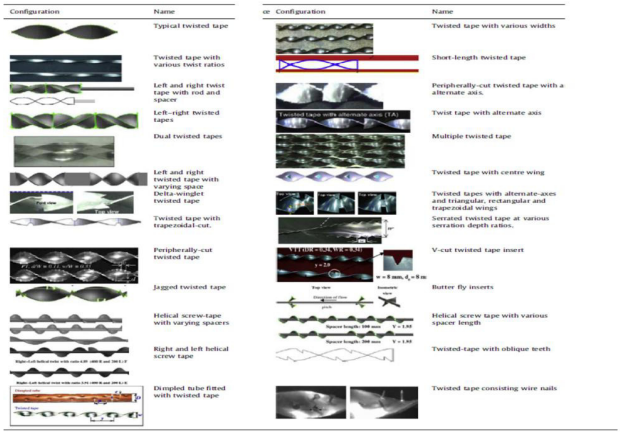


Fig 1: Configuration sketches of various twisted tapes

2. LITERATURE

(A) STUDIES ON OPTIMIZATION OF VARIOUS PARAMETERS OF THE SYSTEM

Kulkarni et al (2008) have discussed the arrangement of daylight based warm systems utilized for limit of pressurized heated water for mechanical applications. In this examination work the makers have developed an arrangement space approach framework for section measuring of concentrating experts, pressurized bubbling water accumulating.

Badescu (2006) has driven an examination on progression of size and structure for sun fueled essentialness gathering system by considering three sun arranged imperativeness applications and saving documents like net present regard and inside return rate. based radiation in thermosyphon sun based water heating structure and this consequently can be used to evaluate the execution of the same.

(B) STUDIES ON SPECIAL TYPE OF SOLAR HOT WATER SYSTEMS

Assari et al (2011) have analyzed the execution of twofold reason sun fueled specialist. In this, specialist plate of sun based bubbling water structure is associated with V shape air pipe just underneath the defend tubes and heat essentialness is transmitted in the meantime to the gatherer fluid and air. The trial result exhibits that twofold reason expert is more compelling than single water heater or air heater. Also, essentialness which isn't traded to the water in light of higher cove temperature can be utilized for air heating.

Siqueira et al (2011) have separated the execution of negligible exertion sun arranged heater. In this model, the gatherer is made of uncovered level sheets of resolute PVC and the limit tank is made of polyethylene secured with polystyrene. This straightforwardness sun controlled heater was attempted and the results reveal that overall heat trade coefficient of limit tank is appealing eventhough the warm efficiency is less stood out from the normal daylight based heaters.

(C) STUDIES ON INTRODUCTION OF PERFORMANCE ENHANCEMENT EQUIPMENT AND TECHNIQUES

Hobbi and Siddiqui (2009) have considered the effect of various heat move change devices in level plate daylight based specialists. The examinations are coordinated in the lab by embeddings twisted tape, circle spring wire and cone molded edges inside the expert tubes, every one thus. The relationship of various results shows that heat trade overhaul contraptions don't have any effect in upgrading the heat move rate in the thought about range and geometry.

Zambolin and Del Col (2010) have considered the warm execution of conventional covered level plate expert with purged tube daylight based gatherers under a comparative working conditions and expected that in light of the geometry, most of the protect zone is displayed to sun arranged radiation to the most extraordinary time of sunlight hours, cleared tube gatherer gives higher viability than the consistent one.

(D) STUDIES ON SMALL SCALE WIND ENERGY USE

Pope et al (2010) have pondered the level and vertical turn twist turbines in perspective of imperativeness and exergy viability. Two conventionally used air impedes in even center breeze turbine NACA 63(2)- 215 and FX63-131 are differentiated and Savonius and Zephyr sort vertical center point wind turbine. Examination of the more than four sorts of rotors, in light of first and second law of thermodynamics, was finished numerically and with the help of FLUENT programming. The result communicates that a refinement in first and second law efficiencies of between 50-53% is seen for airfoil systems however 44-55% complexity was represented vertical rotate wind turbines.

Al-Karaghouli et al (2009) have inspected about the diverse odds of utilizing daylight based and contort essentialness for sun arranged desalination in Arab countries. The makers have investigated the economical/standard cross breed systems, for instance, daylight based/Multi Stage Flash (MSF), Solar/Multi Effect Distillation (MED) and sun based breeze/RO and gather that sun based desalination structures working in practical power sources can match common structures in particular circumstances.

(E) RECENT STUDIES ON FORCED CIRCULATION SOLAR HOT WATER SYSTEM

Tremendous number of studies using obliged scattering has been represented.

Lambert et al (2006) have demonstrated another thought of oscillatory streams in sun situated specialists to update the heat swapping scale. A reacting pump is used to make oscillatory development of the fluid and the trial is driven with Newtonian and visco flexible fluids. As the warm diffusivity of fluid in oscillatory development is a couple of solicitations of degree higher than the fluid sub-nuclear diffusivity, this sort of stream enhances the heat move rate in relationship with the standard compelled spread mode with unidirectional stream.

Jaisankar et al (2009) have considered the heat exchange and grating variable normal for constrained course sun based boiling water framework fitted with helical bent tapes. The analyses were directed with different curve proportions of 3, 4, 5 and 6 and the outcomes are contrasted and the plain tube authority. The outcome demonstrates that contort proportion of 3 gives higher heat exchange and weight drop due whirl age and henceforth warm execution of turned tapes gatherer with least curve proportion is superior to the ordinary level plate authorities. Additionally, because of expanded heat exchange, a decrease in authority zone of 8-24% is watched for a similar yield.

G) STUDIES ON EFFECT OF PHASE CHANGE MATERIALS IN SOLAR HOT WATER SYSTEMS

Shukla et al (2009) have underlined the utilization of stage change material (PCM) as thermal energy stockpiling medium in solar water heaters. The creators have proposed that the utilization of PCM with high idle is a standout amongst the most productive approaches to store thermal energy for heating water by the energy got from the Sun.

Al-Hintiet al (2010) have explored the utilization of stage change material in the capacity tanks of customary solar water heating frameworks. Round and hollow holders loaded with paraffin wax as PCM was set in two lines in economically accessible capacity tank and the tests were led. It was seen that PCM keeps the capacity tank water temperature of 45ºC under every single climatic condition.

H) OTHER STUDIES RELATED TO SOLAR HOT WATER SYSTEMS

Michaelides and Eleftheriou (2011) have finished the exploratory examination of the execution furthest reaches of a sun based water heating structure. The trial was driven with 3 m2 level plate specialist with 68 liter tank for quite a while. It was revealed that stream rate assortments from 0.07 - 0.25 lit/sec did not convey any distinguishable effect on the essentialness accumulated in the storagetank and discovered by and large mix-ups in the structure quick capability kept running from 34% for low stream and 20% for high stream.

A joined examination of a sun controlled heated water (SHW) system in the UK private part was finished by Allen et al (2010) to assess its general vivacious, biological and money related execution. The examination assesses that the SHW structure would breakeven with its exemplified essentialness 'commitment' in 0.7– 2.4 years, and that it will payback its typified carbon commitment inside 2 years. These results exhibit that the SHW system will give a net imperativeness and carbon advantage for most of its evaluated 25 year lifetime.

I) CONCLUSIONS FROM THE LITERATURE REVIEW

At the point when all is said in done, distinctive systems for redesigning NCS sort SHW have been attempted and sensible improvements are represented. The going with are the huge conclusions arrived out of the review:

(i) As sun based bubbling water systems are most promising and found sweeping business use, critical number of headway ponders have been finished to enhance distinctive parts for better broad structure execution.

(ii) Attempts have been made with trade system sections either to reduce cost or to upgrade the structure execution.

(iii) To deal with cementing issues, refrigerants and ethylene glycol as gatherer fluids are tried.

(iv) Techniques like embeddings reshaped tapes, circle spring wires in the expert tubes and throbbing stream using reacting pumps are tried and its impact on system execution and disintegration incident are presented.

(v) Combined photovoltaic and warm imperativeness recuperation systems are built and are concentrated to an amazing degree.

(vi) Phase change materials are used for better heat accumulating and to keep gatherer tank temperature rise inside limit. It is found to improve structure viability by around 5 – 8 %.

(vii) Various sorts of wind process rotors are delivered for little scale control age and water pumping.

(viii) One analyze has tried breeze driven attract flow to overhaul the daylight based refining system execution.

3. INTRODUCTION OF CFD

Computational Fluid Dynamics (CFD) has created from a logical enthusiasm to twist up recognizably a major contraption in essentially every branch of fluid flow, from flying drive to atmosphere desire. CFD is frequently recognized as suggesting the sweeping subject including the numerical plan, by computational methods. These directing conditions, which portray fluid stream, are the course of action of Navier-Stokes condition, congruity

condition and any additional source terms, for example, penetrable medium or electric body drive.

Since the presence of the automated PC, CFD, as a making science, has become expansive consideration all through the all inclusive gathering. The interest of the subject is twofold. At first, there is the need to have the ability to demonstrate physical fluid ponders that can't be easily emulated or measured with a physical examination, for example, atmosphere systems. Likewise, there is need to have the ability to investigate physical fluid structures more cost suitably and more rapidly than with test techniques.

Regular imprisonments in stream examination and configuration oblige the precision in appreciating and impression of the fluid stream issues. This applies to both single and multi-arrange streams, and is particularly substantial for issues that are three dimensional in nature and incorporate turbulence, additional source terms, and moreover heat and mass trade. All these can be seen as together in the utilization of CFD, a viable strategy that can vanquish various imprisonments trademark in standard examination.

CFD is a system for understanding complex fluid stream and heat trade issues on a PC. CFD grants the examination of issues that are too much troublesome, making it difficult to unwind using conventional systems. The stream inside the ESP is mind boggling and this can be destitute down using CFD gadget, which gives a comprehension into the bewildering stream direct.

❖ CFD SIMULATIONS

The route toward performing CFD generations is part into three portions:

- Pre-dealing with
- Solving
- Post Processing
- Pre-dealing with

The pre-processor contains all the fluid stream commitments for a stream issue. It can be seen as a simple to utilize interface and a change of all the commitment to the solver in CFD program. At this stage, a lot of activities are done before the issue is being handled. These stages are recorded underneath:

Geometry Definition - The zone of interests that is the computational space, which must be described.
Framework age It is the path toward isolating the territory into different smaller and non-covering sub-spaces.

Physical and invention properties - The stream lead in regards to physical and substance qualities are to be picked.

Fluid property Definition - The fluid properties like thickness and consistency are to be described.

Cutoff conditions - All as far as possible conditions must be resolved on the cell zones.

Course of action

In the numerical course of action strategy, there are three unmistakable streams that shape the commence of the solver. They are constrained refinement, restricted part and restricted volume methods. The complexities between them are the way in which the stream factors are approximated and the discretisation frames are done.

Finite Difference Element (FDM)

FDM delineates the dark stream variables of the stream issue by techniques for point tests at center point reasons for a system encourage. By FDM, the Taylor's improvement is ordinarily used to create restricted differences estimation.

Finite Element Method (FEM)

FEM uses the clear piecewise limits genuine on segments to portray the adjacent assortments of darken stream factors. Speaking to condition is unequivocally satisfied by the right game plan of stream factors. In FEM, residuals are used to measure the bumbles.

Finite Volume Method (FVM)

FVM was at first made as an extraordinary restricted qualification design. The business CFD code packs using the FVM approaches are PHOENICS, FLUENT, FLOW 3D and STAR-CD. Basically, the numerical computation in these CFD business packs incorporates the formal blend of the regulating condition over all the constrained control volume, the discretisation system incorporates the substitution of a combination of FDM sorts to evaluated the incorporation state of the stream issue, and the game plan is gained by iterative technique. Discretisation in the solver incorporates the approaches to manage settle the numerical incorporation of the stream issue. For the most part, two various procedures are made, every one thus.

Explicit approach: More frequently than not, this is the most supportive approach that looks good. It is by and large simple to set up and program. The repression is that for a given t and x, the time must be not as much as some limit constrained by quality constraints. Now and again, t must be little to keep up the security, and in this way long running time is required for the figuring over a given time between time t.

Verifiable approach: For this approach, the quality can be kept up completed a tremendous estimation of t and less time steps are required for making the most of achieving less PC time. Regardless, it is perplexed to set up and program. The PC time per time step is fundamentally greater than the express approach due to the structure control, which is required for each time step. This

approach is to a great degree exact to take after the right vagrants, i.e., the time assortments of the independent variables.

Post-Processing

The CFD package gives the data observation gadgets to picture the results of the stream issue. This consolidates – vectors plots, territory geometry and structure show, line and shaded counter plots, atom following et cetera. Late workplaces are assisted with movement for dynamic result show and they moreover have data exchange workplaces for encourage control outside to the code.

Governing conditions

Conservative Law

Navier-Stokes conditions are the administering conditions of Computational Fluid Dynamics. It depends on the preservation law of physical properties of fluid. The guideline of conservational law is the difference in properties, for instance mass, energy, and force, in a question is chosen by the info and yield.

For instance, the difference in mass in the question is as per the following

$$\frac{dM}{dt} = \dot{m}_{in} - \dot{m}_{out} \tag{1}$$

If $\dot{m}_{in} - \dot{m}_{out} = 0$, we have

$$\frac{dM}{dt} = 0 \tag{2}$$

Which means

$$M = const \tag{3}$$

Navier-Stokes Equation

Applying the mass, momentum and energy conservation, we can derive the continuity equation, momentum equation and energy equation as follows.

Continuity Equation

$$\frac{D\rho}{Dt} + \rho\frac{\partial U_i}{\partial x_i} = 0 \tag{4}$$

Momentum Equation

$$\underbrace{\rho\frac{\partial U_j}{\partial t}}_{I} + \underbrace{\rho U_i\frac{\partial U_j}{\partial x_i}}_{II} = \underbrace{-\frac{\partial P}{\partial x_j}}_{III} \underbrace{-\frac{\partial \tau_{ij}}{\partial x_i}}_{IV} + \underbrace{\rho g_j}_{V} \tag{5}$$

Where

$$\tau_{ij} = -\mu\left(\frac{\partial U_j}{\partial x_i} + \frac{\partial U_i}{\partial x_j}\right) + \frac{2}{3}\delta_{ij}\mu\frac{\partial U_k}{\partial x_k} \tag{6}$$

I: Local change with time
II: Momentum convection
III: Surface force
IV: Molecular-dependent momentum exchange (diffusion)
V: Mass force

Energy Equation

$$\underbrace{\rho c_\mu\frac{\partial T}{\partial t}}_{I} + \underbrace{\rho c_\mu U_i\frac{\partial T}{\partial x_i}}_{II} = \underbrace{-P\frac{\partial U_i}{\partial x_i}}_{III} + \underbrace{\lambda\frac{\partial^2 T}{\partial x_i^2}}_{IV} \underbrace{-\tau_{ij}\frac{\partial U_j}{\partial x_i}}_{V} \tag{7}$$

I: Local energy change with time
II: Convective term
III: Pressure work
IV: Heat flux (diffusion)
V: Irreversible transfer of mechanical energy into heat

If the fluid is compressible, we can simplify the continuity equation and momentum equation as follows.

Continuity Equation

$$\frac{\partial U_i}{\partial x_i} = 0 \tag{8}$$

Momentum Equation

$$\rho\frac{\partial U_j}{\partial t} + \rho U_i\frac{\partial U_j}{\partial x_i} = -\frac{\partial P}{\partial x_j} - \mu\frac{\partial^2 U_j}{\partial x_i^2} + \rho g_j \tag{9}$$

General Form of Navier-Stokes Equation

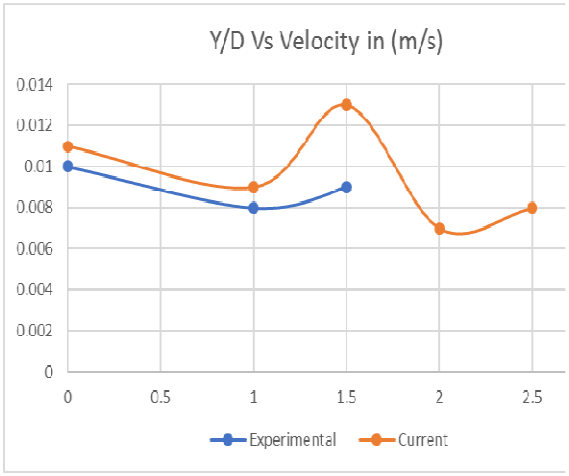
To simplify the Navier-Stokes equations, we can rewrite them as the general form.

$$\frac{\partial(\rho\Phi)}{\partial t} + \frac{\partial}{\partial x_i}\left(\rho U_i\Phi - \Gamma_\Phi\frac{\partial\Phi}{\partial x_i}\right) = q_\Phi \tag{10}$$

When $\Phi = 1, U_j, T$, we can respectively get continuity equation, momentum equation and energy equation.

4. RESULTS AND DISCUSSIONS

Validation



The above results shows the Validation of the experimental results which is simulated using the Cfd the results good and validated

Y/D	Experimental	Current
0	0.01	0.011
1	0.008	0.009
1.5	0.009	0.013
2		0.007
2.5		0.008

The percentage error between experimental and the theoritical value is 10.

Fig 2: Dimensions or model from the base paper

The above is the notation of the Schematic diagram of the insert In the solar water heater.

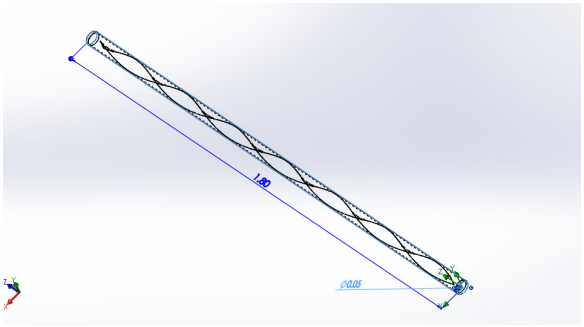


Fig 3 : Designed model in solid works

The above figure represents the 3d representation of the pipe with twisted tape insert representing the length of the model and the co-ordinate system while designing.

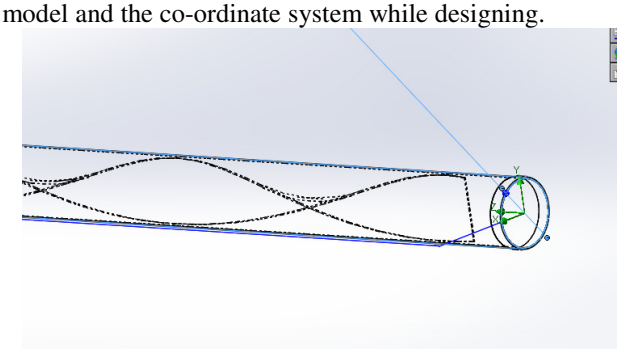


Fig 4: Twisted tape insert

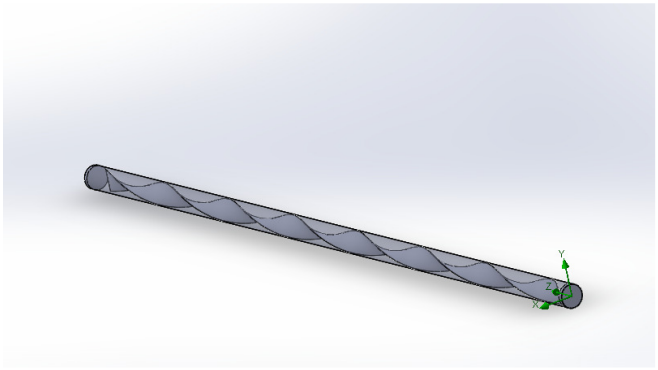


Fig 5 : Isometric view

Further Project can be Improvised by changing the twist tape y= (l/w) in the base paper the author has done the simulation for y=2.5 and y=4. Now the Project can be extended to y=1,y=3 to determine the optimal Twist tape insert.

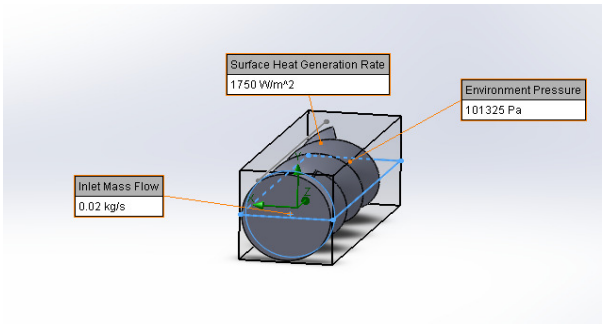


Fig.6 boundary conditions

Above Figure represents the schematic of the Solar water heater boundary conditions Where the inlet represents the mass flow inlet at 0.02 kg/s and the heat source coming from the sun is assumed to be 1750 w/m2 and the outlet is set at environmental pressure.

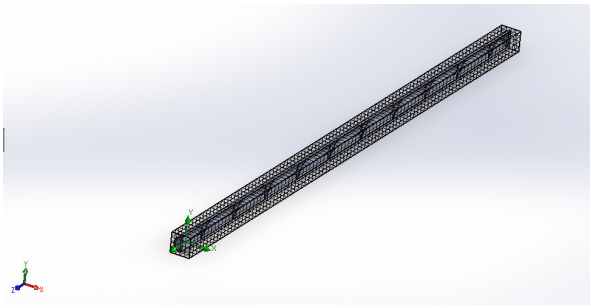


Fig 7: Optimal Twist tape insert

The above figure represents the computational discretization using Finite volume method with finite quadrilateral elements.

Case 1:

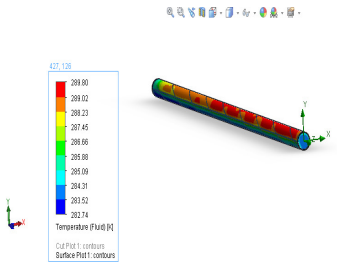


Fig 8: Temperature Contours

The above figure represents the temperature contour of solar water heater with the heat source from the top direction and the inlet from the far end of the model left side bar.

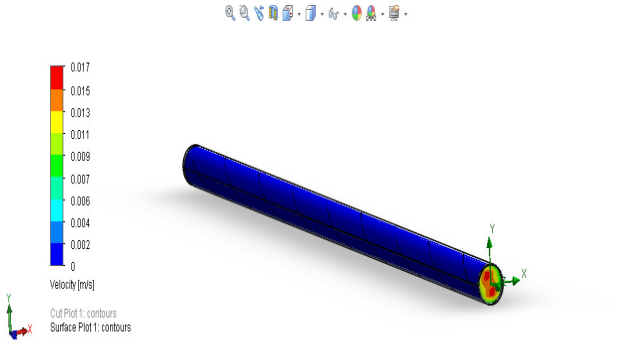


Fig 9: Velocity Contours

The above figure represents the velocity of the water inside the solar water heater where left side colored bar is the legend blue color represents the minimum velocity and the red color represents the maximum velocity.

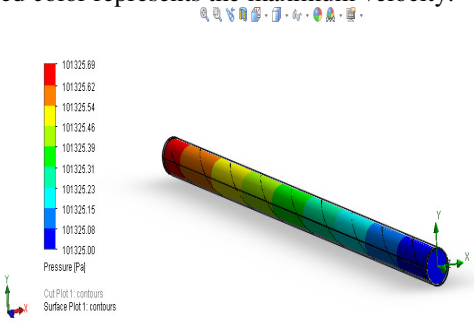


Fig 10: Pressure Contours

The above figure represents the Pressure of the water inside the solar water heater where left side colored bar is the legend blue color represents the minimum pressure and the red color represents the maximum pressure.

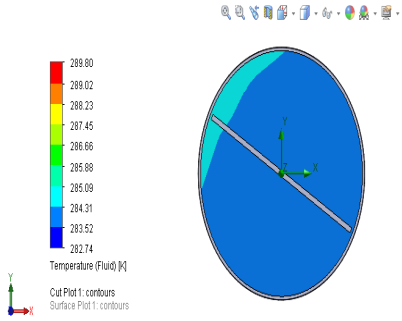


Fig 11: Temperature cut plot case 1

The above figure represents the cut plot of the water inside the solar water heater where left side colored bar is the legend blue color represents the minimum Temperature and the red color represents the maximum temperature.

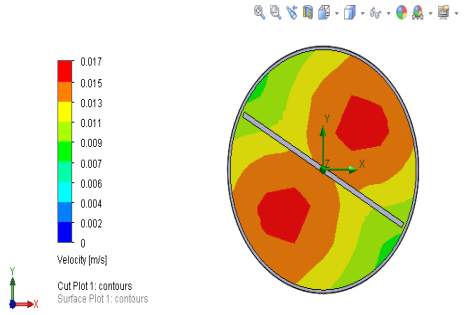


Fig 12: Velocity cut plot case 1

The above figure represents the Cut plot of the velocity of the water inside the solar water heater where left side colored bar is the legend blue color represents the minimum velocity and the red color represents the maximum velocity.

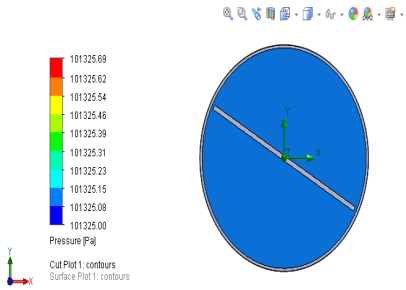


Fig 13: Pressure cut plot case 1

The above figure represents the Cut plot of the Pressure of the water inside the solar water heater where left side colored bar is the legend blue color represents the minimum pressure and the red color represents the maximum pressure .The presuure remains decreasing because of the helix.

Case 2

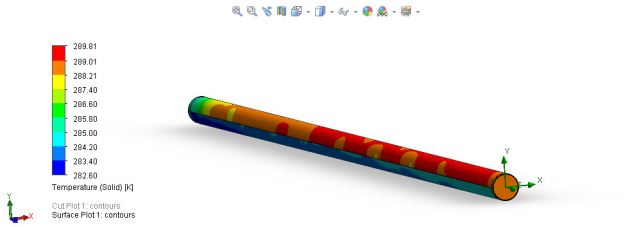


Fig 14: Temperature solid case 2

The above figure represents the temperature contour of solar water heater with the heat source from the top direction and the inlet from the far end of the model left side bar is known as legend where blue represents the minimum value and the red represents the maximum value we can observe that the maximum temperature 289.81K.

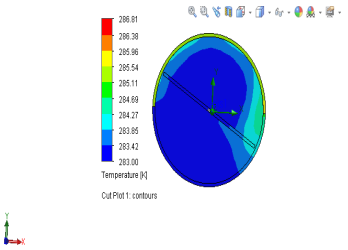


Fig 15: Temperature cut plot case 2

The above figure represents the cut plot of the water inside the solar water heater where left side colored bar is the legend blue color represents the minimum Temperature and the red color represents the maximum temperature.

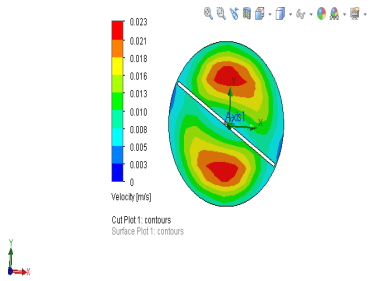


Fig 16: Velocity cut plot case 2

The above figure represents the Cut plot of the velocity of the water inside the solar water heater where left side colored bar is the legend blue color represents the minimum velocity and the red color represents the maximum velocity.

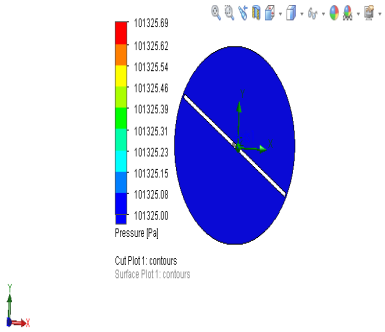


Fig 17: Pressure cut plot case 2

The above figure represents the Cut plot of the Pressure of the water inside the solar water heater where left side colored bar is the legend blue color represents the minimum pressure and the red color represents the maximum pressure.The presuure remains decreasing because of the helix.

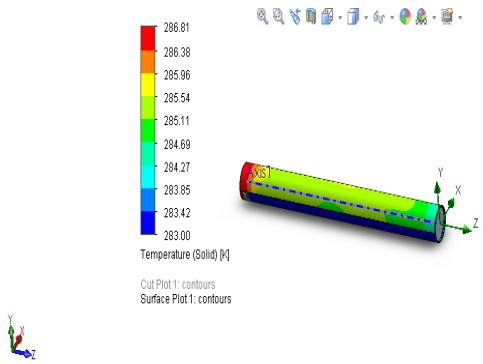


Fig 18: Temperature solid plot case 2

The above figure represents the temperature contour of solar water heater with the heat source from the top direction and the inlet from the far end of the model left side bar is known as legend where blue represents the minimum value and the red represents the maximum value we can observe that the maximum temperature 286.81 K.

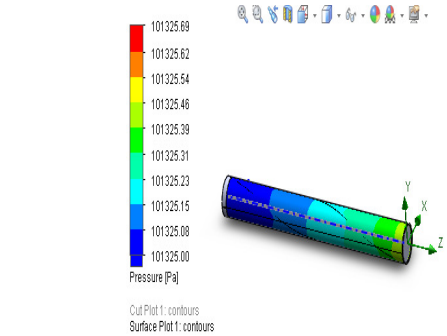


Fig 19: Pressure plot case 2

The above figure represents the Cut plot of the Pressure of the water inside the solar water heater where left side colored bar is the legend blue color represents the minimum pressure and the red color represents the maximum pressure.

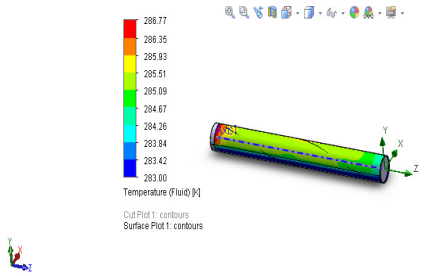


Fig 20: Temperature fluid plot case 2

The above figure represents the temperature contour of solar water heater with the heat source from the top direction and the inlet from the far end of the model left side bar is known as legend where blue represents the minimum value and the red represents the maximum value we can observe that the maximum temperature 286.77 K.

Case 3

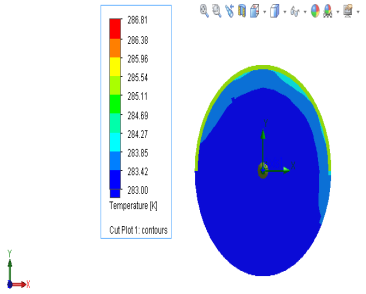


Fig 21: Temperature cut plot case 3

The above figure represents the cut plot of the water inside the solar water heater. The picture states within the arrangement of the helical angle the fluid rotation around the spiral is producing the temperature increase of the fluid where the initial temperature in 281K the average temperature of the Fluid when subjected to the solar radiation is 286.81K we can state a significance increase in the Heat of the Water.

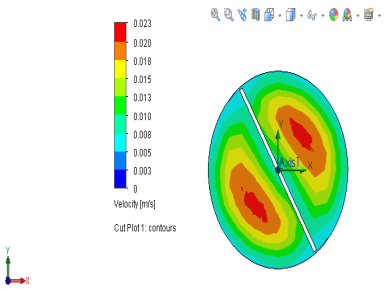


Fig 22: Velocity cut plot case 3

The above figure represents the Cut plot of the velocity of the water inside the solar water heater. The blunt shape of the flow profile inside the tube and around the helix is because of the rotation of the fluid where at the lower edges of the fluid interacting helix the velocity in increasing these results in the above profile the maximum velocity at helix edges is 0.023m/s.

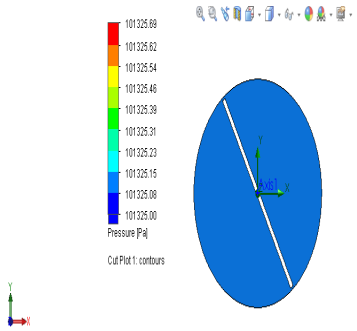


Fig 23: Pressure cut plot case 3

The above figure represents the Cut plot of the Pressure of the water inside the solar water heater where left side colored bar is the legend blue color represents the minimum pressure and the red color represents the maximum pressure.

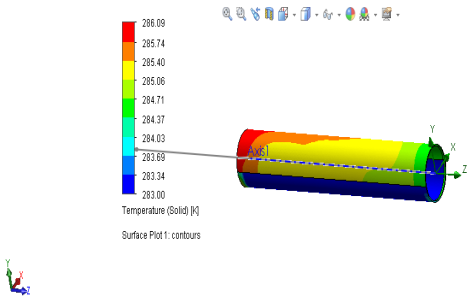


Fig 24: Temperature solid plot case 3

The above figure represents the temperature contour of solar water heater with the heat source from the top direction and the inlet from the far end of the model left side bar is known as legend where blue represents the minimum value and the red represents the maximum value we can observe that the maximum temperature 286.09 K.

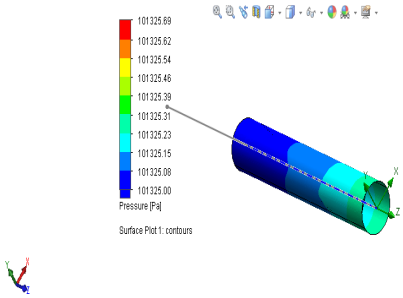


Fig 25: Pressure plot case 3

The above figure represents the Cut plot of the Pressure of the water inside the solar water heater where left side colored bar is the legend blue color represents the minimum pressure and the red color represents the maximum pressure. The pressure remains decreasing because of the helix.

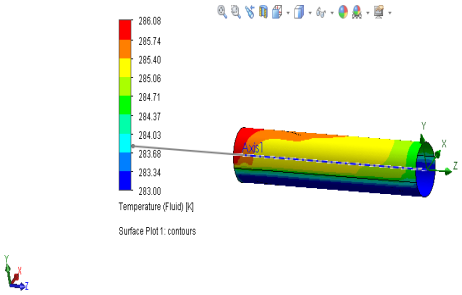


Fig 26: Temperature plot case 3

The above figure represents the temperature contour of solar water heater with the heat source from the top direction and the inlet from the far end of the model left side bar is known as legend where blue represents the minimum value and the red represents the maximum value we can observe that the maximum temperature 286.09 K

5. CONCLUSION

The flow and heat transfer performance of solar water heaters for different initial temperatures with twist tape inserts are evaluated and compared with normal solar water heater using numerical simulation. The predicted results match fairly well with experimental data. Results indicate that, the twist tape inserts makes the mixture of the water near the top and bottom half of the tube more intense, destroys the original orderly flow and generates more eddy, which leads to a higher dissipation of mechanical energy and thus reduces velocity magnitude to 0.008, at the same time, makes the temperature field more uniform with 286K. The twist tape inserts helps heat transfer at relatively high temperature and is not conducive to heat transfer at relatively low temperature. Over the range investigated, the mean Nusselt number of the solar water heaters for y=2.5 and y=4. Now the Project can be extended to y=1 , y=3 to determine the optimal Twist tape insert

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