HEAT TRANSFER OF HELICAL COIL PIPE WITH DIFFERENT TORSION PARAMETERS

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In the current work, the CAD model of helical pipe has been developed by using UNI-GRAPHICS NX-8.0. The model has been simulated using Ansys software on fluent domain 15.0 workbench in order to observe various parameters affecting the thermal and hydraulic performance of helical pipe. Four types of configurations of helical pipe have been used with different profile i.e. type-1, type – 2, type-3, type-4. An optimized model of helical pipe has been developed with different coil diameter and pitch difference. The simulations have been performed at a constant wall temperature of 320K that is the temperature at wall with different Reynolds no. varied from 1000 to 4100. The simulation of the type - 2 gives higher value of nusselt no, less temperature. It has also been observed that at torsion parameter of 0.050 with 1mm thickness of copper foam material in coil – 2 configuration shows higher convergence compared to previous configurations. The results are validated with reported base paper results. The configuration of type-2 gives maximum convergence on all parameters amongst all the configurations used.

Keywords— *Helical pipe, Nusselt Number, Reynolds Number, torsion parameter, copper foam, coil diameter, fluent, unigraphics.*

I INTRODUCTION

Helically coiled heat exchangers have been widely applied in many power conversion systems for their advantages, such as compactness and high efficiency in heat transfer. In the sphere of nuclear energy, helically coiled steam mills are followed by means of unique types of nuclear electricity flora, specifically with the aid of small and medium size reactors (SMRs). In the beyond, helically coiled steam mills were specially followed with the aid of gasoline cooled reactors and sodium cooled fast reactors. More recently, they're deployed as the steam generators for numerous modern pressurized water reactors of fundamental and modular kind and so forth. Generally, a helically coiled steam generator is a as soon as-through kind steam generator. In the steam generator, the number one coolant flows downward across the shell side of the helical tubes, even as the feed-water flows upward in the tube facet. Under the regular operation circumstance, the heat transfer mode of the primary coolant is single segment warmness transfer, whilst that of the feed-water stories unmarried segment warmth transfer of sub cooled water, nucleate boiling, submit-dry out and unmarried phase heat switch of superheated steam. Therefore, suitable heat transfer fashions for each the tube aspect and the shell aspect of the helically coiled steam generator are necessary.

Helical coils are widely used in many industrial applications due to their compact structures and good thermal expansion performances. The nuclear industries use a helical coil because the steam generator for strength production. Due to compact shape, the helical coil reactor is an attractive alternative for the marine propulsion. Most helical coil warmth exchangers used for industries and industrial application require the nearby warmth transfer and neighborhood heat switch coefficient facts for design purposes to improve the effectiveness of heat exchanger. Research to use helical coil tubes for receiver of concentrating type solar collector for energy era device goes on. For this gadget, maximum warmth flux is on the concave side of the tube. To investigate this device, know-how of local warmness switch coefficient on internal aspect and outer facet require. The information ought to help to design and growth the efficiency of the receiver

HEAT TRANSFER

Heat transfer is a discipline of thermal engineering that concerns the generation, use, conversion, and exchange of thermal energy (heat) between physical systems. Heat switch is classed into various mechanisms, which includes thermal conduction, thermal convection, thermal radiation, and switch of strength through section modifications. Engineers additionally recall the transfer of mass of differing chemical species, either cold or warm, to attain heat switch. While those mechanisms have distinct traits, they often occur simultaneously in the identical gadget.

Heat conduction, additionally referred to as diffusion, is the direct microscopic change of kinetic power of particles thru the boundary among two structures. When an item is at a one-of-a-kind temperature from every other body or its surroundings, warmth flows in order that the frame and the surroundings attain the same temperature, at which point they're in thermal equilibrium. Such spontaneous warmness transfer usually happens from a vicinity of excessive temperature to every other area of decrease temperature, as described with the aid of the second regulation of thermodynamics.

Heat convection occurs when bulk flow of a fluid (gas or liquid) carries heat along with the flow of matter in the fluid. The float of fluid can be forced by using external methods, or every so often (in gravitational fields) by using buoyancy forces brought on whilst thermal energy expands the fluid (for example in a hearth plume), accordingly influencing its own switch. The latter process is regularly called "natural convection". All convective approaches additionally circulate warmth in part with the aid of diffusion, as well. Another shape of convection is compelled convection. In this case the fluid is forced to drift via use of a pump, fan or other mechanical way

TYPES OF CONVECTIVE HEAT TRANSFER

Free or natural convection: when fluid motion is caused by buoyancy forces that result from the density variations due to variations of thermal temperature in the fluid. In the absence of an internal source, when the fluid is in contact with a hot surface, its molecules separate and scatter, causing the fluid to be less dense. As a consequence, the fluid is displaced while the cooler fluid gets denser and the fluid sinks. Thus, the hotter volume transfers heat towards the cooler volume of that fluid. Familiar examples are the upward flow of air due to a fire or hot object and the circulation of water in a pot that is heated from below.

Forced convection: when a fluid is forced to flow over the surface by an internal source such as fans, by stirring, and pumps, creating an artificially induced convection current.

Internal and outside go with the flow also can classify convection. Internal drift happens whilst a fluid is enclosed by means of a stable boundary such whilst flowing thru a pipe. An external drift takes place whilst a fluid extends indefinitely without encountering a solid surface. Both of those varieties of convection, either natural or compelled, can be inner or external because they may be unbiased of every different.[citation needed] The bulk temperature, or the average fluid temperature, is a convenient reference factor for comparing houses associated with convective warmness switch, mainly in packages related to glide in pipes and ducts. Further class can be made depending at the smoothness and undulations of the stable surfaces. Not all surfaces are clean, although a bulk of the available records offers with smooth surfaces. Wavy irregular surfaces are typically encountered in warmth transfer devices which consist of solar creditors, regenerative warmth exchangers and underground electricity storage systems. They have a large function to play in the warmness switch approaches in these packages. Since they bring in an brought complexity due to the undulations in the surfaces, they want to be tackled with mathematical finesse thru stylish simplification strategies. Also they do affect the flow and heat transfer traits, thereby behaving otherwise from directly smooth surfaces

II LITERATURE REVIEW

Imani-Mofrad etal. (2016) [1] - the experimental research on the impact of various styles of filled beds on the thermal performance of a wet cooling tower through the use of zinc oxide (ZnO)/water nanofluid. Different concentrations of ZnO/water Nano fluid had been organized thru -step process through using pure water with electric conductivity of two lS/cm. First, by way of the use of ZnO/water Nano fluid (zero.08 wt%), effect of six extraordinary filled beds have been investigated on the thermal performance of the cooling tower. Moreover, after each test the carried out stuffed mattress become reviewed so that you can look at any aggregation or settlement of nanoparticles at the surfaces of the bed. It changed into discovered that making use of metal reticular mattress (Bed 1) is the exceptional preference while ZnO/water nanofluid is used. In the alternative word Bed 1 results better thermal traits for cooling tower and much less settlement of nanofluids. Then exceptional awareness of ZnO/water Nano fluidin the variety of 0.02–zero.1 wt% is hired within the cooling tower by way of using Bed 1. The results showed thatby the use of nanofluids, cooling variety, tower characteristic (TC) and effectiveness of cooling tower are enriched compared to water.

Satish Kumar (2016) [2]-this investigation in most of the places, the water deliver is restrained and thermal pollution is likewise a extreme subject. Considering the latest increase of hobby in analysing those problems and fixing them for the well-being of the surroundings, this paintings is an attempt to deal with the generation, packages of cooling towers. In this gift take a look at, the elements affecting the performance like environmental conditions, cooling water satisfactory have been studied on Induced draft cooling tower of 32 Mw thermal energy plant. The overall performance parameters like range, technique, cooling potential, evaporation loss liquid to gas ratio were evaluated whilst the plant is operated at complete load and element load underneath the equal water drift charges.

Donald R.Bakeretal.(2016) [3] - the research in predicting cooling tower overall performance are without delay associated with the precision that is required. There is not any trendy agreement on what constitutes an acceptable diploma of accuracy. The users are reluctant to allow a tolerance of 1⁄2° in method while reputation exams are involved. Cooling tower capacity is extra accurately expressed in phrases of water charge for a given set of situations. This ability is approximately proportional to variations in approach when different conditions are consistent, so 1⁄2° corresponds to a difference of 10 in step with cent in capacity for a five° method. This presents an indication of what constitutes an inexpensive maximum restriction of proper tolerance.

A. Vijayaragavan et al. (2016) [4] - the investigation when cooling the refrigerant, the bloodless water will become the new water. The warm water temperature is decreased by way of cooling towers. When warm water enters into the prompted draft cooling tower and sprayed via nozzles. So warm water is transformed into bloodless water .The powerful cooling of water relies upon upon the dry bulb temperature and wet bulb temperature, size, peak of the cooling tower and velocity of air .The venture deals with the overall performance have a look at and analysis of triggered draft cooling tower, which is one of the determining elements used for increasing the electricity plant efficiency also modelling and analysis of waft the use of software program .A cooling tower is an enclosed device for the evaporative cooling of water by means of touch with the air. Cooling tower is a warmth rejection device. Common software includes cooling the circulating water used in oil refineries, petrochemical, and different chemical plant life, thermal energy stations and HVAC gadget for cooling homes. The efficiency and effectiveness of cooling tower relies upon on wide variety of parameter like inlet air angle, inlet and outlet temperature of air and water, fill materials, fan velocity.

A. Ataei etal. (2008) [5] - this investigation performance assessment of wet cooling tower is finished. To achieve this intention, first, thermal behavior of counter-drift moist cooling tower is studied thru a simulation model. The impact of the environmental conditions on the thermal performance of the cooling tower is investigated. The cooling tower overall performance is simulated in phrases of varying air and water temperatures, and of the ambient conditions. This version allows the use of a spread of packing substances. Second, the exergetic evaluation is applied to observe the cooling tower capability of performance development.

Abdul Hadi N. Khalifa(2015) [6] - this research a counter flow prompted draught cooling tower with a few simplifications. The governing equation became solved with the aid of an iterative technique. The tower was divided into 100 horizontal elements, the temperature distinction in every detail become zero.1 K. Mass, strength and exergy balances have been evaluated for each detail the use of Engineering Equation Solver (EES) software program. For such tower, it become observed that the ratio of mass flow fee of water to that for air (L/G) is within the range of one.25 to one.Five. Since the exergy of air is ate up to wreck the exergy of water, then, extra exergy destruction offers higher exergy efficiency for cooling tower. As the moisture content material of the air increases the air chemical exergy increases, on the any other hand, as air temperature techniques to water temperature air thermal exergy tend to lessen. And subsequently, Merkel assumption, that nation that saturated air leaving cooling tower, gives curvature direction for saturation system rather than a immediately line.

Xiaoni Qi etal. (2013) [7] -This research is descriptive mathematical model of electricity and exergy for a bath cooling tower (SCT). The version is used to expect the variation in temperature and exergy alongside the tower period. The validity of the model for predicting versions in gas and liquid characteristics along the tower length became examined in opposition to some working records measured in a cooling tower organisation. The effects display that the exergy of water decreases as tower top increases. The distribution of the exergy loss is high at the bottom and regularly decreases shifting up to the top of the tower. Moreover, 1.50 m/s air velocity results in less exergy destruction. With a decrease inside the size of the water droplets, the fluids carrying energy have extra possibilities for mass and energy transfers.

MohamadAmin etal. (2015) [8] -this investigation a Merkel simulation is first implemented to mass and warmth switch strategies, that is then used in nearly all analyses of cooling towers. Taking under consideration thermodynamic houses of water and air and calculating heat switch among the 2, differential members of the family between enthalpy and temperature changes are then acquired at the middle of cooling towers. Using right numerical methods, the equations are numerically and extra precisely while in comparison with different articles together with those of Darvishi and Ashraf Kotb solved. The acquired values are then compared with output values for a real powerhouse (Ramin Power plant, Khouzestan). Finally, some variables which includes air wet bulb temperature, enter air volume, and wide variety of lovers are modified and the affect of those parameters is studied on performance of cooling towers and output water temperature.

S.Satheeshetal. (2016) [9] - this research Coolingtowers can also either use the evaporation of water to get rid of procedure heat and cool the working fluid to close to the moist-bulb air temperature or within the case of closed circuit dry cooling towers rely solely on air to chill the running fluid to near the dry-bulb air temperature. Common packages include cooling the circulating water used in oil refineries, chemical vegetation, power stations and building cooling. Industrial cooling towers may be used to cast off heat from various resources which includes equipment or heated manner material. The primary use of big, business cooling towers is to dispose of the heat absorbed in the circulating cooling water systems utilized in strength flora, petroleum refineries, petrochemical vegetation, herbal fuel processing flora, meals processing vegetation, semi-conductor flowers, and for other industrial centers such as in condensers of distillation columns, for cooling liquid in crystallization.

YogeshParkhi etal. (2013) [10] - the research indicates the Common programs encompass cooling the circulating water utilized in oil refineries, petrochemical and other chemical plant life, thermal strength stations and HVAC systems for cooling homes. The performance and the effectiveness of cooling tower is depend on range of parameter like inlet air attitude, inlet and outlet temperature of air and water, fill materials, fan pace and so on. In current work the air inlet attitude is optimize by deciding on three exclusive inlet angles. For this CFD evaluation of brought on draught cross flow cooling tower is accomplished in ANSYS workbench.

R. Sattanathan (2013) [11] -The investigation is to increase the cooling fee with the aid of editing the layout i.E by replacing the fill material with the aluminum trays and reducing the height to provide an strength efficient. In this, use trays for the water to move horizontally in every tray and get a large surface area for the water to evaporate. Thus the height of the tower is reduced through use tray kind. This cooling tower is counter-go with the flow kind. Thus understand the primary principles of cooling tower operation, forms of cooling tower, diverse additives utilized in cooling tower, the factors affecting the cooling tower performances and electricity saving opportunities in cooling tower. A trendy examine changed into made on the design attention of cooling tower, significance of energy stability and mass stability while designing the cooling tower, have an effect on of Wet bulb temperature in cooling tower performance, applicability of Psychometric chart in cooling tower layout &formulation used for designing the cooling towers and overall performance calculations. The performance of counter glide tray kind cooling tower Such as efficiency, losses outcomes were in comparison with the fill material bottle type cooling tower and also investigating the overall performance of counter flow tray kind cooling tower in distinct seasons.

Merw etal. (2002) [12]-This look at definitely makes a specialty of A numerical version to expect the flow field in and around a counter .Flow precipitated draft moist cooling tower was developed and tested. The numerical model consisted of the third version, a Lagrangian droplet version and a packing version. The droplet version exposed the need to model the impact of the packing at the droplets and a simplified version turned into implemented to extend the droplet retention time in the packing.

ChunlaiTianetal. [2014][13] - the investigation the computational fluid dynamics version of the air flow area across the cooling tower is set up in this paper. The exquisite big scale cooling tower is specifically designed for the inland nuclear electricity plant. The unfastened open source computational fluid dynamics solver software named OpenFOAM is used. The speed, temperature and stress fields are proven. The minimum pace seems close to the pinnacle lee facet of the tower. The highest temperature seems at the tower exit and the temperature subject ought to are expecting the plume motions. With the increase of the gap, the plume rises to 250 m at the placement one thousand m away from the cooling tower and might upward thrust constantly. This paper offers a low-price reliable numerical simulation technique to predict the plume and air go with the flow characteristics across the cooling tower.

2.1 Objective of the Work

The main objective of the current work is

Validation of the ANSYS models by comparing the present simulated results with Anup Kumer Datta (Author of Base Paper).

To predict temperature distribution and the nusselt number of a helical pipe with different configurations.

To define nusselt number by using thickness and copper foam material for the helical pipe of different profile.

To determine the optimum configuration for helical pipe design for better heat transfer with copper foam and optimal thickness.

V MODELING AND ANALYSIS

The procedure for solving the problem is:

Create the geometry.

Mesh the domain.

Set the material properties and boundary conditions.

Obtaining the solution

Preprocessing

Preprocessing include CAD model, meshing and defining boundary conditions.

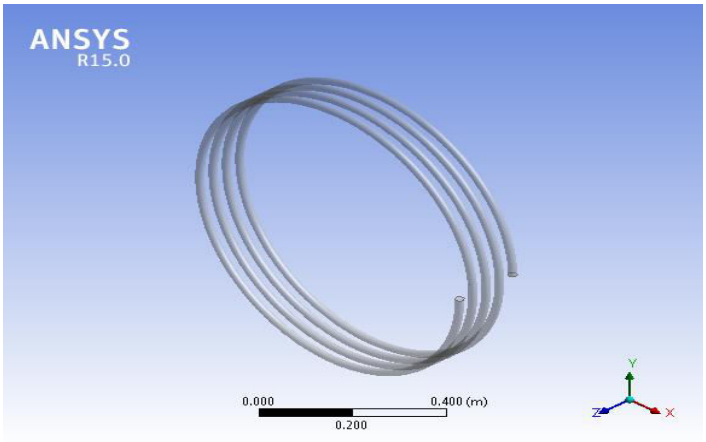

***Figure**: 5.1 CAD model of helical pipe Type - 1.*

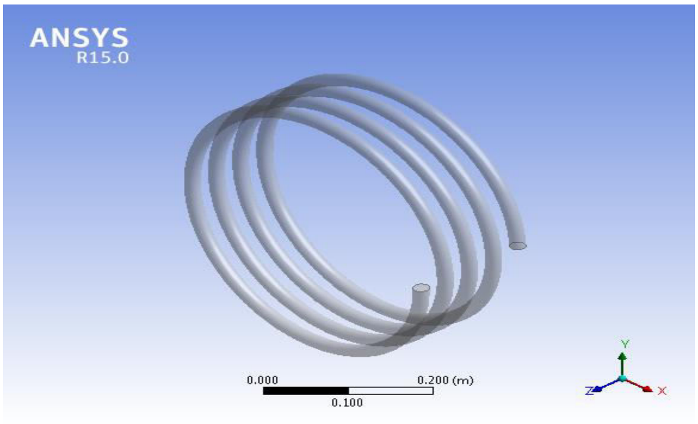

Figure 5.2 CAD model of helical pipe Type - 2.

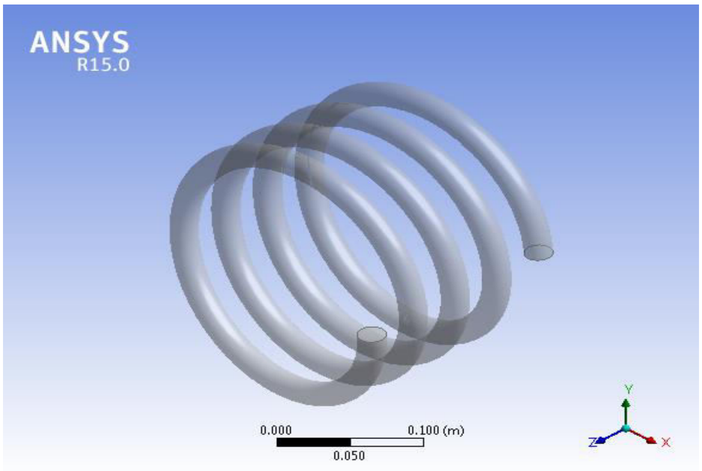

Figure 5.3: CAD model of helical pipe Type - 3.

Meshing of the Domain

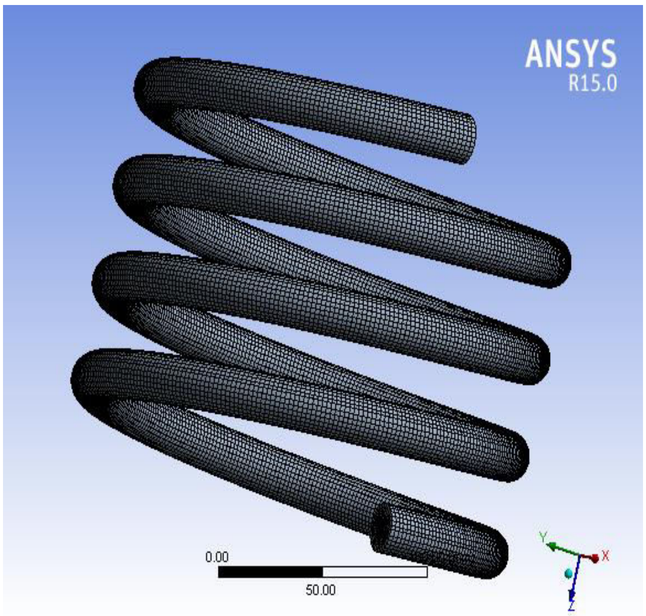

Figure 5.4 Meshed model of Helical Pipe.

VI RESULT AND DISCUSSION

A three-dimensional model has been developed to investigate heat transfer in the helical pipe for heat removing process. A series of numerical calculations have been conducted using commercial CFD code FLUENT 15.0.The results are presented in order to show the effects of temperature distribution with respect to coil diameter and pitch difference also the Reynolds no. in the helical pipe.

The Numerical result has been compared with the base paper Open foam (numerical) results of Anup Kumer Datta et.al.

4.2 Nusselt no. of different shaped helical pipe

Table 4.2 Nusselt number variation of different configuration of helical pipe

Nusselt no. (Different Configurations)				
Reynolds no.	**Coil - 1**	**Coil - 2**	**Coil - 3**	**Coil - 4**
1000	17	19.7	19.7	18.5
1600	18.6	20	17.9	19.2
2200	20.7	22.5	20.2	21
2500	22	23.7	21	22.9
2700	23.9	25	22.3	24.7
3400	27.6	29.2	26	28.8
4100	30	33.2	29.7	31.5

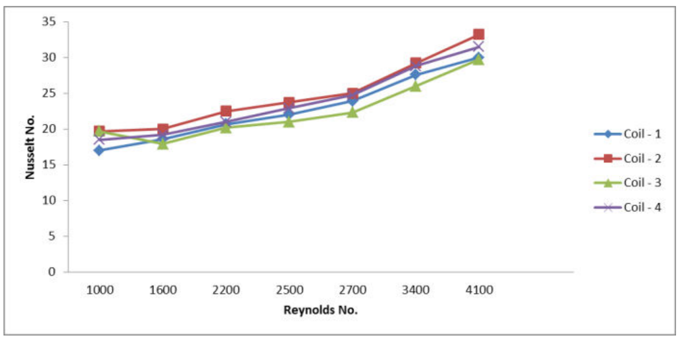

Figure 4.5 Nusselt number variation of different configuration of helical pipe

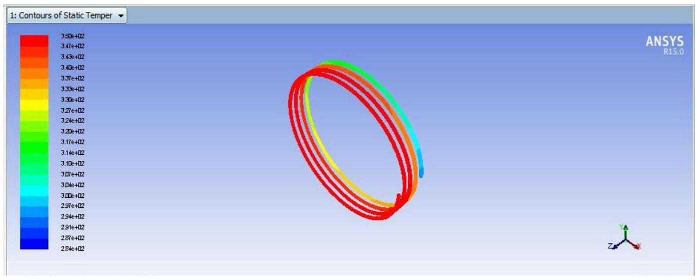

Figure No.:6.1 Temperature variation of helical pipe of type - 1.

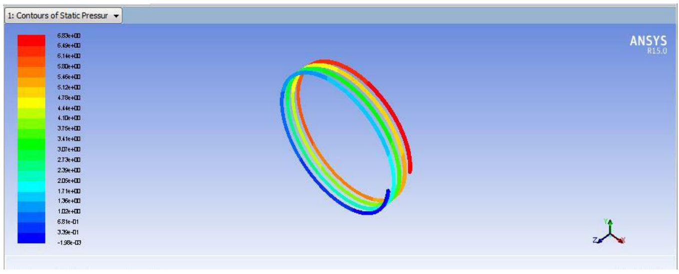

Figure No.:6.2 shows the pressure variation on Type – 1 helical pipe of cooling tower.

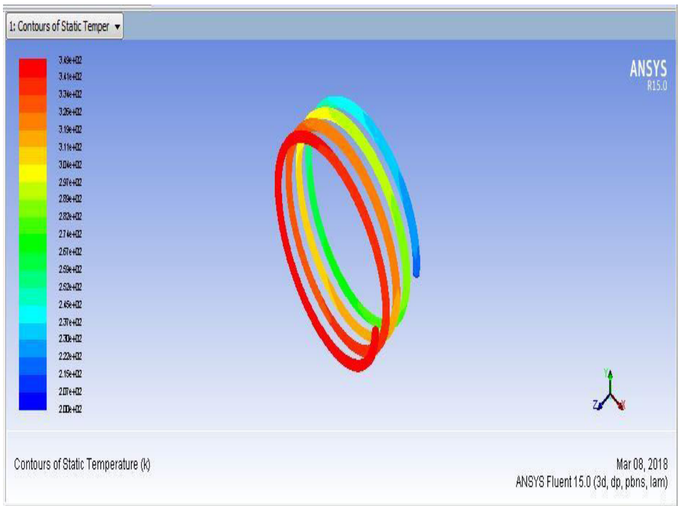

Figure No.: 6.3 Temperature variation of coil – 2 (Type - 2).

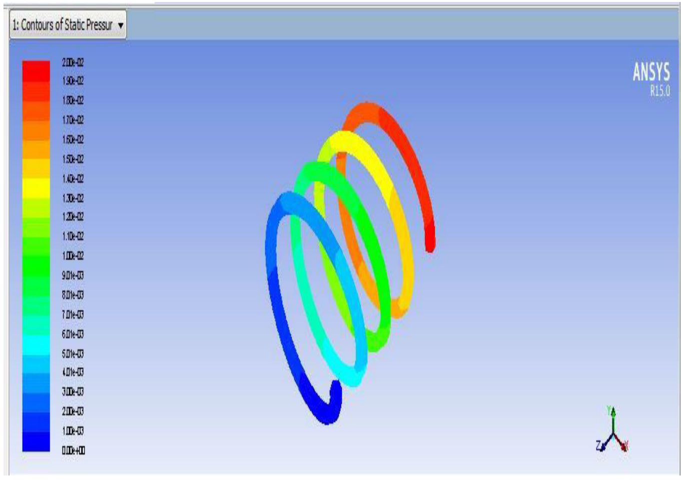

Figure:6.4 *Pressure variation of coil – 2 (Type - 2).*

4.3 Nusselt no. of different shaped helical pipe made of copper foam:

Table 4.3 Nusselt no. of different shaped helical pipe made of copper foam

Nusselt no. (Copper Foam)				
Reynolds no.	**Coil - 1**	**Coil - 2**	**Coil - 3**	**Coil - 4**
1000	18	19.9	16	19
1600	19.6	20.7	17.9	19.4
2200	21	23	20.2	22
2500	22.4	24.9	21	23.4
2700	23.9	26.8	22.3	25.8
3400	28	30	26	28.8
4100	30.7	33.5	29.7	31.6

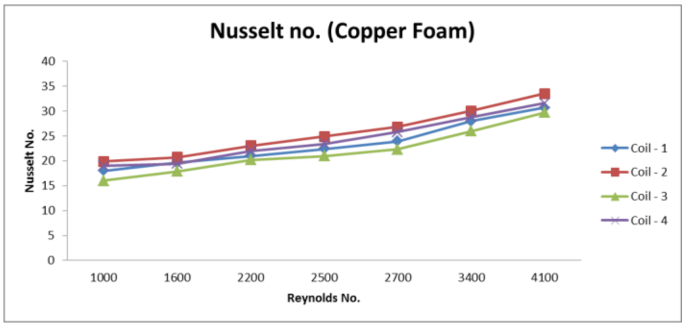

Figure 6.5 Nusselt number variation of helical pipe made of copper foam.

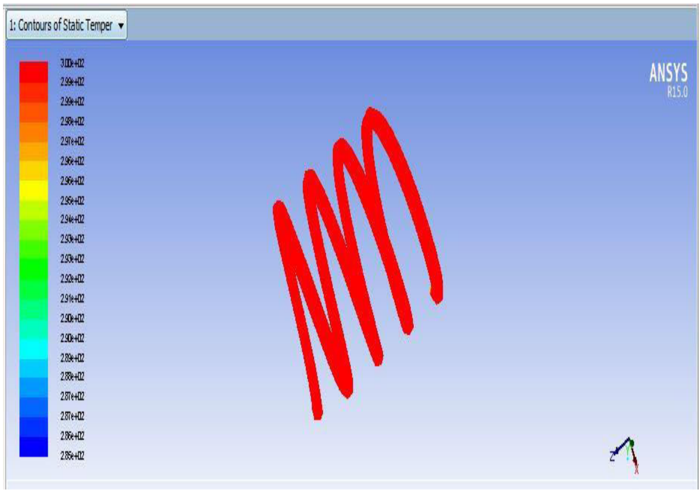

Figure: 6.6 *Temperature variation of Coil – 4 (type - 4).*

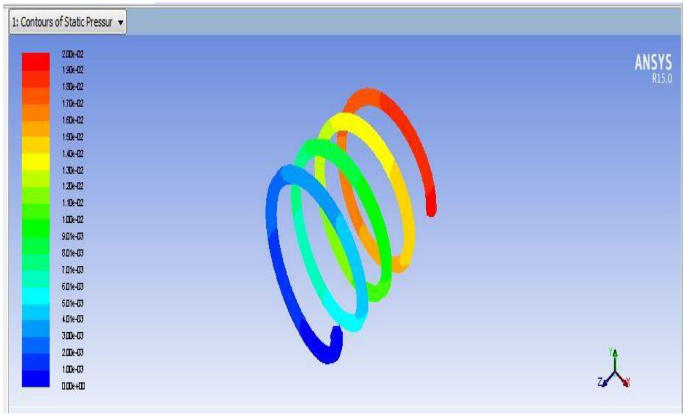

Figure: 6.7 *Pressure variation of helical pipe (type – 4).*

VII CONCLUSION

15.1 Conclusion

1. Computational model has been developed in UGNX 8.0 and analysis has been done in Fluent 15.0.

2. Numerical results are in good agreement with base paper results.

3. The internal consistency of the results confirms the validity of the CFD model.

4. From results, higher value of temperature is found out for different configurations of helical pipe.

5. Coil – 2 with 1mm thickness of copper foam material shows more convergence than other configurations of helical pipe thus result shows improvement of 6.8% average deviation on temperature.

6. Nusselt no. shows 0.73% average on simulation results than base paper results thus convergence on nusselt no. is achieved.

7. Thus numerical simulation of helical pipe with respect to configuration torsion parameter and copper foam shows an optimum result on both temperature and nusselt no.

5.2 Future Scope

1. CFD analysis can also be done for traditional pipe configuration Methodology and Boundary condition.

2. Inclination angle of helix angle can be further varied and its effect can be studied on its performance.

3. Same methodology can be used to check the performance of indirect type of variable shaped helical pipe also.

4. Surface area of fluidized bed should be fixed on different helix angles to increase heat transfer and for better temperature distribution.

5. Velocity of flow could be increased in case of cooling tower process for a higher amount of temperature removal

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