# Comparison On Cfd Analysis Of Acetoacetate /Water & Investigational Analysis Of Heat Transfer Characteristics Of Acetoacetate /Water By Using Tube In Tube And Shell And Tube Heat Exchanger

M.SAI SANDEEP[1], Dr.V. Lakshmikanth Chowdary[2], k.madhu babu[3]

*[1]B.Tech (M.TECH), Mechanical Engineering, Jawaharlal Nehru Technological University, Kakinada. NRI Institute of Technology (NRIIT) Agiripalli, Krishna district, and Andhra Pradesh.*
*[2]MS, M.TECH, PhD, Associate professor in NRI Institute of Technology (NRIIT) Agiripalli, Krishna district, and Andhra Pradesh*
*[3]M.TECH, (PhD), purchasing Ph.D, VIT AP, Mechanical Engineering*

*Email ID: [1]mssd25mech@gmail.com, [2]lucky.19862@gmail.com, [3]k.madhu681@gmail.com*

***Abstract: Cooling is critical to preserve the required effectiveness and reliability in a large range of products such as automobiles, high and medium cogeneration power plants, high power laser systems. Part of heat load magnification and the heat fluxes induce by more industrial products, cooling is one of the industry's main technical troubles such as manufacturing, transport and in microelectronics. The main concept of the paper is to study the LMTD (logarithmic mean temperature difference), Heat transfer Coefficient and Effectiveness (ε) of combined heat exchanger using acetoacetate/water mixture as a function of a diverse mass flow rates. This paper deals with the investigational study on the three different heat exchangers like tube in tube, shell and tube and combined (tube in tube & shell and tube) heat exchanger with acetoacetate/water mixture mostly to check the elevation of convective heat transfer coefficient, LMTD, effectiveness, overall heat transfer coefficient. These conducting tests give a synopsis of, the investigational study of the forced convective heat transfer and flow characteristics of a 25% acetoacetate consisting of 75% water. Acetoacetate/water mixture flow in to a parallel, counter direction in the tube in tube, shell and tube heat exchanger and combined heat exchanger under laminar flow conditions. A maximum increase in the coefficient of convective heat transfer of 56.3% and an effectiveness of 49.6% is recorded. And also compare this investigation with CFD analysis. However, combined heat exchanger provides better heat transfer characteristics than parallel and counter flow tubular and shell and tube heat exchanger due to the multi-pass flow of Acetoacetate/water. The overall heat transfer coefficients, Reynolds number, logarithmic mean temperature difference, the effectiveness of the acetoacetate/water are also considered and the results are obtainable in tabular columns and figures.***

***Keywords: acetoacetate /water, LMTD, Overall heat transfer coefficient, Effectiveness, Nusselt number and Reynolds number, CFD analysis.***

## 1. INTRODUCTION

Heat exchangers are equipment that affects the heat exchange progression between two fluids at distinct temperatures. These heat exchangers are usually categorized according to the method of transferring them. Tube in tube & shell and tube Thermal exchangers are mostly used along with all kinds of heat exchangers. Based on fluid flow, these heat exchangers are again categorized. They are sort of parallel flow, type of counter flow and sort of cross flow. In this experiment, we will manufacture and combine a tube in a fixed tube type tube heat exchanger & shell and tube heat exchanger. Using thermocouples, the efficiency and heat transfer coefficient of the fixed tube in tube Heat exchanger & shell and tube is produced at varying temperatures. Either hot or cold fluid occupies the annular space and other fluid moves through the internal tubes in tube & shell or tube heat exchanger. If a fluid flow in the direction of the other fluid, the flow is said to be parallel and if the fluid flow is contrary to the direction of another fluid flow, the flow is said to be counter flow.

## 2. LITERATUREREVIEW

Vijaykant Pandey et. al. [1] has done research on the effect of geometrical parameters on heat transfer in helical coil heat exchanger at three different mass flow rate 0.005, 0.02 and 0.05 kg/s.
By bending 1000 mm of aluminium tube with a tube diameter of 6,8,10 mm, the helical coil was manufactured and each coil diameter should be 40 mm and 15 mm at the same pitch and at the same length. Increasing the tube diameter of 10 mm and the curvature ratio of 0.25 at mass, he found that flow rate of 0.05 kg/s there is increase in pressure drop of about 12100 Pa (262.275 %) and Nusselt number also increases about 2.25% in comparison to tube diameter 6 and 8 mm and at mass flow rate 0.005 and 0.02 kg/s. This can increase heat transfer in helical coil heat exchangers.

Kumar Shiva et.al [2] on both the straight tube and helical tube heat exchanger, worked. Under similar operating conditions, he compared the CFD results with the results obtained by simulating a straight tubular heat exchanger of the same length. The results showed that helical heat exchangers improved the heat transfer rate over the straight tube by 11 percent. The results of the simulation also showed an improvement in nusselt number of 10 percent for the helical coils whereas pressure drop in case of helical coils is higher when compared to the straight tube.

J.S.Jayakumar et. Al.[3] performed an experimental analysis of the conversion of fluid to fluid heat through a helical coiled tube at various PCDs, diameter and pitch of the inside tube. Using fluent CFD code, heat transfer features were also studied. For all operating conditions, they found that CFD predictions correlate fairly with experimental findings. The effect of coil curvature is to eliminate turbulent upward fluctuations in the flowing fluid. It thus boosts the value of The number of Reynolds needed to achieve a fully turbulent flow. The effect of coil curvature on mass flow rate decreases as the PCD increases and the centrifugal force therefore plays a lesser role. The differentiation between the inner and outer position of the Nu increases. The gap in Nu increases, just as the coil pitch increases. Although the diameter of the pipe is small, the secondary flows are weaker and there is less mixing.

K. Abdul Hamid et.al. [4] Worked on the pressure drop for nanofluid-based ethylene glycol (EG). The nanofluid is prepared at three volume concentrations of 0.5 percent, 1.0 percent and 1.5 percent by the dilution technique of TiO2in-based mixture water and EG fluid in the volume ratio of 60:40. The pressure drop has been observed to increase with the increase in nanofluid volume concentration and decrease with the increase in nanofluid temperature. Compared to EG fluid, he finds that TiO2 is not substantially elevated. Due to the decrease in nanofluid viscosity, the working temperature of the nanofluid can minimize the pressure drop.

M.Balchandaran et.al [5] performed a helical coil heat exchanger experimental a helical Coil heat exchanger experimental. He discovered that the flow rate of hot fluid mass increases, the total heat transfer coefficient, the amount of Nusselt, the coefficient of cold fluid heat transfer and thus increases efficiency. This is attributable to the coil's helical nature and the cold fluid's increased flow distribution.

Fakoor et.al. [6] Studied the pressure drop characteristics of nano fluid flow within a vertical helical coiled tube for laminar flow conditions. Experiments were carried out by changing the diameters of the pitch circle and the diameters of the conduit as well. The findings revealed that the use of helical tubes raises the pressure drop exponentially instead of straight tubes.

Tushaar A Sinha et. al. [7] has done experimental investigation into the thermal properties of nano fluid, and he found that with the increase in sonication time, the thermal conductivity of nano fluid increases, but with it, and the viscosity of nano fluid decreases. Thermal conductivity also decreases and viscosity increases with the rise in settling time. The thermal conductivity and specific heat of the Nano fluid increases and viscosity decreases with the rise in temperature.

## 3. COMPUTATIONAL FLUID DYNAMICS (CFD)

Computational fluid dynamics, as the name suggests, is a topic that deals with the computational approach to fluid dynamics with the numerical solution of the fluid dynamics equations, even though it is also called computational fluid dynamics; it does not only deal with the fluid flow equations, it is also sufficiently generic to be able to solve them As well as the equations that decide the rates of chemical reaction and how the chemical reaction proceeds and mass transfer takes place, all of these topics can be tackled in the same format together. This description helps one to deal with a very complex flow scenario in a relatively quick time, so that an engineer will be able to model and see how the flow takes place and what sort of temperature is distributed for a specific set of conditions. In order to make adjustments to the parameters under his influence, we should adjust the way these things happen. So, in that case, CFD is an outstanding design tool for an engineer. It is also a perfect method for evaluating a reactor or machinery that does not perform well due to traditional industrial applications.

## 4. METHODOLOGY

The heat exchangers are designed normally by using either Kern’s method or Bell-Delaware method. Kern’s method is mostly used for the preliminary design and provides conservative results whereas; the Bell-Delaware method is more accurate method and can provide detailed results. It can predict heat transfer coefficient with better accuracy. In this paper we have designed as fixed tube type heat exchanger to cool the water from 70 to 40 by using Acetoacetate/water at room temperature.

*A. For Tube in tube Heat Exchanger, shell and tube heat exchanger and for combined heat exchanger*

- Firstly the Acetoacetate/water is heated to the required temperature with an immersion heater.
- Then supply the hot Acetoacetate/ water in inside of the tube and cold Acetoacetate/water is supplied to outer tube.
- Experiment is repeated for different mass flow rates and at each flow rate the temperature value of hot Acetoacetate/water inlet noted down the readings of inlet and outlet temperatures in the observation table.
- After getting the values in the observation table, calculate the required parameters using mathematical expressions in tube in tube heat exchanger.
- First parallel flow observations were taken and then interchanged the pipe connections to carry out the same procedure for counter flow arrangement.

*B. Objective in selection of Acetoacetate as a fluid in heat exchanger*

Acetoacetate is produced and disposed of in the human body by ordinary metabolic processes. It typically occurs in diabetes mellitus. It is developed by people with diabetes in greater amounts. Reproductive toxicity testing indicates that it may cause reproductive problems with low potential. Keto genicicdiets are used to treat epileptic attacks in babies and children with recalcitrant refractory epilepsy to improve ketone bodies in the blood (Acetoacetate, β-hydroxyl butyric acid and acetoacetic acid).

*C. Preparation of Acetoacetate/Water Mixture*

It is an important stage under taker while mixing both fluids by using measuring jar mix the 25% of Acetoacetate liquid and 75% of water by measuring with 2-liter jar 0.5 liters Acetoacetate and 1.5 liters water as shown in the figure 2. The properties of the mixture (Acetoacetate/ water) as shown in Table I

Table-I: Properties of mixture (Acetoacetate/ water) fluid

| **S.No** | **Property** | **Liquid Acetone-water mixture fluid** |
|---|---|---|
| 1. | Specific heat (c), J/kg-K | 2148 |
| 2. | Thermal Conductivity (k), W/mk | 0.5234 |
| 3. | Density (ρ), $kg/m^3$ | 949.6 |
| 4. | Thermal diffusivity (α), $m^2/s$ | $1.351 \times 10^{-7}$ |

**Step-1**

CFD analysis of tube in tube and shell in tube heat exchanger is done by using analysis software i.e. Ansys 19.0

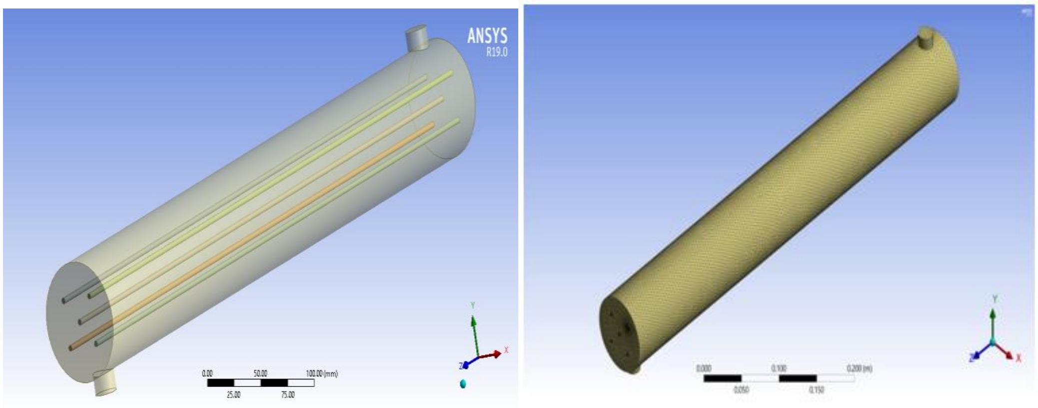



Fig-1 geometry and meshing of shell and tube heat exchanger

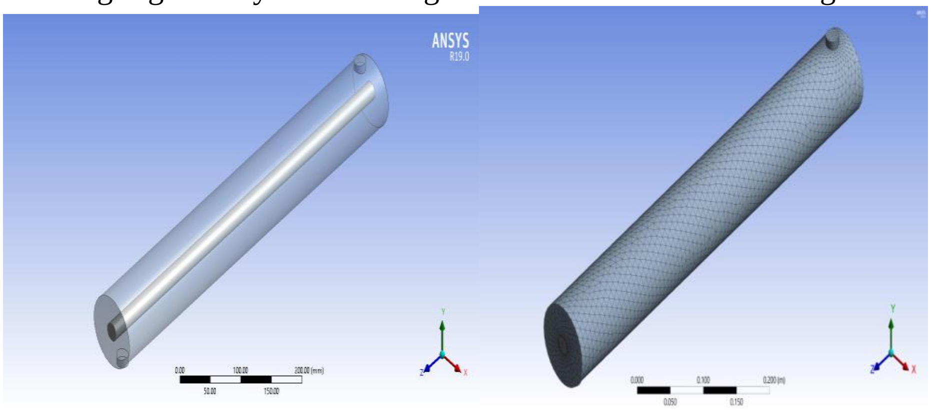



Fig-2 geometry and meshing of tube in tube heat exchanger

## 5. RESULTS AND DISCUSSION

*Mathematical Observation at Various Mass Flow Rates to Calibrate Heat Transfer rate Effectiveness*

Initially, the experimental setup is verified for any defects by allowing the water to flow in the heat exchanger. Then, Acetoacetate/water is used as the fluid to exchange the heat. The inlet and outlet temperature of the hot and cold fluid is measured using K type thermocouple and the temperature indicator. This is like digital thermometer. Experimentation was used to measure the hot fluid inlet temperature and the hot fluid outlet temperature, the cold fluid inlet temperature and the cold fluid outlet temperature at distinct Mass flow rates. Based on the mass flow rate and several parameters, the Reynolds number (Re) was calculated, several parameters such as Overall heat transfer coefficient (U), Logarithmic mean temperature difference (LMTD), Effectiveness (ε), Convective heat transfer coefficient (h) W / m2k and was calculated using equations.

Table-II: Experimental Results of Acetoacetate/Water fluid of Parallel flow by varying mass flow rate

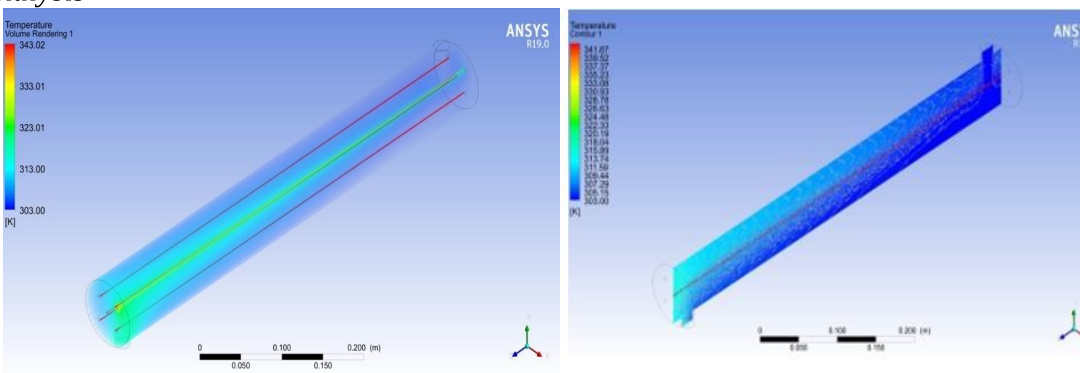
| Parallel flow heat exchanger arrangement | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Mass flow rate (kg/sec) | Tube in tube | | | Shell and tube | | | Combined heat exchanger unit | | |
| | LMTD (°C) | (ε) | h (W/m²K) | LMTD (°C) | (ε) | h (W/m²K) | LMTD (°C) | (ε) | H (W/m²K) |
| 0.143 | 9.34 | 0.21 | 144.63 | 11.34 | 0.24 | 149.90 | 14.02 | 0.464 | 155.08 |
| 0.0762 | 10.12 | 0.18 | 116.35 | 13.69 | 0.22 | 113.67 | 16.07 | 0.443 | 118.34 |
| 0.0489 | 11.29 | 0.163 | 97.17 | 15.81 | 0.20 | 101.42 | 18.14 | 0.476 | 106.87 |

Table-III: Experimental Results of Acetoacetate/Water fluid of Counter flow by varying mass flow rate

| Counterflow heat exchanger arrangement | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Mass flow rate (kg/sec) | Tube in tube | | | Shell and tube | | | Combined heat exchanger unit | | |
| | LMTD (°C) | (ε) | h (W/m²K) | LMTD (°C) | (ε) | h (W/m²K) | LMTD (°C) | (ε) | h (W/m²K) |
| 0.143 | 10.03 | 0.275 | 148.32 | 12.08 | 0.311 | 153.06 | 13.03 | 0.391 | 158.53 |
| 0.0762 | 11.89 | 0.187 | 119.97 | 13.37 | 0.242 | 122.68 | 14.89 | 0.305 | 126.37 |
| 0.0489 | 13.45 | 0.152 | 103.36 | 15.18 | 0.187 | 108.92 | 16.82 | 0.264 | 110.83 |

The LMTD of Acetoacetate and water mixed fluid in a tube in tube, Shell and tube &combined Heat exchanger concerning the Mass flow rate (m) which varies from 0.0489 to 0.143 kg/sec in the counter flow heat exchanger as shown in Figure 4. The increase in LMTD of mass flow rate0.142 kg/sec is observed to be 23.34% in Combined Heat Exchanger, when comparing with tube in tube Heat Exchanger. The combined heat exchanger is 9.13 % increment than shell and tube heat exchanger by using an Acetoacetate and water mixture fluid.

A. *Temperature Distribution in Shell and Tube, Acetoacetate /Water as a Fluid by using CFD analysis*



ISSN 2515-8260 Volume 07, Issue 08, 2020

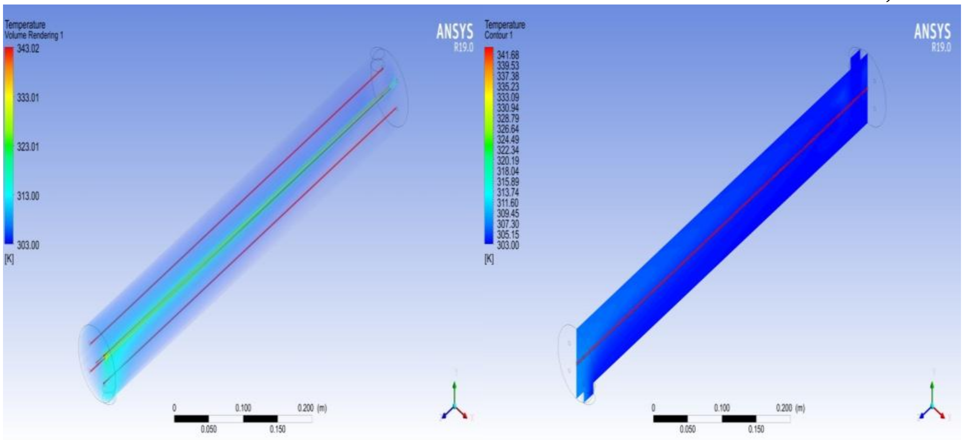



**Fig-3** Distribution of Temperature in Shell and Tube, Acetoacetate /Water as a Fluid.

CFD analysis has been carried out for shell and tube and tube in tube heat exchanger which is subjected for different boundary conditions. The numerical study considers the effect of natural fluid that is, Acetoacetate /Water on the flow and heat transfer characteristics of tube.

B. Temperature Distribution in Tube in Tube, Acetoacetate /Water as a Fluid by using CFD analysis

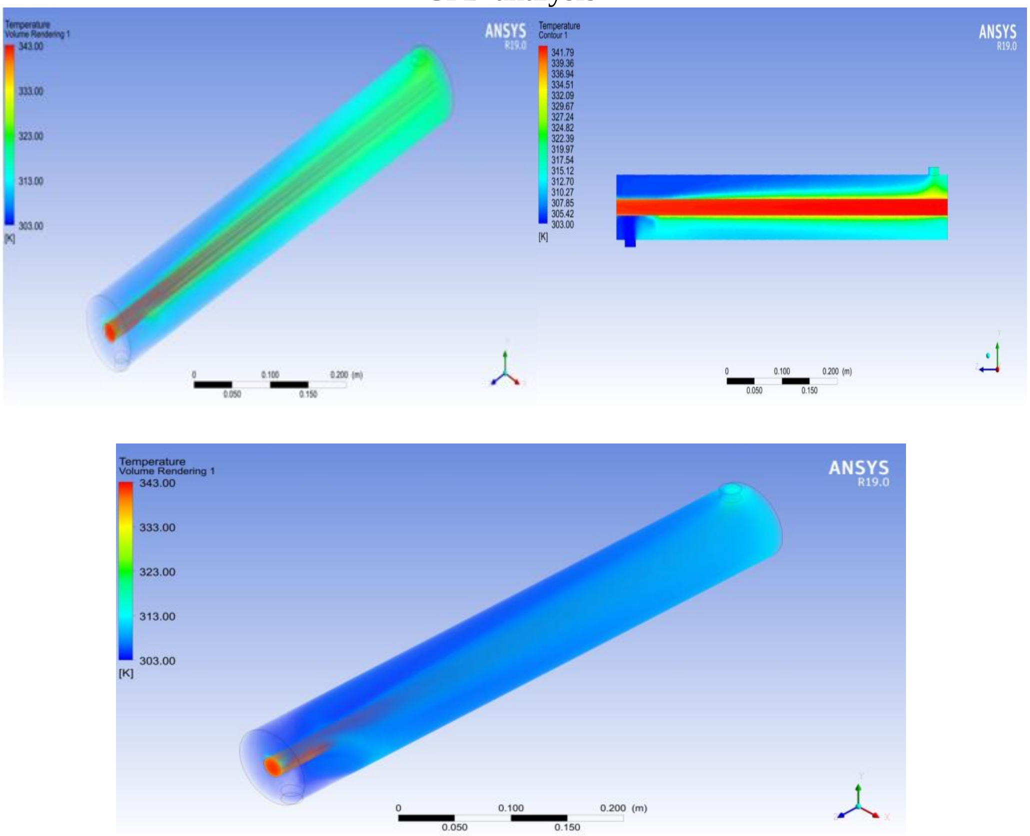



Fig-4 Distribution of Temperature in Tube in Tube, Acetoacetate /Water as a Fluid.

*C. Velocity flow in Shell and Tube, Acetoacetate /Water as a Fluid by using CFD analysis*

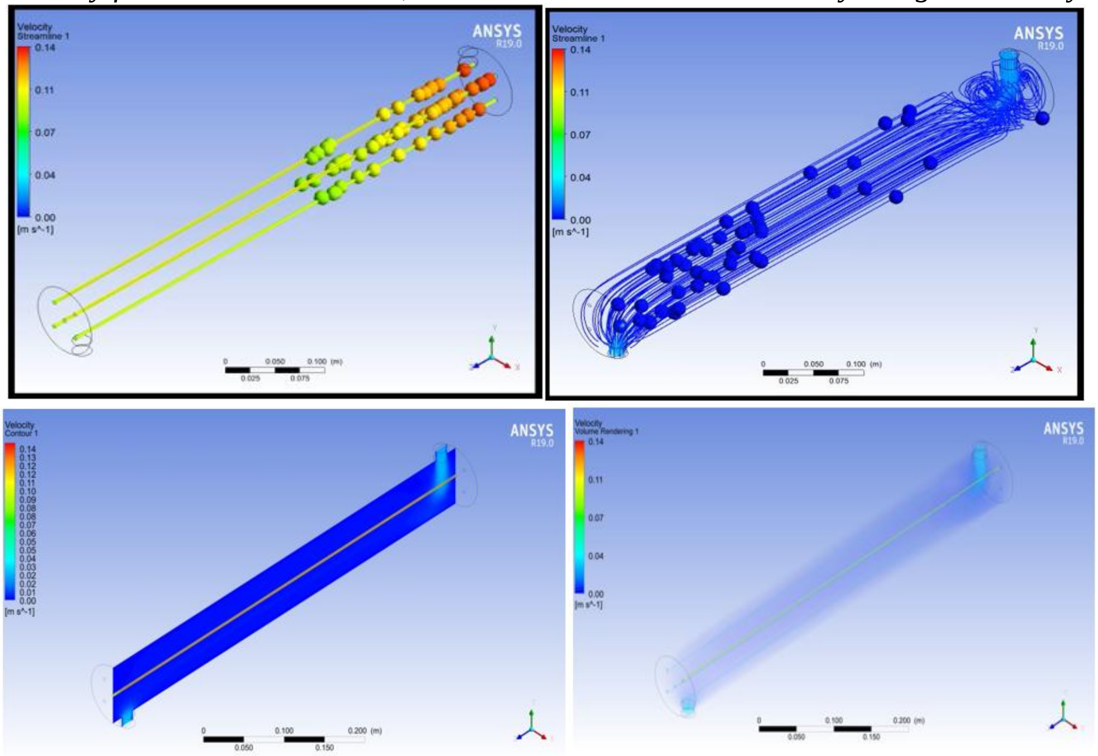
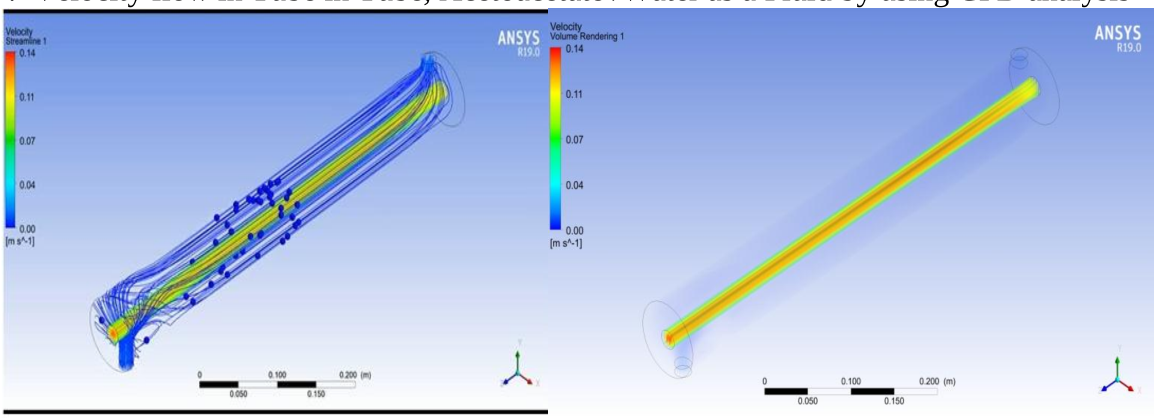
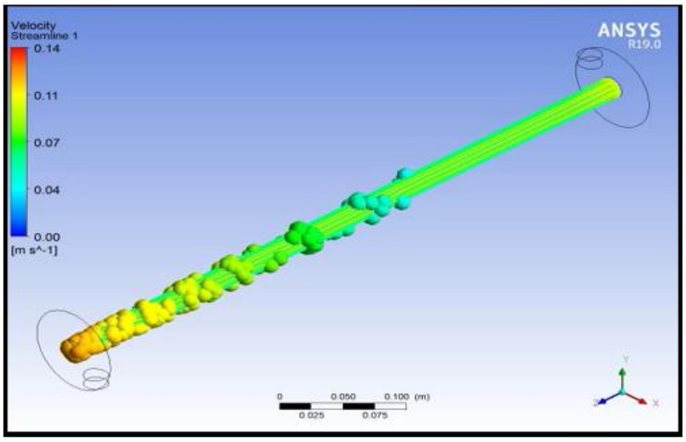



Fig-5 velocity flow in Shell and Tube, Acetoacetate /Water as a Fluid.

D. Velocity flow in Tube in Tube, Acetoacetate /Water as a Fluid by using CFD analysis





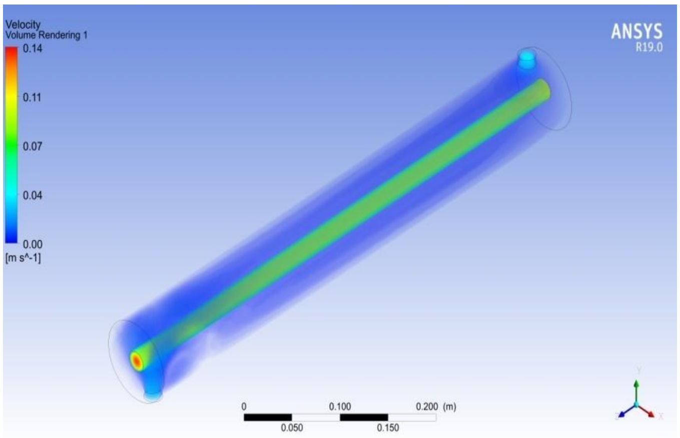




Fig-6 velocity flow in Tube in Tube, Acetoacetate /Water as a Fluid

From above it is clear that when we used the Acetoacetate /Water as a Fluid then pressure and velocity increase in shell and tube in tube heat exchangers. From that of the CFD observation the turbulence of fluid increases cause of these increases its heat transfer rate. The numerical study considers the effect of Acetoacetate /Water as a fluid that is lower than the CFD analysis on the flow and heat transfer characteristics of tube. The thermal properties of fluid are lesser as compared to Acetoacetate /Water. Acetoacetate /Water fluid particles, which increase the thermal conductivity and effectiveness of heat exchangers because of the thermal properties of this Acetoacetate /Water fluid, better than fluid water.

Table-4 CFD Analysis Results

| **Velocity(m/sec)** | **Cold water out (k)** | **Hot water out (k)** | **Thermal conductivity ($w/m^2k$)** |
|---|---|---|---|
| 0.01 | 319.14 | 334.61 | 112.87 |
| 0.02 | 314.23 | 340.20 | 124.06 |
| 0.03 | 311.83 | 339.71 | 158.20 |

| **Velocity(m/sec)** | **Cold water out (k)** | **Hot water out (k)** | **Thermal conductivity ($w/m^2k$)** |
|---|---|---|---|
| 0.01 | 309.24 | 339.51 | 163.40 |
| 0.02 | 306.40 | 339.17 | 128.27 |

| | | | |
|---|---|---|---|
| 0.03 | 305.44 | 338.55 | 115.83 |

## 6. CONCLUSION

In this paper, analytical investigations are done on the shell and tube, tube in tube heat exchanger, to determine velocity flow and temperature distribution of Acetoacetate /Water flowing under turbulent flow conditions. By observing the CFD analysis results, we know that the fluid which has high thermal conductivity that fluid will give high effectiveness. The temperature difference between the mathematical and CFD analysis give some difference but in these cases of investigation the thermal conductivity of the heat exchanger very effective because of the Acetoacetate /Water fluid. A maximum enhancement in Convective Heat Transfer coefficient is 163.40 W/m2K of 56.3% and effectiveness of 49.6% at combined heat exchanger.

## REFERENCES

[1] Vijaykant Pandey, Dinesh Kumar Koli 2015, “CFD analysis of helical coil heat exchanger” International Journal of Engineering Associates, Volume 4, Page 95-99.
[2] Jayakumar J. S., S.M. Mahajani, J.C. Mandal, P.K. Vijayan, Rohidas Bhoi, 2008, “Experimental and CFD estimation of heat transfer in helically coiled heat exchangers” Chemical Engineering Research and Design, Volume 86, Page 221-232.
[3] K. Abdul Hamid, W. H. Azmi, RIzalmanMamat, N. A. Usri and Gohalam Hassan Najafi 2015, “Effect of Titanium Oxide Nanofluid Concentration on Pressure drop” ARPN Journal of Engineering and Applied Sciences, Volume 10, Page 7815-7820.
[4] M. Balachandaran 2015, “Experimental and CFD study of a Helical Coil Heat Exchanger using Water as Fluid” International Journal of Mechanical and Production Engineering, Volume 3, Page 87-91.
[5] Fakoor-Pakdaman, M.A. Akhavan-Behabadi,P. Razi 2013, “An empirical study on the pressure drop characteristics of Nanofluid flow inside helically coiled tubes” International Journal of Thermal Sciences, Volume 65, Page 206-213.
[6] Vinita Sisodiya, Dr. Ankur Geete 2016 “Heat Transfer analysis of Helical coil Heat Exchanger with Al2O3Nanofluid” International Journal of Engineering and Technology, Volume 3, Page 366-370
[7] Tushar A. Sinha, Amit Kumar, Nikhilesh Bhargava and Soumya S Mallick 2014, “An Experimental Investigation into the Thermal Properties of Nano Fluid” Applied Mechanical Engineering, Volume 4, Issue 1
[8] Saurabh Sharma & ritesh kumar dewangan-2017. “Review of the shell and tube heat exchanger using the different orientation angle of the baffle”.
[9] Roopesh Tiwari, Dr.Govind Maheshwari. “Effectiveness and Efficiency Analysis of Parallel Flow and Counter Flow Heat Exchangers”. International Journal of Application or Innovation in Engineering & Management (IJAIEM) Volume 6, Issue 6 pp: 314-319, (2017).
[10] Ahmadghozatloo, M-Niassar. “Convective Heat transfer of graphene nanofluids in Shell and tube Heat exchanger”.
[11] P.B.Dehankar, K.K.Pandhare, M.J.Vagare, V.M.Nerlekar.“A Double Pipe Heat Exchanger –Fabrication and Standardization”. International Journal on Recent and Innovation Trends in Computing and Communication Volume: 3 Issue: 4 pp: 1845-1847(2015).

[12] H.S.Dizaji, et al. "Experimental studies on the Characteristics of Heat transfer and pressure drop for the new arrangement of corrugated tubes in a Double pipe Heat exchanger" International journal of thermal sciences-2015.

[13] Karthik Silaipillayar Puthur, Hassan khurshid. "The Design of shell and tube heat exchangers-a review". International journal of mechanical and production engineering research and development (IJMPERD) vol. 9, issue 1 pp: 88-102(2019).

[14] Durgesh bhatt et al. "Shell and tube heat exchanger performance analysis". Issue on 9-2014, International journal of science and research, volume 3.

[15] Kanade Rahul H, Kailash B A, Gowreesh. "Heat transfer enhancement in a double pipe heat exchanger using CFD". International Research Journal of Engineering and Technology, (IRJET). Volume: 02, Issue: 09 pp: 419-430(2015).

[16] K.L.Logeshanet al."Process and Mechanical Design of shell and tube heat exchanger". Special issue 8-2016, International journal of innovative research in science, engineering and technology, volume 5.

[17] VishalHAcharya. "A Review on Investigation of Shell and Tube Heat Exchanger for Different Parameter". International Research Journal of Engineering and Technology (IRJET) Volume: 04Issue:02 pp:875-878(2017).

[18] Alokvyaset al. "Experimental analysis study to improving the performance of tubular heat exchangers". Issue 6-2013, Journal of engineering research and applications, volume 3.

[19] L.Godson, K.Deepak. "Heat transfer Characteristics of Silver / Water nano fluids in a Shell and tube Heat exchanger". Department of mechanical engineering, Karunya University, Tamil nadu, India.

**Author's Profile:**

M.SAI SANDEEP, B.Tech (M.TECH), received his B.Tech degree in mechanical engineering from HITS, in 2018 College affiliated to Jawaharlal Nehru Technological University, Kakinada. Now he is doing M.Tech in NRI Institute of Technology (NRIIT) Agiripalli, Krishna district, and Andhra Pradesh from 2019-2021 onwards. His Area Of interest on THERMAL Engineering.

Dr. VELIVELA LAKSHMIKANTH CHOWDARY, MS, M.TECH, PhD, received his Ph.D degree in lean auto machine in 2019. Now he is working as Associate professor in NRI Institute of Technology (NRIIT) Agiripalli, Krishna district, and Andhra Pradesh from 2019-2021 onwards


K.madhu babu, M.TECH, (Ph.D), doing Ph.D in VIT AP, Complete M.Tech in LBRCE Mylavaram on the area thermal engineering. He completed his B.Tech in Kodada Sana College Of Engineering And Technology Department Of Mechanical Engineering.