EVALUATING THE ROLE OF SINGLE FLOW CONCENTRIC HEAT EXCHANGER PIPE IN MODERN SCIENCE

Abstract

This research work is mainly focuses on the importance and significance of a single flow concentric type heat exchanger in the modern science of heat transfer. Impact of such single flow heat exchanger on scientific theories regarding heat transfer and efficiencies is described. In order to achieve research objectives, researchers have taken extensive literature review in order to continue the research work with the help of relevant working principles of fluid dynamics and other functional issues. From the literature review, it can be stated that single flow concentric type heat exchanger works on mainly three principles of fluid analysis with dynamic considerations. Heat is transferred in three basic methods of heat transfer. Heat is conducted through the solid mediums and is transferred in a convective and radiative way through a fluid medium. In case of a heat exchanger, radiative heat loss is minimal and can be neglected for calculation purpose. Heat is transferred through the wall of tube structure in conduction process of heat transfer and it propagates through the exchanger fluid in a convective way. Primary method research is selected in order to achieve respective research objectives. To obtain an ANSYS analysis of this specific type of heat exchanger, a virtual sample model in simplest form is taken and relevant dimensions regarding design criteria are taken along with a significant scale ratio which would be suitable for 3D prototyping. With the help of ANSYS software, virtual models are analyzed based on different contours. The significance of such contours are described and a numerical analysis is done for the virtual sample of a concentric heat exchanger in CFD analysis method. This analysis part helps respective readers in understanding different factors and assumption, which is considered to avoid the complexity of a problem. Impact of a heat exchanger on environmental issues is taken into consideration. The Certain recommendation is provided by a researcher with an intention of improving efficiency and work design in case of single flow concentric heat exchanger. Parameters affecting the efficiency of this heat exchanger are identified in order to reduce loss. There are still a lot of scopes of future work with a possibility of attaining better efficiency.

Acknowledgement

Preparing this research study has been one of my best experiences. This research has provided me a lot of opportunities to enrich my knowledge about this research topic and analytical skills. It will help me in finding inspiration for further researching on this topic. I would like to thank my supervisor ………………………………………….. for continuous guidance and constant support during preparing this research.

Heartfelt Thanks and warmest wishes,

Yours Sincerely,

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Chapter 1: Introduction

1.1 Introduction

The research focuses on some basic significance of the single flow heat exchanger pipe as well as its relevance and contribution in the modern science. Some essential and basic theories of heat exchanger pipes are the illustrative heart on the efficiency and safety regarding different purposes.

Heat exchanger equipment builds with the efficiency of heat transfer from one medium towards another medium without mixing the two. These two media can separate from one another by the conductive and solid structure for preventing the mixing of two materials. The concentric heat exchanger pipe functions on the thermodynamic laws, various metals used for the heat exchanger. Energy destruction, entrench or entropy generation can evaluate during different steps of the mass flow of heat.

The heat exchanger has an important role for operating the contribution of the efficiency of heat in different processes. A concentric heat exchanger generally consists of two separate tubes that are arranged concentrically, therefore one of the two fluids flows within the tube whereas another flows through the annulus. As asserted by Ali *et al.* (2016), principally the concept of heat transfer illustrates the flows of the energy due to the vast differences in their relative temperature. The transfer of heat generally happens via one method or by the combination of three modes of heat transfer. These three models include Conduction, Convection and radiation.

1.2 Background

Here the concentric heat exchanger focused based on the primary theory regarding the forced convection for a parallel passing of different fluids in different temperature. In most organisations, some heat exchanger devices are principally use for air conditioning, food processing and material processing. The devices are driving different temperatures for passing the streams of any fluid with the extreme difference in temperature in each pipe. As mentioned by Said *et al.* (2016), this mechanism is principally used in the sewage treatment, petrochemical plants, and power station and or petroleum refineries; therefore it has the enormous significance in the modern science. With the modern technologies, different devices are emerging as well as becoming more compact to fulfil some basic requirements for improving the efficiency of that particular device. As commented by Kundu *et al.* (2016), different theories explained to calculate the rate of change of heat could be increases with the help of constraints through its definite path. In the constraint, the spaces are limited as the parameter can hardly change. As asserted by Kumar (2013), to define the proper effectiveness of any heat exchanger, scientists need to evaluate the possibilities of heat transfer that can achieve hypothetically through a counter flow exchanger of a specific length. Therefore, the fluids will experience the temperature difference in the single flow concentric pipe. Here, the pipe material will help to measure the increasing or decreasing amount of heat and calculate the rate of heat transfer within the concentric pipe. As commented by More *et al.* (2016), here the design of the constraints needs to consider as a perimeter of the transformation of heat. The heat exchange procedure is widely accepted in different industries to measure the generation of heat as well as the engine coolant flow through radiation of airflows and coils in various instruments.

Proper inspection regarding the generation of steam in a single concentric pipe is critical for the operation of heat flow in nuclear power organisations. As asserted by Imran *et al.* (2015), an automatic heat flow and detection procedure for the inspection regarding the generated current is measure based on several combinations of the detection system to prevent as well as predict the failure of any measurement. As asserted by Soni *et al*. (2015), due to increase capacity of any plant, very differences of temperature of the fluids or transformation of greater heat from any single concentric pipe. As commented by Bhadouriya *et al.* (2015), during such incident, an outlet temperature of any one of particular streams can depart from the optimum condition of the exchanger tube. Basic disadvantages of operating such heat exchanger instruments may continue high energies of their interrelated equipment.

The harmful effects regarding the capacity of any plant should measure to improve the services of heat exchanger pipe and to upgrade the heat exchanger engineering. As mentioned by Mangtani *et al.* (2016), this helps to identify the optimal condition of any types of equipment, ensure better result and enrich the benefits for achieving improvement of such equipment. As commented by Sadeghzadeh *et al.* (2015), heat exchanger refers to a device that transfers energy from one fluid towards another, therefore exchanger design and analyse both the method of conduction as well as convection. Radioactive transfer of heat between the environment and the exchanger is neglect until it becomes an uninsulated exchanger and the external surface becomes very hot. As asserted by Motlagh *et al.* (2013), nowadays, some heat exchanger reveals some source of different issues regarding the application and resulting in some poor plant.

Current research shows that the fouling regarding the heat exchangers principally refers to the deposition as well as accumulation of some unwanted substances from the internal as well as an external surface of different processing equipment in a plant. As commented by Salviano *et al.* (2016), the scientist suggested that concentric heat exchanger equipment should monitor properly for maximising the refinery yield, reducing the processing cost as well as minimise the fouling regarding a heat exchanger. As commented by Han *et al.* (2015), the inventors currently unable to illustrate the proper monitoring of the concentric heat exchanger pipe which will help to calculate heat transfer and its efficiency time to time.

1.3 Rationale

In different circumstances, existing heat in the exchanger may lead adequate pressure as well as temperature that cause damage in the optimised process. As commented by Bhadouriya *et al.* (2015), the temperature rising causes affects on the environment. Pollutions and emissions from such equipment will decrease the acceptable condition of the environment. As commented by Bhadouriya *et al.* (2015), a concentric heat exchanger can fail its mechanisms for many reasons, due to the excessive heat generation vibration of the tube may occur, that can lead causes of tube leaks on that place where one tube come to the contact with adjacent one. Many industries and laboratories require the simultaneous exchange of heat between two or more than two fluids. As commented by Levenspiel (2014), there are different possibilities in the combination of a two-fluid heat exchanging operation in the multiplied arrangement of a concentric heat exchanger.

The concentric heat exchanger is principally use for the transmission of heat between different fluids at the different temperature without mixing the fluids with each other. As commented by Farokhnia (2016), regarding the uses of the concentric heat exchanger there are issues such as tubular exchanger that contains tubes and shell. These are a vital category of equipment in some industries and are used for heating, preheating, condensation, evaporation or cooling purposes. Corrosion and fouling generally cause minor or major problems for different industries. As asserted by Cavazzuti *et al.* (2015), lots of production of heat is observed on the outlet of the equipment that will persuade sudden pressure towards the environment, increasing temperature will different strategies on an environment. The heat exchangers include the process of flow sheets in different industrial plant and play an important part in modern science. As asserted by Diamond *et al.* (2014), in different industrial processes concentric heat exchanger used to minimise the loss of heat in the atmosphere to recover the amount of heat produces in that during discharge stream of equipment. Sometime the concentric heat exchanger is used to reduce the total heat in the process stream recycle from the late stage towards the previous stage. As mentioned by Hussien *et al.* (2016), for all cases, the engender entropy generally minimise by reducing the generated heat in a particular system.

The modern science incorporates some mechanism for produce electricity in the form of primary as well as non-renewable sources of energy that are finite in the environment. Technologists and inventors illustrate that the concentric heat exchanger provides service to reduce the harmful effect of electronic equipment. It needs to evaluate the transfer of heat towards residual as well as industrial application to motivate the research and improve the performances of different types of equipment. It is an issue now because the single pipe heat exchanger is a crucial device that used in various real-world applications. The cost effectiveness of a single pipe concentric heat exchanger should be considers as an important attribute in the research work. Increasing surface area, reducing fouling or less heat leakage are the different parameters that need to develop for getting the exact measurement of heat in industrial plants or research laboratories. Heat exchanger pipes generally play a vital role in the reduction of environmental pollutants as well as cause emission and improve sustainable equipment. Concentric heat exchanger principally facilitates the changes of the heart that generate between two fluids and they have differences in the temperature. Engineering software on the heat exchanger is designing new heat exchanger for avoiding tube vibration that is causes due to the improper thickness and arrangement as well as spacing of different metal of the tubes.

The research sheds light on the proper measurement of the generated heat, which will help to evaluate the efficiency of a heat exchanger that can help to monitor the equipment in the end. Different parameter regarding the emission of heat in the environment is evaluates in the research to reduce the extreme thermal efficiency of a heat exchanger. Numerous stimulators are discussed for investigating the enhancement of heat transfer method and modification of the divergent-convergent single pipe concentric exchanger. To make people sure about the performance of effective concentric heat exchanger pipe, the concentric heat exchanger has to meet some design specification to remove the fouling as much as possible. Nowadays, the modern science has developed some technologies in the concentric heat exchanger to produce electricity from the non-renewable resources that are infinite in nature. These will help to reduce the emission of heat in the environment as well as decrease different issue regarding the single flow concentric pipe.

1.4 Research aims

The aim of the research work is evaluating the significance of single flow concentric heat exchanger pipe in the application of modern science and industrial plants. This research will help to identify the contribution and importance of the heat exchange through the single flow concentric pipe.

1.5 Research Objectives

Some basic objectives of the research work will be-

1. To identify some specifications regarding the single flow concentric pipe
2. To evaluate the importance of single flow concentric heat exchanger in industry and daily life
3. To access and examine the contribution of the single flow concentric heat exchanger towards the applications in modern science
4. To recommend different way to improve heat exchanging techniques for the benefits of the society

1.6 Research Questions

What is the different specification of the heat exchanging through the single flow concentric pipe?

1. In what way the data can be evaluated for the importance of the single flow concentric heat exchanger?
2. How can scientists access and examine the contribution of single flow concentric heat exchanger in the application of modern science?
3. What will be the different techniques to improve a single flow heat exchanger for the benefitting environment?

1.7 Significance of the Study

The illustration of the contribution of a concentric heat exchanger in the research will help to discover different methods that will improve the production and manufacture of those equipment. The source of energy for particular equipment is limited. This research on concentric heat exchanger pipe will help to reduce energy consumption and provide benefits for different developmental as well as scientific endeavours. The energy conversion remained the preliminary function in different research institution and industries.

In some circumstances, the inefficiency of the energy conversion persuades waste of the energy source. Therefore, the concentric heat exchanger improves the conversion of heat in specific equipment. The concentric heat exchanger principally performs an energy balance on the specific heat exchanger. The research work helps to identify some key variables that are preliminary affecting the heat transfer as well as measure the quality of heat to execute the emission towards the environment. This research work based on evaluating the role of single flow concentric heat exchanger pipe in the modern science. This work principally helps to identify several techniques that will benefit for the environment as well as our society. This study will evaluate the importance as well as the significance of the concentric heat exchanger in different industrial plants and laboratories. The research will help to set different pattern of changes of the pressure regarding the loss and the power of the utilisation of concentric heat as well as its technological and structural parameters of a heat exchanger. This study will help to develop different techniques of the concentric heat exchanger for increasing the benefits of the environment. This research work will also provide valuable information to identify different specification of the concentric heat flow to evaluate its significance in the modern science.

1.8 Structure of the dissertation

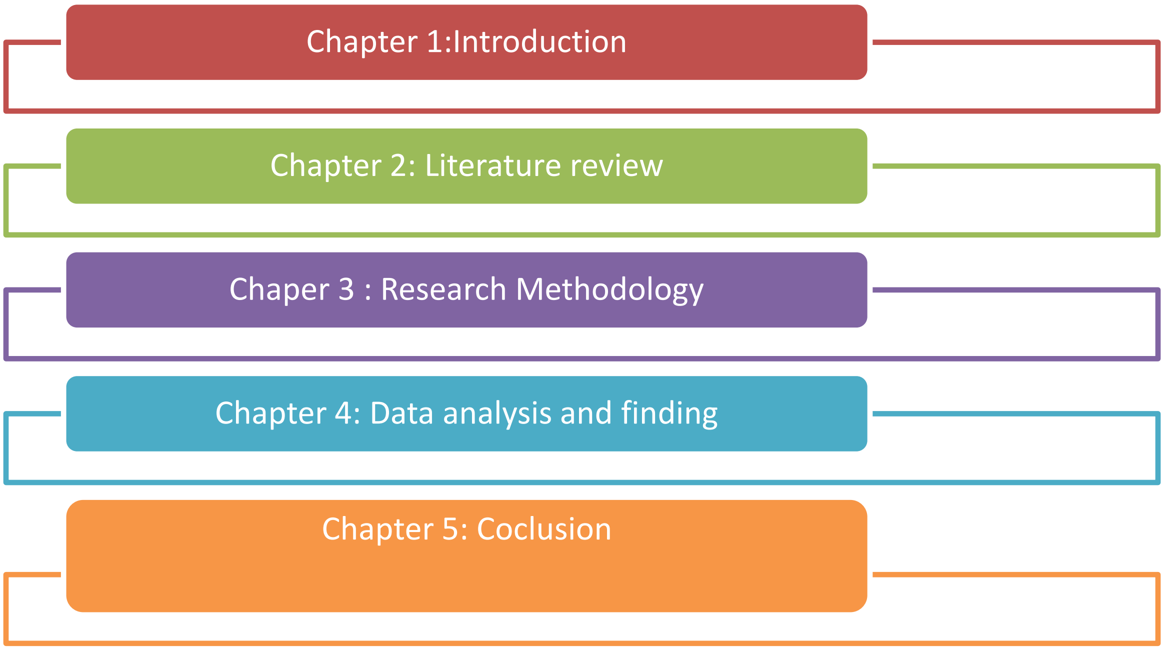

Figure 1.1: Structure of the dissertation

(Source: created by the author)

1.9 Summary

This research work is principally focus on the contribution of single flow concentric heat exchanger pipe as well as its relevance towards the application of modern science today. Heat transfer generally takes place by the means of electromagnetic waves; here the movement of the materials does not require transferring the heat from one metal to another. The rate of the heat transfer from the hot surface towards the cold surface depends on the surface temperature of the equipment, surface area of the single flow concentric heat exchanger pipe, the surrounding temperature of the environment and the emissivity of that particular equipment. In this chapter, the aim and the objectives are mentions to evaluate the importance of the single flow concentric heat exchanger pipe modern science. The rate of the transfer of heat that transfers through the metals are indicates by the thermal conductivity of those metals.

Chapter 2: Literature Review

2.1 Introduction

Single pipe concentric heat exchanger generally functions according to the laws of thermodynamics, the thermodynamic behaviour of heat can illustrate with various empirical as well as numerical analysis. As commented by Levenspiel (2014), the optimum design of single flow concentric heat exchanger generally focused on the goals that include minimising thermal procedures, minimise the generation of entropy and minimise the drop of pressure. Correlation of metals used for the transfer of heat. For turbulent fluid as well as non-viscous fluid, principally Dittus-Boelter Equation used to evaluate the heat coefficient that is responsible for generating heat in both inner as well as outer stream. As asserted by Diamond *et al.* (2014), the Tate correlation procedure explained here for some specific cases to evaluate the thermal properties of the liquids that are principally vary enormously. Here in current chapter different concepts of the fluid dynamics illustrated to analyse the heat transfer procedure in the single flow concentric heat exchanger. Some theories such as conduction, convection or radiation are describes for the critical analysis of single flow heat exchanger pipe in the modern science. As commented by Levenspiel (2014), some applications verified to examine the contribution of single flow heat exchanger in the industrial plant as well as research laboratories.

2.2 Conceptual framework

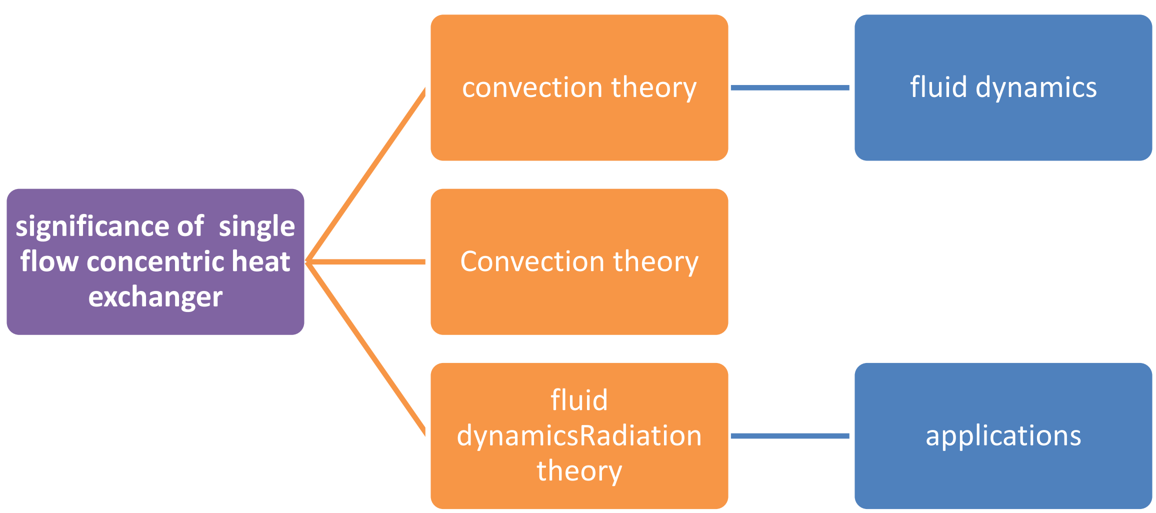

Figure 2.1: Conception framework

(Source: created by author)

2.3 Gap of literature

In the previous research work, some drawback on the concentric heat exchanger is identifying to measure some cryogenic application of the single flow concentric pipe in the modern science. During previous research work, it is observe that the researchers were unable to determine the heat transfer coefficient with respect to the frictional factors. There is lack of implementation of the theories in the previous researches. Moreover, the difference between the single flow and the dual flow pipe are not illustrate in the previous research, theoretical analysis fail to calculate the coefficient of heat transfer in the single flow concentric heat exchanger. Here some models are illustrates to understand the numerical solutions of different theory that are responsible for the transmission of heart in the single flow heat exchanger. The extensive research work is conducts to examine the contribution of the single flow concentric exchanger in the laboratories and different industrial plants. Here in the research work, the experimental setup is build to verify the calculation in the exchanger. The uses, applications and differences between the single flow and dual flow illustrated to verify the specification as much as possible.

2.4 Specification of single flow concentric heat exchanger pipe (structure)

The concentric heat exchanger is generally uses in the energy from one substance to another. The process is necessary to control the generated incoming heat as well as outgoing stream. The single flow concentric heat exchanger consists of two coaxial tubes one inside another; they carry fluid of different temperature. As mentioned by Hussien *et al.* (2016), due to the extreme differences of the temperature, heat flows from hotter stream towards the cooler stream. From this heat exchanger design, generated heat can analyse by the empirical mathematical equations. As commented by Rashidi *et al.* (2015), the concentric tubes are arranges in the U format to decrease the length and provide the measuring point at the mid position of the format.

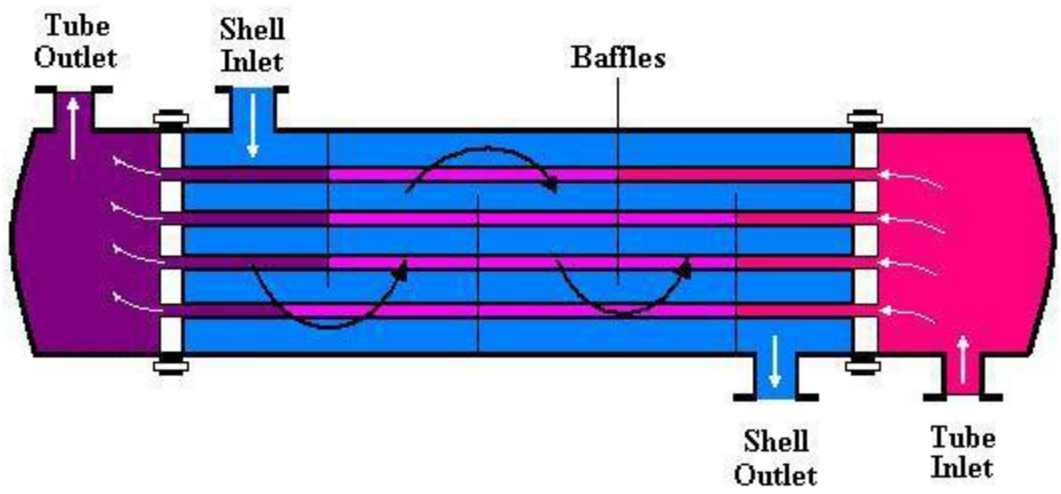

Figure 2.2: Structure of single flow concentric heat exchanger pipe

(Source: engineering.wustl.edu, 2017)

The midpoint of both cold and hot streams, the tube is fitted with K type thermocouple sensor that is uses to determine the stream temperature during the heat emission from any equipment. As asserted by Diamond *et al.* (2014), the miniature plug of the thermocouple sensor takes the signal of the temperature indicator as well as the data logger. The hot host terminate with that particular socket and the cold host with a particular plug is used to prevent the cross connection in that equipment. The tube material is composed of stainless steel with the diameter of 0.012 m and thickness is 0,001m. As asserted by Shah and London (2014), this structure helps to demonstrate the indirect cooling or heating transfer from one fluid stream to another when a solid wall separates them. As commented by Levenspiel (2014), during the operation of the single flow concentric heat exchanger pipe at first the main switch must turn on and after that the heater switch. The temperature has to set to 60-degree centigrade. The test result will help to evaluate the effects of the temperature differences during the transfer of heat in the concentric heat exchanger. In the concentric heat exchanger the produced heat generally flows from higher temperature to lower, therefore, if a cold fluid and a hot fluid are separates by a heat conducting surface, the heat can be flow from the hotter fluid to the cooler one. As mentioned by Hesselgreaves *et al.* (2016), the measurement of the temperature change in the heat exchanger will help to determine the temperature coefficient of equipment. The fluid of the equipment is heated by the stream that condenses the annulus and the annulus is further cooled by the cooling water and return back to the tank. As commented by Levenspiel (2014), the steam trap captures the steam to condense it, and these will control the flow of the heat through the concentric heat exchanger. Safety precaution is also important to execute the measurement of the heat exchanger in the single flow concentric pipe. All time operators have to wear hardhats and safety glasses. While opening and closing the steam valve Woking people have to wear heat resistant gloves and after the hot steam, turn on care should be, maintain to observe the emission of heat on the surface of the heat exchanger. As commented by Incropera *et al.* (2017), the rate of the heat flow principally depend on the heat transfer coefficient, that is the basic function of the properties of the involved fluid, its velocity, the materials of construction or cleanliness of the concentric heat exchanger. The total transfer of heat depends on the surface area, coefficient and the average temperature differences between two streams. (Refer to appendix 1)

Heat exchanger is classifies into two major groups that include Recuperate and Regeneration. Recuperator is the special feature of the counterblow of heat exchanger; here the flow of energy is positioned within the exhaust air stream of the equipment to recover the waste heat in that system. As mentioned by Oon *et al.* (2014), it can again classify as direct contact type and indirect contact type. In direct contact type, the heat transfer principally takes place between different immiscible fluids in the concentric heat exchanger such as if gas and liquid coming into the direct contact. In direct contact type of heat exchanger, an impervious wall of the tube separates cold and hot fluids from each other. As commented by Ramos *et al.* (2015), here the fluids remain separated; this process is known as the surface heat exchanger. In Regeneration, type of heat exchanger heat from a comparative hot fluid is intermittently transfers to the cold fluid. The regeneration type can again classify as fixed matrix generator type and rotary generator type. The indirect contact type heat exchanger is of three types, that includes tubular, extended surface and plate. As commented by Nawi *et al.* (2015), plate contact type heat exchanger is classified into a spiral plate, plate, frame, and gasket and welded plate. Whereas tubular type again sub divided into a double pipe, spiral tube and shell and tube. The extended surface type heat exchanger is again classifies into two types, they are plate fin and tube fin. The rotary type heat regenerators are sub divided into drum type and disc type.

2.5 Working principle of single flow concentric heat exchanger (theories)

The heat exchanging process between the two fluids at a different temperature are separated by solid walls occurs different applications in modern sciences. As asserted by Nkwetta and Haghighat (2014), the heat exchanging devices used to implement the exchanges to reduce the emission of heat for executing the chemical processes. There are three mechanisms regarding heat transfer that includes conduction, convection and radiation. Heat conduction refers to the transfer of heat from one portion of the system to another one of the same equipment. As asserted by Vanaki *et al.* (2016), the energy exchange by the conduction procedure is accomplishes by the molecular interaction; here a particular molecule at a higher temperature of in energetic level imparts the energy towards the adjacent body that is in the lower state of energy. This mechanism is significant for the metallic solids; the possible concentration of those free electrons varies for different alloys that become lower for the non-metallic solids. As asserted by Shah and London (2014), single flow concentric heat exchanger pipe may enhance the differences of the conduction mechanisms may take place at the boundary of any particular equipment or across its body. (Refer to appendix 2)

Convection mechanisms generally happen in the fluid by mixing one part of the fluid with another due to, in the gross movement of the mass of total fluid. As mentioned by Rashidi *et al.* (2015), this process the energy is transfers from one fluid molecule to another one, here the energy is exchanges from one place to another by the displacement of the fluids. This theory is responsible for the heat exchange in the single flow concentric heat exchanger; the molecules of the involved fluids transfer the electron from higher excited state to lower. In the single flow concentric heat exchanger, heat transformed by the Thermal radiation refers to the electromagnetic radiation that is principally emits from the surface of the equipment. As commented by Nkwetta and Haghighat (2014), this electromagnetic radiation can emits in all directions.

After reflecting it on another body one part of the electromagnetic radiation may transmutes, one part is reflects whereas one part strikes to the adjacent body. In the single flow concentric heat exchanger, thus the heat may pass from one body to another one without any medium of transport between them. This mechanism is responsible for the exchange of heat in the single floe heat exchanger. As commented by Rahman (2013), in some equipment, separating medium is observed, such as the mediums are separated by air, that is unaffected by the energy passage of that equipment. In a heat exchanger, the temperature gradient facilitates the transfer of heat by three methods such as conduction, convection and radiation. As commented by Levenspiel (2014), the heat exchanger theory concern with the shell of the single flow concentric heat exchanger. The segmented concentric heat exchanger transfers the emitted heat from an exhausted body to the working fluid. The theory illustrates that the procedure of heat exchanger includes the coming working fluid and the exhausted fluid, the working fluid, as well as exhausted fluid, generally travel through one portion of the heat exchanger in the parallel flow configuration. As commented by Incropera *et al.* (2017), moreover, it includes another heat exchanger to receive the working fluid from the mentioned first heat exchanger and release the exhausted fluid from another third heat exchanger. The Boltzmann theory provides a mathematical basis for discussion for verifying different approaches of equilibrium in the concentric heat exchanger. This theory deals with several approaches of the equilibrium condition of the liquid in the heat exchanger.

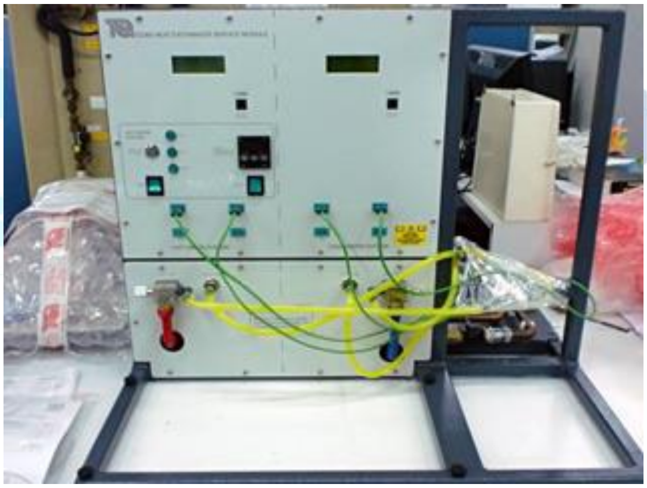

Figure 2.3: Working principle of single flow concentric heat exchanger

(Source: fst.umac.mo, 2017)

The Boltzmann theory helps to describe the kinetic theory of gasses. As commented by Levenspiel (2014), therefore, it explains that theoretical biophysics includes mathematical models to illustrate the calculation of generated heat in a concentric heat exchanger. This theory also helps to examine the hydrolytic limits of the fluids and help to derive transport equation of the involved fluid for the macroscopic quantities of the fluids. It is observes that macroscopic equation of the motion is the conservation of energy for a continuous field. Thermodynamics laws are also responsible for the energy flow from one stream to another in the concentric heat exchanger. As mentioned by Rashidi *et al.* (2015), the first laws state that the total energy in the universe is constant; therefore the energy cannot be created or destroyed in any system. Here in the concentric heat exchanger the total amount of heat in both stream is constant it changes the form of energy or transferred from one stream to another. The second law of thermodynamics states that the increasing heat has randomness in the universe. The degree of the randomness or the disorder in a system knows as its entropy. Therefore, the energy transfer in the concentric heat exchanger results from the conversion of the heat from the stable form to unstable form. As commented by Incropera *et al.* (2017), the zeros law of thermodynamic involve the basic ideas on thermodynamic equilibrium. This thermodynamic equilibrium deals with the large scale of change of temperature and related with the energy of the molecules of different fluid involved in single flow concentric heat exchanger. The laws of thermodynamics help to explain the possible states of the fluids in the heat exchanger. (Refer to appendix 3)

2.6 Concept of Fluid Dynamics and Heat exchanger analysis for a concentric heat exchanger

Enhancing the exchange of heat by the helical coils is observes that due to the fluid dynamism inside the pipe of the helical coil of the heat exchanger the heat flows from one stream to another. As commented by Levenspiel (2014), this configuration offers a compact structure and a high heat transfer coefficient. Therefore, the Computational Fluid Dynamics principally provide the flexibility regarding the change of different parameters in the concentric single flow heat exchanger. As commented by Rahman (2013), it also helps to decrease the design cycle and time of the heat exchanger; however, it helps to understand the different existing problem in equipment. In order to perform the CFD analysis of tubes and shells of a heat exchanger using FLUENT after modelling concentric heat exchanger with the CFD modular. As commented by Nkwetta and Haghighat (2014), the prediction regarding the chemical reactions, heat and mass transfer or the measurement of fluid flow phenomenon is conducts by the Computational Fluid Dynamics. This prediction is persuades by the mathematical equations regarding the energy and mass conservation of energy, an effect of momentum and body forces and much more. As commented by Rahman (2013), the CFD analysis for the single flow concentric heat exchanger involves nine steps; the first stage includes different problem identification in the different domain to analysis the effectiveness of the concentric heat exchanger. In the second step, some mathematical formulas and geometric models should be constructing with the designing of the heat exchanger.

As asserted by Nkwetta and Haghighat (2014), at the final step, the obtained data should evaluate to understand the prior to post process of the single flow heat exchanger concentric pipe. Different models are analyses to develop the heat exchanger procedure and fluid dynamics in the single flow heat exchanger, RANS based model is appropriate to analyse the concentric single flow heat exchanger. As asserted by Vanaki *et al.* (2016), during this analysis the flow of fluids need to analyse to calculate the CFD for the single flow concentric heat exchanger. This CFD analysis is mainly performed in the initiation stage by the by the geometric model to make the computation data simpler and easier. As commented by Incropera *et al.* (2017), the simplified model of the concentric heat exchanger includes symmetric fluid part; it needs to mesh after simplification of the model. Meshed step enables the discretion of the whole structure into its finite volume.

As commented by Rahman (2013), the temperature condition of the surface in include during the analysis of the transmission of heat at the nodes of each finite volume. As asserted by Diamond *et al.* (2014), after that the analyses procedure help to execute the calculation, the process of CFD computation starts after incorporate the required data in the software. This procedure will remain to continue until the result is displays in a proper convergent manner. This analysis is performs to validation of the design of a single flow concentric heat exchanger. As commented by Rahman (2013), the possible result takes after the computation and the calculated data will help to measure the velocity distribution of fluid in the concentric heat exchanger. It is also observed that single flow concentric heat exchanger with the minimum distribution of velocity principally show the high exchange of heat in the heat exchanger. The distribution of the temperature is also measures in the software by incorporating the received data from a computation.

2.7 Environmental implications of concentric heat exchanger

Single flow concentric heat exchangers are relevant for its major implication in the different domain; it has the positive effect on the developmental as well as sustainable endeavours for preserve the natural sources and reduces the consumption of energy in the environment. It has a vital role towards the reduction of heat emission and population in the atmosphere. As commented by Nawi *et al.* (2015) the single flow concentric heat exchanger helps to decrease the emission of heat from the equipment by increasing the efficiency of the power plant. A huge range of laboratories as well as industrial processes generally involves the transmission of energy in the form of heat between two fluids. The efficiency of heat transfer process is based on the efficiency of the energy utilisation in the single flow concentric heat exchanger.

Fouling of the heat exchanger in different industries persuades several chronic issues that compromise environmental as well as energy recovery welfare. As mentioned by Khaldi *et al.* (2015), due to the excessive heat generation in the concentric heat exchanger some major problems may arise, they include loss of the heat transfer between the fluids or under the deposit of the corrosion in the single flow concentric heat pipe. As asserted by Wang *et al.* (2015), these will increase the atmospheric temperature and sound emission from the industries. There are some positive perspectives also evaluated that the concentric heat exchanger improves the efficiency of the energy conversion. Heat exchanger principally works on the basis of the thermodynamics laws. The recuperation of the exchanger helps to save the huge quality of the energy and fuel during the conversion of heat in the pipe. As commented by Prasad *et al.* (2015), the single flow concentric heat exchanger basically helps to increase the consumption of water, fossil fuels, electricity as well as other resources in the environment. Although some heat issue responsible gases are also releases from the heat exchanger such as sulphur dioxide, nitrogen dioxide as well as carcinogenic effluents, it has a vital role in the harnessing power and energy from biomass. As mentioned by Oon *et al.* (2014), concentric heat exchanger increases the uses renewable energy sources like hydropower or solar power for the industrial activities.

This practice will reduce the dependence on non-renewable resources and will help to decrease the input cost for the industry. The emission of heat from the surface area of the heat exchanger increases the environmental hazards, during the heat exchanging carbon dioxide is emitted from the concentric heat exchanger that causes the long lasting impact on the heat as well as the ecosystem. As mentioned by Tu *et al.* (2014) the evaluation help to demonstrate that the precipitations of some harmful element in the single flow concentric heat exchanger generally increases the discharge of the greenhouse gases in the atmosphere. The emission of the greenhouse gases is dependent on the thickness of the deposition in the pipe as well as on the surface of the heat exchanger. It was examine that produces carbon dioxide, as well as other greenhouse gases, reduce the heat transfer in the single flow concentric exchanger.

2.8 Differences between the single flow and dual flow of concentric heat exchanger pipe

In the single flow concentric heat exchange, it contains tubes inside the shell that are used widely in different industries and can handle the high temperature. As asserted by Wang *et al.* (2015) based on the design pattern, fluid flows in the single pipe, which is U-shaped and accomplishes duties of the condenser during heat transfer from single flow concentric pipe. In the exchanger, this arrangement of the tubes operates the current as well as counter-current flow pattern and their various approaches are dependent on the different surface area of the pieces of equipment. As argued by Oon *et al.* (2014), the dual flow concentric heat exchanger, commonly known as the double pipe heat transfer contain double pipe that is principally fitted in a manner that one pipe is adjusted inside another one. As stated by Khaldi *et al.* (2015), in the cross section view they formed concentric to each other, the required length of the pipe can exceeds by the hair pin shape present at one of the edges of the heat exchanger. It consists of parallel tubes, the ends of the parallel can expand into the tube sheets. Inside the cylindrical shell, the tube provide two distinct channels. As commented by Prasad *et al.* (2015), this specific structure help to remove the non-condensable gas from the tube of the dual flow concentric heat exchanger. In the tubes involved two fluids are separated physically but there is a physical contact between these two fluids. In the tube walls, heat generally flows from condensing vapour towards the cooler pipe in the concentric heat exchanger. As supported this and stated that Khaldi *et al.* (2015), during the heat exchanging of the fluid, the tubes gain heat and increase the temperature from the inlet to the outlet of the heat exchanger. The total temperature of the fluids will remain constant as the pressure is maintains inside pipe of the dual concentric heat exchanger.

The single flow concentric heat exchangers are capable of handling heavy temperature as well as pressure in the heat exchanger. Although, this system is easy to operate and control, Wang *et al.* (2015), argued that the equipment needs the large place and the maintenance cost is higher than the dual pipe concentric heat exchanger. This single flow heat exchanger generally uses for the regular exchange of heat for steam heating and cooling purpose in different chemicals equipment, the distillation of columns in different industries. Whereas the dual pipe heat exchanger is easy for construction and slurries can handle properly. As commented by Ramos *et al.* (2015), moreover, the maintaining cost of dual pipe exchanger is cheaper than the single flow concentric heat exchanger. The dual flow exchanger is easy to clean and the current, as well as the concurrent flow of heat, can adjust easily but leakage of the corner may arise due to the excessive pressure in the adjacent tubes. As asserted by Janković *et al*. (2015), the maintenance of the dual pipe is time-consuming and occupies less floor place compared to other. These dual flow concentric heat exchangers are generally used in the refrigerator as well as domestic heating purposes or car radiators.

2.9 Application of single flow concentric heat exchanger pipe

Concentric heat exchangers are generally utilised in the wide range of the industrial as well as laboratory purposes, the industries include power generation, gas and oil industry, chemical processing and much more. In the single flow concentric heat exchanger, the relatively lower humidity enhances the comfort of the heat generation process. As asserted by Prasad *et al.* (2015), the heat pipe is placed between the warm air and the cooling coil, the cool air leaving that coil after transferring the sensible heat to the comparative cold outgoing air. As commented by Nawi *et al.* (2015), some fundamental uses of the single flow concentric pipe include the cooling and heating of different large-scale equipment.

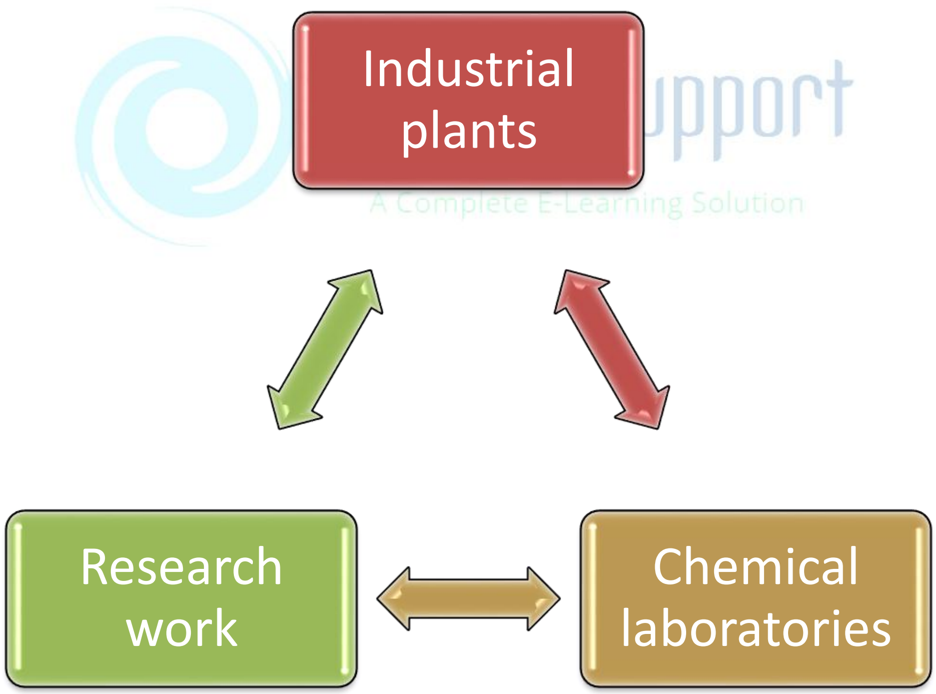

Figure 2.4: Application of the single flow concentric heat exchanger

(Source: Nawi *et al.* 2015)

Different investigations of the enhancement efficiency of the single flow heat exchanger stated that the surface of the dimpled tube is uses to increase the heat transfer coefficient with the increase of the friction factor inside it. In the oil and gas industries, different technologies are provided to the customer with the multitude of the benefits. As asserted by Wang *et al.* (2015), these involving the capabilities at the extreme pressure and temperature as well as the compact size, that is compared with other heat exchanger available in the market. In industrial gases, high level of energy is requires by the cryogenic air separation in the single flow heat exchanger. The single flow concentric heat exchanger has a specialised structure that is well suited to transfer the heat from one fluid to another. As stated by Khaldi *et al.* (2015), the user of the single flow heat exchanger also includes refrigeration, food and beverage packaging, paper and pulp industries or in HVAC.

The containment vessel, as well as the tube and shell in the single flow concentric heat exchanger, is examines to study the application high pressure of the heat exchanger. The single flow heat exchanger is considered as an accessory piece of equipment in the laboratories as well as industries and chemical plants. In reaction system, the concentric heat exchanger preliminary used for distillation of columns and purification. As commented by Nawi *et al.* (2015), in laboratories heat pipes are generally applied with a particular velocity to enhance the effectiveness of the heat exchanger as much as possible. As asserted by Janković *et al.* (2015), the application of the concentric heat exchanger is principally relevant for different industries due to their simplicity as well as flexibility, as the application of the eat pipes in the heat exchanger in different factories actually come to be common. As stated by Khaldi *et al.* (2015), heat exchangers are used in the food industries to cooling down different products. A large number of products, as well as food paste, are required to cooled down as well as heated up through the further procedures. As commented by Nawi *et al.* (2015), heat exchanger also used in ethanol production, the uses of concentric heat exchangers here fulfil the basic utilisation of the waste heat as well as enable consideration of saving of the energy in some short payback period.

2.10 Importance of concentric heat exchange pipe in modern science

Concentric heat exchangers are efficient equipment that is constructed for the heat exchanges between two fluids at the different temperature. Here a solid wall to prevent the mixture within them separates the media. As commented by Prasad *et al.* (2015), if they are immiscible in nature, they are allows to flow in the direct contact. The concentric heat exchangers are generally used in different industries to prevent the emission of produced heat at the surface of equipment.

As asserted by Wang *et al.* (2015), the single flow concentric heat exchangers come in huge range of sizes, the tubular heat exchanger designs for cooling and heating of viscous products.

The compact as well as heavy duty plate concentric heat exchangers generally help to improve the heat exchanging procedures, basic requirements in a wide range. The scraped outlet of the single flow heat exchanger basically employed in closed processing such as cooking, gelling, mixing or some aseptic processes. As commented by Prasad *et al.* (2015), the shell tube concentric heat exchanger is used in a process when a large amount of fluid needs to be cooled or heated. The concentric heat exchanger has another application in the gas turbine units. In the single flow concentric exchanger heat is transmitted from the wall of the boiler towards the cooler stream. The systematic studies on the exchange of heat show the procedures of heat transfer that includes conduction, convection and radiation. As stated by Khaldi *et al.* (2015), through these processes the heat is transmitted at the molecular level by the direct contact of these elementary particles without their mass movement as a whole. The heat exchanging process in the laboratories, as well as different industries, decreases the energy consumption that will increase the efficiency of equipment.

Heat exchanger within food industries is mainly used to cool down various food products. Processing of food often required abrupt cooling and heating of products, for which, industrial workers depend heavily on single flow concentric heat exchanger pipes. According to Prasad *et al.* (2015), heat exchangers have also gained importance in ethanol production, which has become popular as an alternative fuel source that will replace other convention non-renewable fossil fuels. A network of single flow heat exchangers are used in ethanol production that fulfills utilisation of waste heat as well as enables energy saving in very short payback periods. Wang *et al.* (2015) opined that heat exchangers have occupied crucial position in bioprocess industries, where, cryogenics is a crucial part that requires liquid carbon dioxide, liquid nitrogen and liquid helium to produce very low temperatures below 123K. Use of specially designed heat exchangers is unavoidable in cryogenics.

2.11 Conclusion

Hence, it is conclude that the concentric heat exchangers are use in great variety of its applications. The specification and the structural analysis of the concentric heat exchanger it is observed that the energy flow is positioned in the exhaust stream of an equipment to recover the amount of waste heat in that system. After evaluating the environmental implication of the heat exchanger it is examine that due to excessive emission of heart different environmental problem may arises such as emission of greenhouse gases where as it has positive perspective also such the concentric single flow heat exchanger will increase the effectiveness of equipment. These concentric heat exchanger is utilise in huge range of industrial, chemical laboratory and many more, the relative lower humidity in the heat exchanger enhance comfort in the heat emission mechanisms. The importance of the single flow heat exchanger is measure and the systemic study shows that the heat transmission occurs in the molecular level by direct contact of the evolved fluid without their movement as a whole.

Research Methodology

3.0 Introduction

This chapter of this research reflects on an entire framework that has been accomplished by the researcher. This chapter is considered as an important mechanism that helped to advance in course of this research. Dynamics of modern science is pretty complicated; therefore, to evaluate the single flow in heat exchanger Piper needs a proper schedule. This schedule has made in this chapter as chosen philosophy, approaches, design, data collection method has been illustrated for a betterment of this research. In addition, data collection methods have also been discussed to construct this research work significantly.

3.1 Research onion

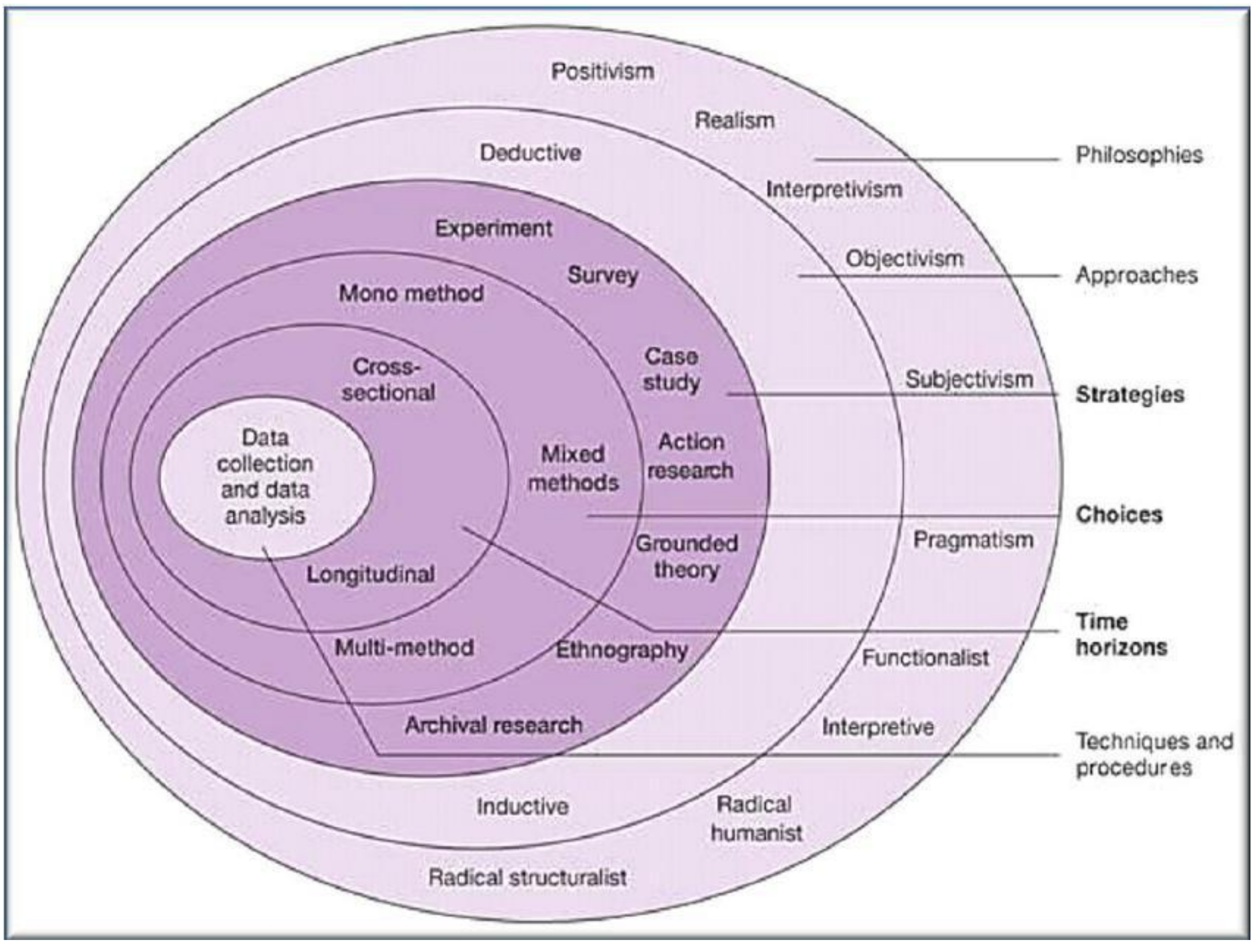

Figure 3.1: Research onion

(Source: Saunders *et al.* 2009)

An important mechanism of this chapter is research onion that generally provides a pictorial view of the entire work. According to Saunders *et al.* (2009), six layers of research onion needs to be kept in mind as it assists a researcher to identify approaches, choices, strategies, time horizons and much more. An in depth research has been made to fulfill criterion related to this research onion.

3.2 Research philosophy

Research philosophies can be segregated into four important sections such as positivism, Interpretivism, realism and post positivism (Flick 2015). Post positivism philosophy has been taken in this context as it has allowed a researcher to develop a significant theory related to a topic. By availing this philosophy researcher has been able to analyse critically on the positivist thought.

Figure 3.2: Research Philosophy

(Source: Created by Author)

As post-positivism is an extraction of positivist philosophy which enables to think more critically about the general science. Status quo, a proper reaction against positivism philosophy has been taken into action, which has allowed the researcher to draw a relevant theory. In addition, a scope of formulating a debate has also been made by applying post positivist philosophy.

3.3 Research approaches

Research approach generally holds the key to setting the tone of a research and in this case, a deductive approach has been applied. The prime reason behind using this approach is to develop a hypothesis based on single flow. This hypothesis is important in explaining about the propositions of the taken theories.

Figure 3.3: Research Approaches

(Source: Created by Author)

Therefore, a proper conclusion has been surfaced by focusing on the working principle of single flow concentric heat exchanger, fluid dynamics and a proper heat changer analysis has also been made to formulate new findings, which might not be effective if inductive research approach has been taken.

3.4 Research design

A researcher has an ample scope of using three types of research designs such as explanatory, exploratory and descriptive research design (Yin, 2013). However, every design possesses different perspective and provides a significant result in a research. In this case, a researcher to make this work a level higher than logical and rational has adopted descriptive research design.

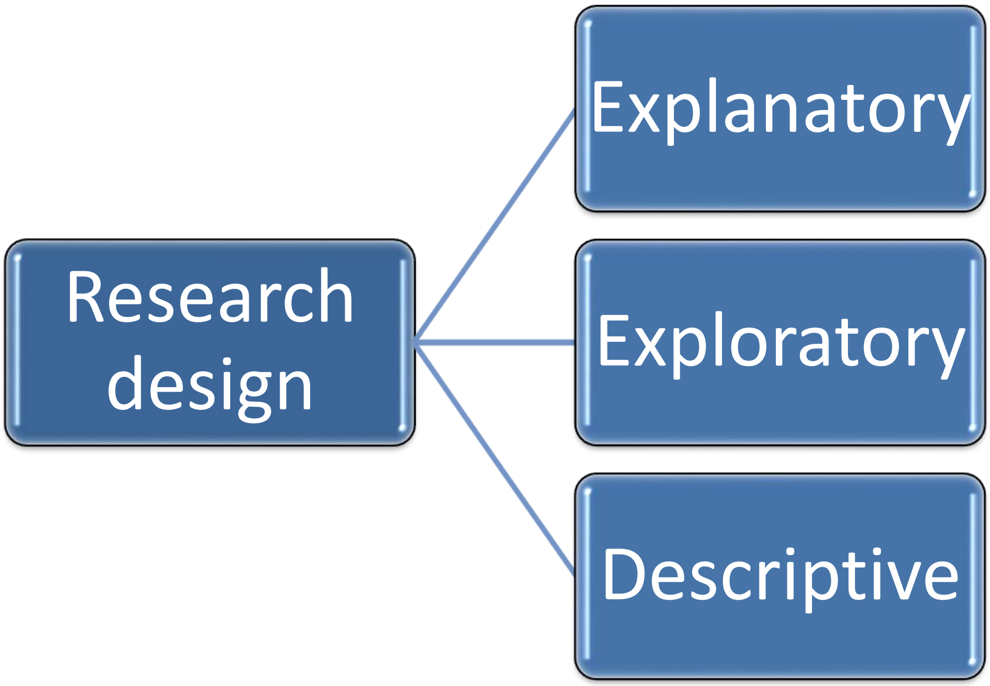

Figure 3.4: Research design

(Source: Created by Author)

As researcher has no control over significant variables like Zeroth law of thermodynamics, heat, fluid dynamics etc. Therefore, descriptive research design ensured researcher to collect data with care and have permitted to analyse those gathered data, in order to make this work coherent.

3.5 Data collection methods

A proper discussion of social science can be made by gathering a proper data from a varied range of sources. Hence, secondary data collection has been conducted in order to construct a proper evaluation based on those gathered data. Authentic sources like online articles on concentric heat exchanger have been accessed to get as much as authentic data possible. In addition, journals, books, databases, Government sites have been availed to generate genuine data, which are effective for this research. Secondary data collection method has been selected because it required less time and allowed the researcher to accomplish this research at a good pace with a proper manner simultaneously. The researcher has accessed EBSCO database as data collection tool.

3.6 Data analysis

Secondary data analysis employed in this research process as a number of benefits can be assessed while using secondary data analysis. Firstly, secondary data can be recorded in an electric medium. Nevertheless, use of secondary data analysis has allowed a researcher to spend a minimum amount of money as there was no need to make any segregation while conducting a proper analysis. These taken data are reliable and valid which has helped to develop a quality of this work.

3.7 Ethical consideration

Data protection Act has been strongly followed as no data has been taken for commercial use or for personal economic benefits. Journals, articles and books, which were restricted to view, have been obeyed sincerely. The researcher has purposefully acknowledged the name of authors to give them credit.

3.8 Timeline

Main activities	1st week	2nd week	3rd week	4th+5th week	6th week	7th week
Selection of the topic	✓					
Composition of the literature review		✓				
Research methodology			✓			
Collection of primary data				✓		
Analysis and interpretation of data				✓		
Findings					✓	

Conclusion and Recommendation					✓	
Final submission						✓

Table 3.5: Timeline

(Source: Created by Author)

3.9 Summary

In this chapter, it has been found that researcher has chosen descriptive design, post positivism philosophy, deductive approach to establish newly originated theories and point of view, which might help others in future. Finally, ethical considerations are also been made to make this research ethically correct and applicable.

Chapter 4: Data analysis and finding

4.0 Introduction

Data analysis and finding section is the most significant part of this particular research study, in which are data is collected in primary collection method regarding flow and heat energy variables of a single flow concentric type heat exchanger. Those variables are analysed to obtain best possible result for designing this kind of heat exchanger in most efficient way using most appropriate material. In this chapter, analysis of some thermodynamic and energy variables (pressure, density, temperature, and others) is done in a context of ansys diagram of a sample heat exchanger. The contour of Energy, density, fluid velocity, pressure and a static temperature is obtained from the ANSYS software, which is further analyzed in CFD method of analysis. Thematic analysis is done for a taken virtual sample of a heat exchanger.

4.1 Primary analysis:

Statement: Data consideration:

Consideration 1: Input geometry:

For research purpose, a virtual imaginary sample is taken into consideration for further analysis and detailed evaluation. Calculations are done based on some input condition which is considered for this analysis. Designs of respective heat exchangers are made considering some specific dimensions in three-dimensional coordinate systems. In this research context heat exchanger geometry is taken as 40mm each along x-axis and y-axis in a specific chart. Along z axis, a dimension is taken as 2000mm, which is basically a length of a chosen heat exchanger. The inner dimensions of the heat exchanger are taken as 18 mm each for x-axis and y-axis and 2000mm for the z-axis. These inner dimensions are basically taken for consideration of the space for fluid flow inside chosen heat exchanger and for calculation of the volume of the expected fluid which is to be considered. This radius, cross sectional area, and a length is calculated from the measurement plotted in a Cartesian coordinate system in the Lagrangian reference system. Volume along centroid-x, centroid-y and centroid-z is taken for further analysis in accordance with initial dimensioning. Relevant and suitable nodes and elemental statistics are taken into consideration to create an ANSYS model.

Consideration 2: Properties:

After defining a specific geometrical structure of certain heat exchanger model in 3dimensional space, mechanical properties of the exchanger material is to be determined by researchers of this project. For the expected working fluid, a coefficient of viscosity, specific heat, and molecular weight are determined using collected data from some handbooks. For the material selection of the heat exchanger wall, some properties (like thermal conductivity, heat resistance, amount of thermal stress and strain generated due to the huge temperature gradient between the wall thickness) are taken into consideration. Although wall thickness is very negligible and taken as zero for calculation purpose, the heat flow gradient between an inner and outer surface of the wall of middle layer (wall separating working fluid and specific heat exchanger fluid) plays a vital role in designing the heat exchanger. Separating wall exists between fluid of very high static temperature and low static temperature.

It creates a huge amount of thermal stress on the wall. For this, a required material should withstand high thermal stress. In order to have a better efficiency of this particular heat exchanger, a rate of heat exchange must be very high. Hence, a thermal conductivity of the wall material should be very high. Thermal capacity, specific heat, and coefficient of viscosity are also considered for heat exchanger fluid. Thus, three different materials (solid material for heat exchanger walls, one working fluid, and one heat exchanger fluid) are defined according to their mechanical and thermal properties. Wall surface is taken to be smooth and roughness is taken as 0. Taken working fluid is water and copper are taken as solid wall material. Taken the model of a heat exchanger is Epsilon model.

Consideration 3: Input and output conditions:

In the input cross sectional portion, some definite states are defined along with some variables in order to obtain desired results. Initial pressure may be taken as gauge pressure and temperature of working fluid is a variable here. Density and pressure exerted by the fluids on certain heat exchanger wall are taken into consideration for ANSYS modelling. Output conditions are also taken based on these thermodynamic states.

Consideration 4: Used variables:

Variables, considered in ANSYS software, are a pressure gradient, momentum of the working fluid, turbulent kinetic energy and dissipation rate, change in density due to pressure and temperature gradient, different radial body forces (because of concentric tubular structure) exerted on the walls, turbulent viscosity.

Analysis:

Pre analysis:

Cross section of the tubular structure of the heat exchanger is taken circular. This is why the flow of heat takes place in an axisymmetric manner in a radial direction from inward to outward and vice versa. Heat transfer directions are plotted in the polar coordinate system depending on the x axis of axial coordinate, radial coordinate r, and azimuthal coordinate θ (Abdulateef *et al.* 2017). Pipe diagram is prepared in a rectangular domain in which azimuthal coordinate is not shown. Here L is taken as the length of the pipe and r is a radius of the cross sectional area of a tubular structure of desired heat exchanger.

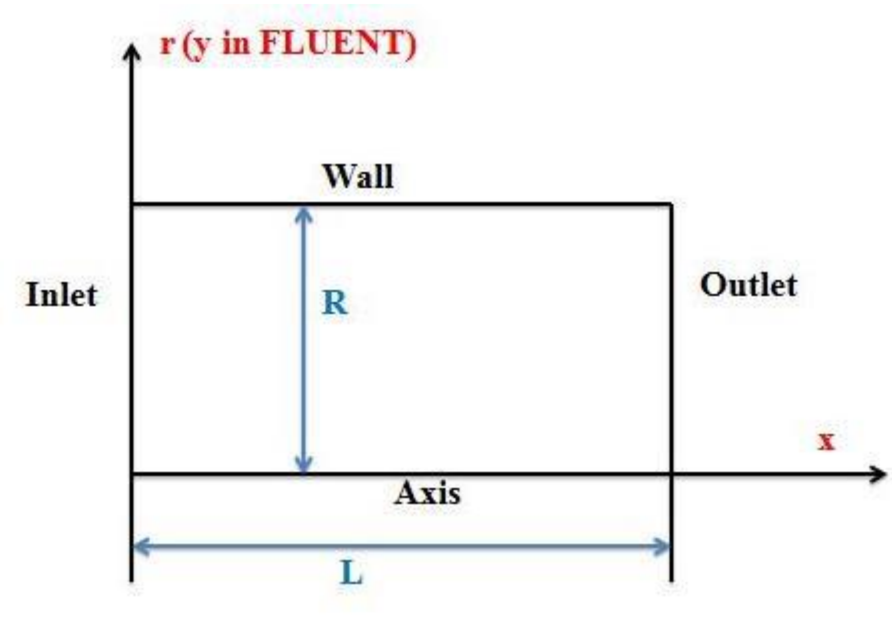

Figure 4.1.1: Pre analysis

(Source: ANSYS)

Fluent analysis:

In case of fluent analysis using ANSYS model, a geometry of forced convection is to be considered. A sketch is done using ANSYS toolbox on the X-Y plane from the origin point of the cartesian coordinate system. The sketch may be modified later according to certain requirements of this project. Dimensioning is given according to the consideration in order to make a 2D model of the heat exchanger system. A structured mesh is prepared where the edges of opposite sides correspond with each other and then edge sizing is done according to a definition of edging and then each edge is named according to the sketches and the models. In the next step, physical setup for forced convection is prepared in form of model.

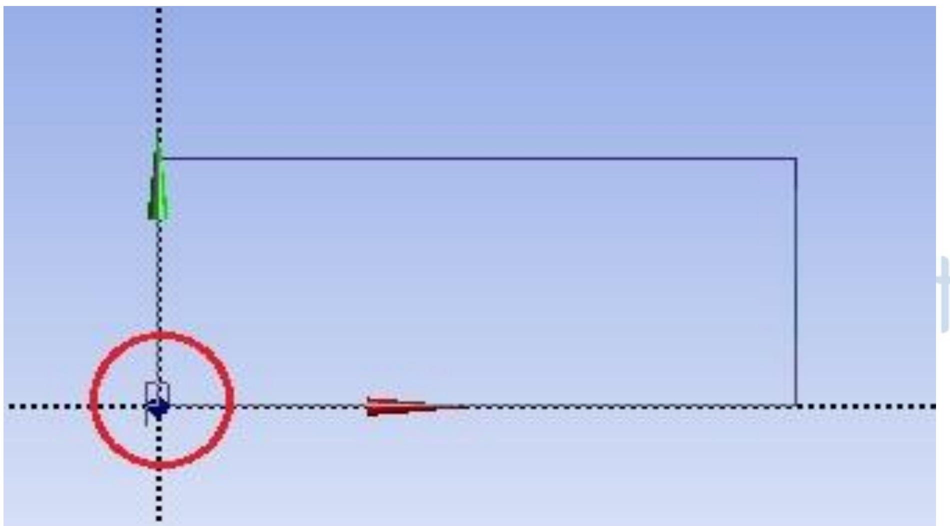

Figure 4.1.2: Convective geometry

(Source: ANSYS)

Taking all the values of the considered variables, an expected formulation is done in form of governing equation. Certain programs in ANSYS model will solve these equations. Boundary conditions are specified to get solution inside the selected domain of the entire thermodynamic system. Boundary pressure states are mentioned at the outlet and inlet of a considered heat exchanger (Yaïci *et al.* 2016).

Governing equations:

General form of the equation of conservation of mass is

/ + ∇.( ) =

This equation is valid for both compressible and incompressible fluid in turbulent flows. Turbulent viscosity is known as eddy viscosity, which can be formulated as

= () ^2/.

Here is coefficient of turbulent viscosity.

Analysis tool:

Finite element method (FEM) is introduced to analyze ANSYS software dynamic analysis which can work with fluid dynamics problems, thermodynamic equations, mechanics along with strength analysis. Using ANSYS, complex analysis is done in form of colored pictures of the taken sample. Each color indicates the different section on a basis of some thermodynamic variables like temperature pressure, and mechanical variables like stressed area. ANSYS creates a very fast and accurate analysis using considered initial and final values of specific spatial conditions.

CFD Model Details

ANSYS 16.2 software is used for 3d prototyping of a tube for single flow arrangement. CFD (Computational fluid dynamics) fluent is selected for numerical analysis on different epsilons for comparison (Onishi *et al*. 2013).

The geometry details for the tube in tube single flow pipe can be found on the excel sheet.

Turbulent results are used to make a comparison of a turbulent model.

(A) **Solution setup**: **(i) General –** solver – pressure base

Time - steady

(ii) Model - Energy Equation – on

Standard K- Epsilon model

(iii)Materials- Fluid - water- Liquid

Solid- Copper

(iv) Boundary Conditions- velocity inlet 1m/s

Pressure outlet (gauge pressure) = 0

Temperature 150 C

(B) **Solution**: **(i) Discretization scheme**

Variable	**Scheme**
Pressure	Second Order
Gradient	Least Square Cell Based
Momentum	Second Order
Turbulent Kinetic Energy	First Order Upwind
Turbulent Dissipation Rate	First Order Upwind

(C) Solution Control:(i) Under- Relaxation Factors

Variable	**Value**
Pressure	0.3
Density	1
Body Forces	1
Momentum	0.7
Turbulent Kinetic Energy	0.8
Turbulent Dissipation Rate	0.8
Turbulent Viscosity	1

(ii) **Solution Initialization** - Hybrid Initialization

(iii) No. of Iterations = 250

(For Running Calculations)

These are the results for the K-epsilon Standard

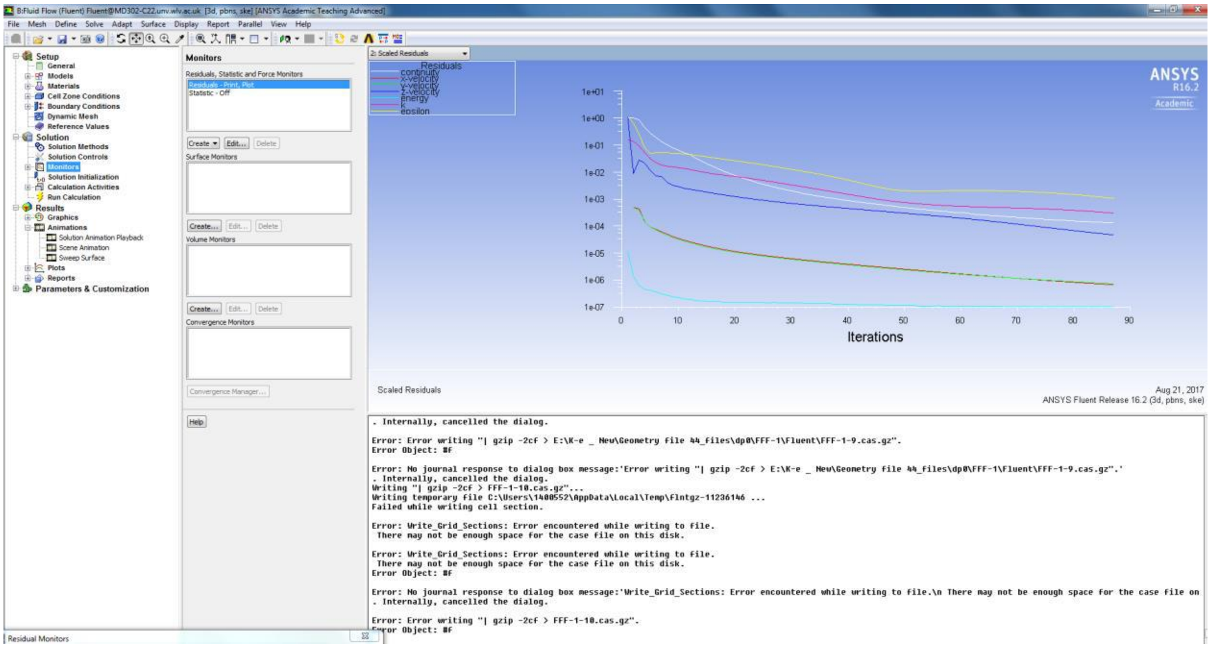

Figure 4.1.3: Residuals

(Source: ANSYS)

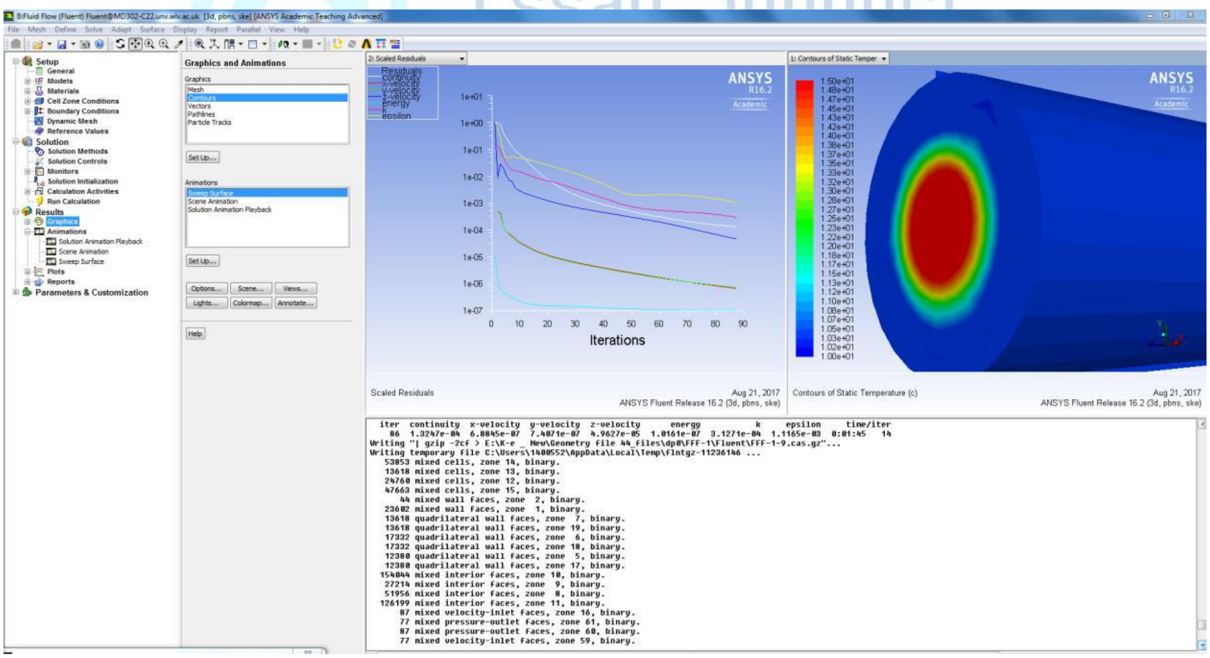

Figure 4.1.4: Temperature contour

(Source: ANSYS)

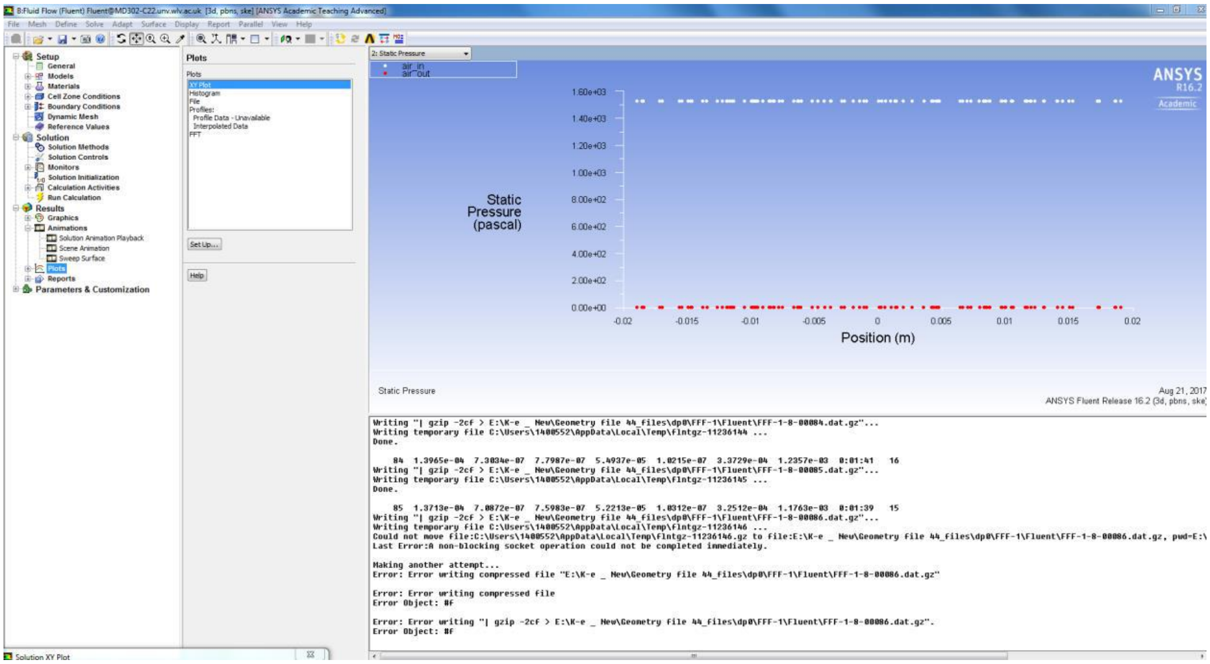

Figure 4.1.5: Static pressure contour

(Source: ANSYS)

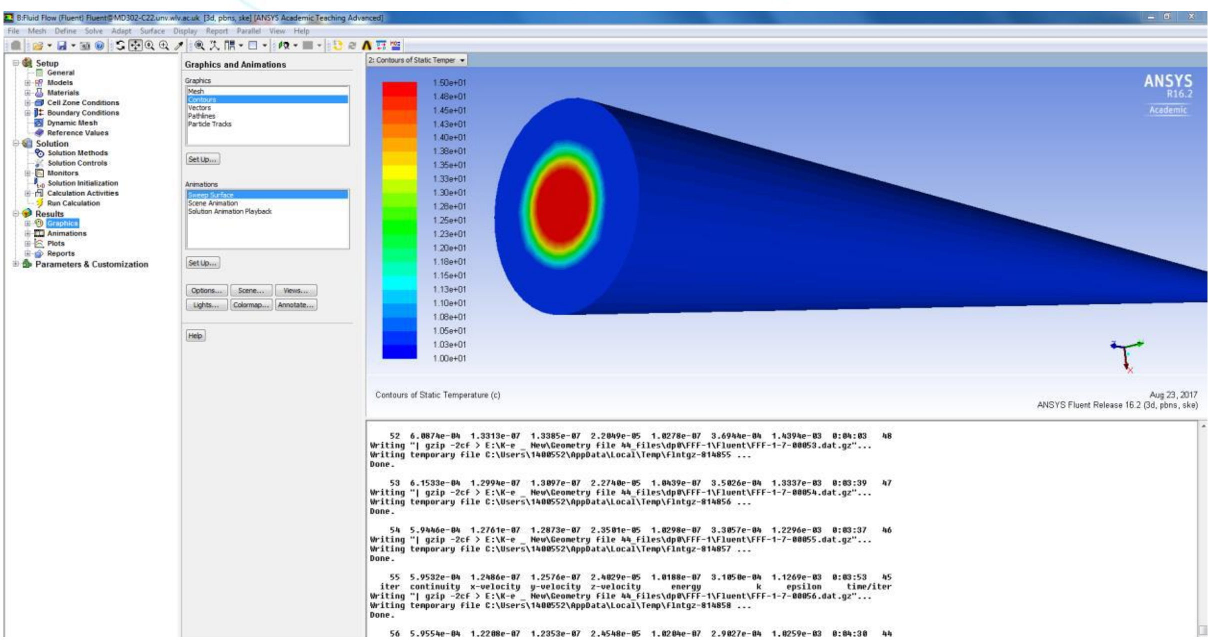

Figure 4.1.6: Static temperature contour 2

(Source: ANSYS)

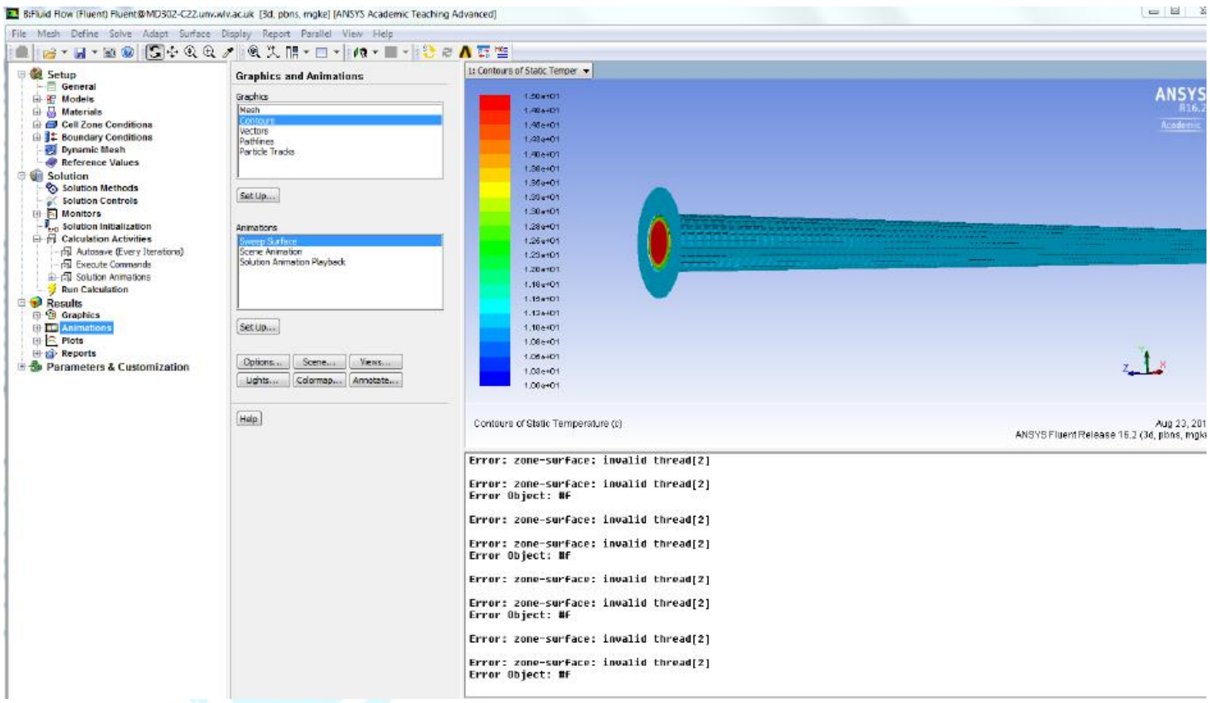

Figure 4.1.7: Static temperature contour 3

(Source: ANSYS)

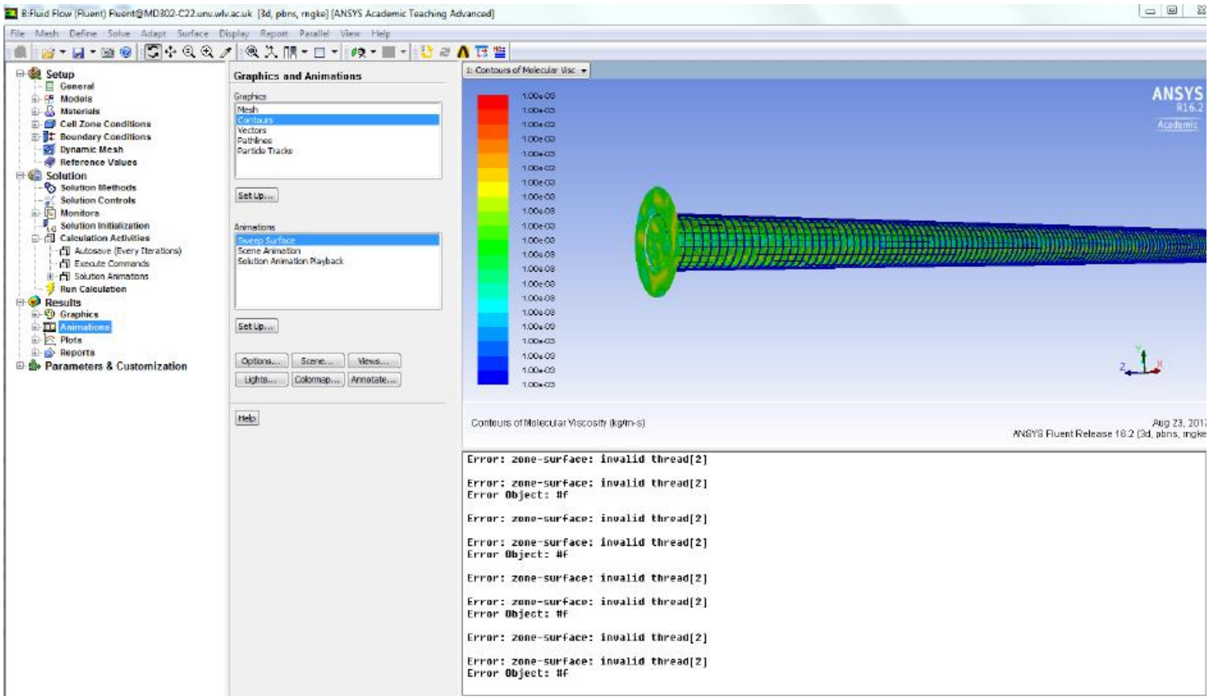

Figure 4.1.8: Molecular viscosity contour

(Source: ANSYS)

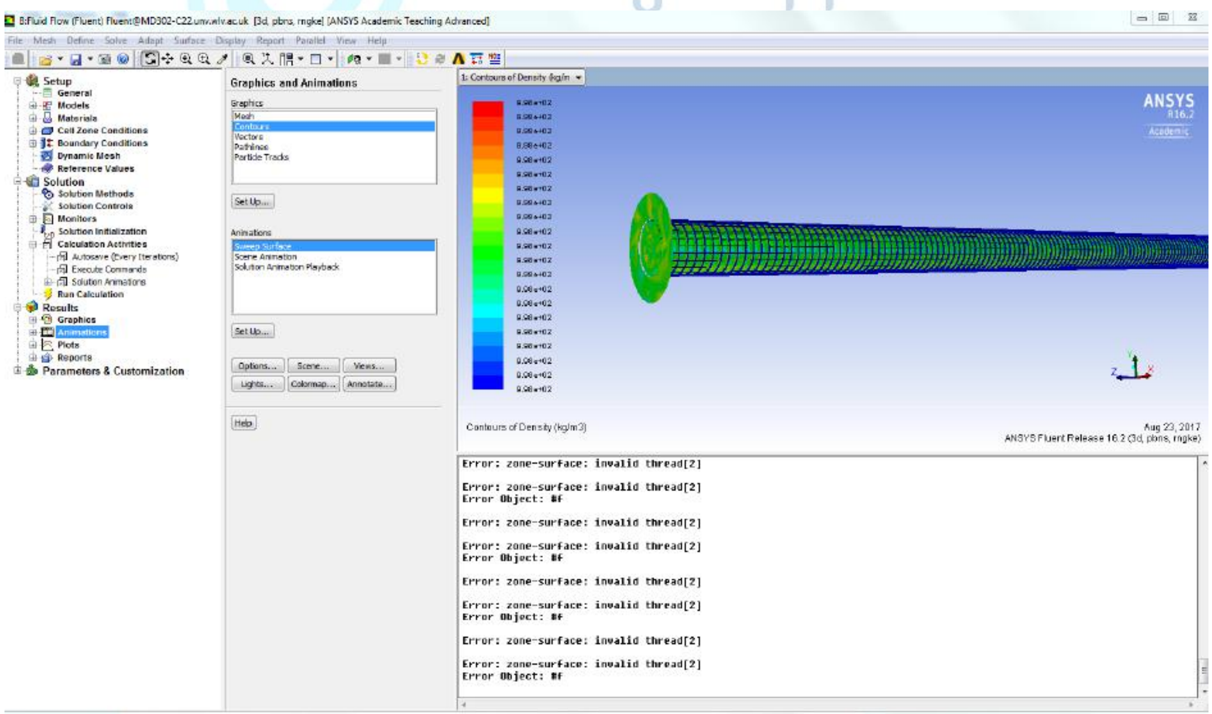

Figure 4.1.9: Density contour

(Source: ANSYS)

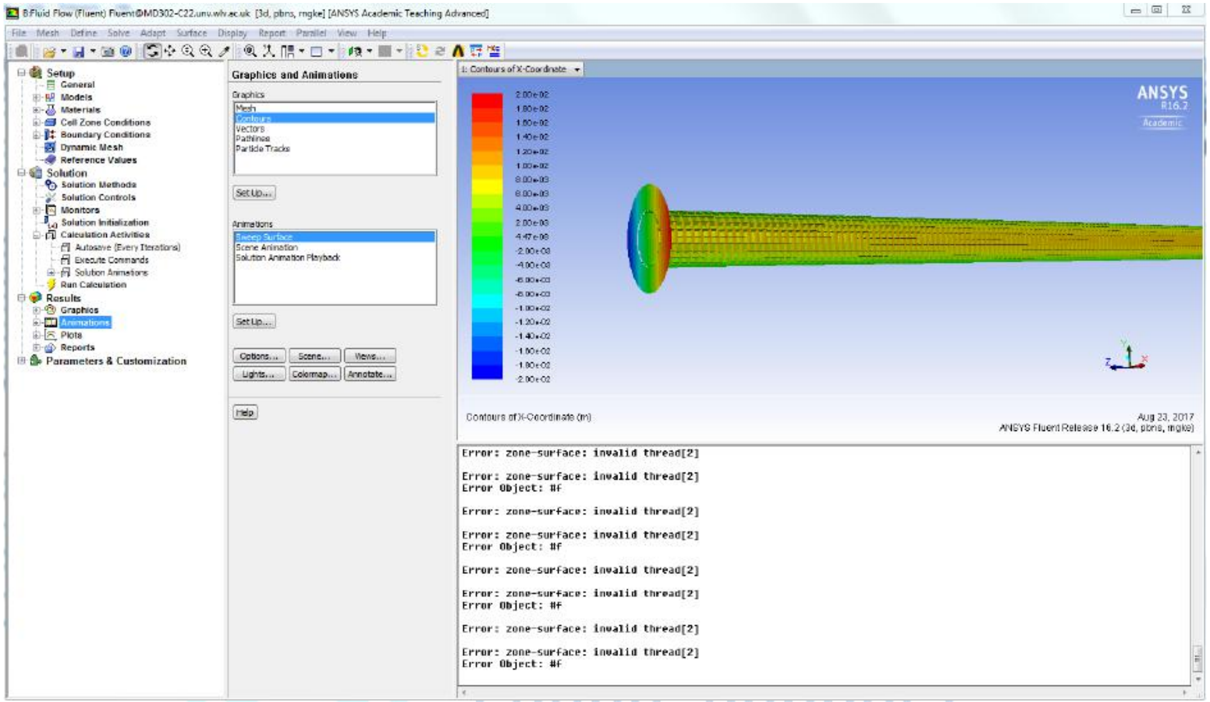

Figure 4.1.10: Contour of X-Coordinate

(Source: ANSYS)

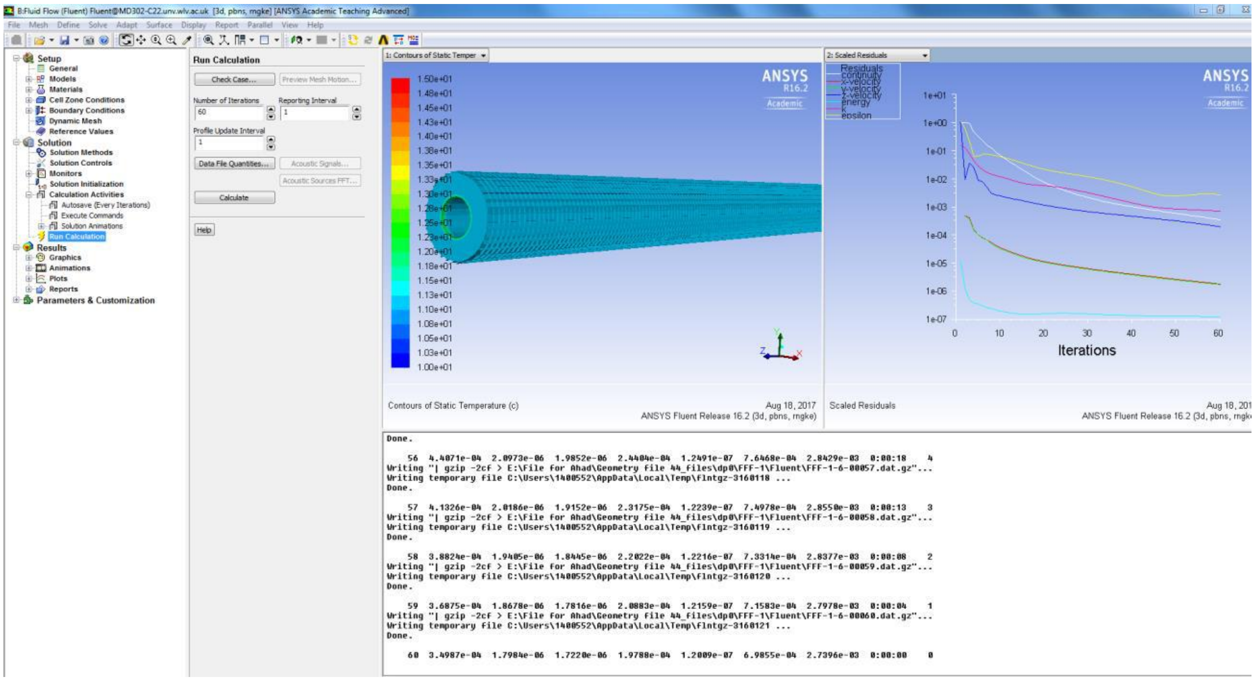

Figure 4.1.11: Contours of Static Temperature - K-e Standard

(Source: ANSYS)

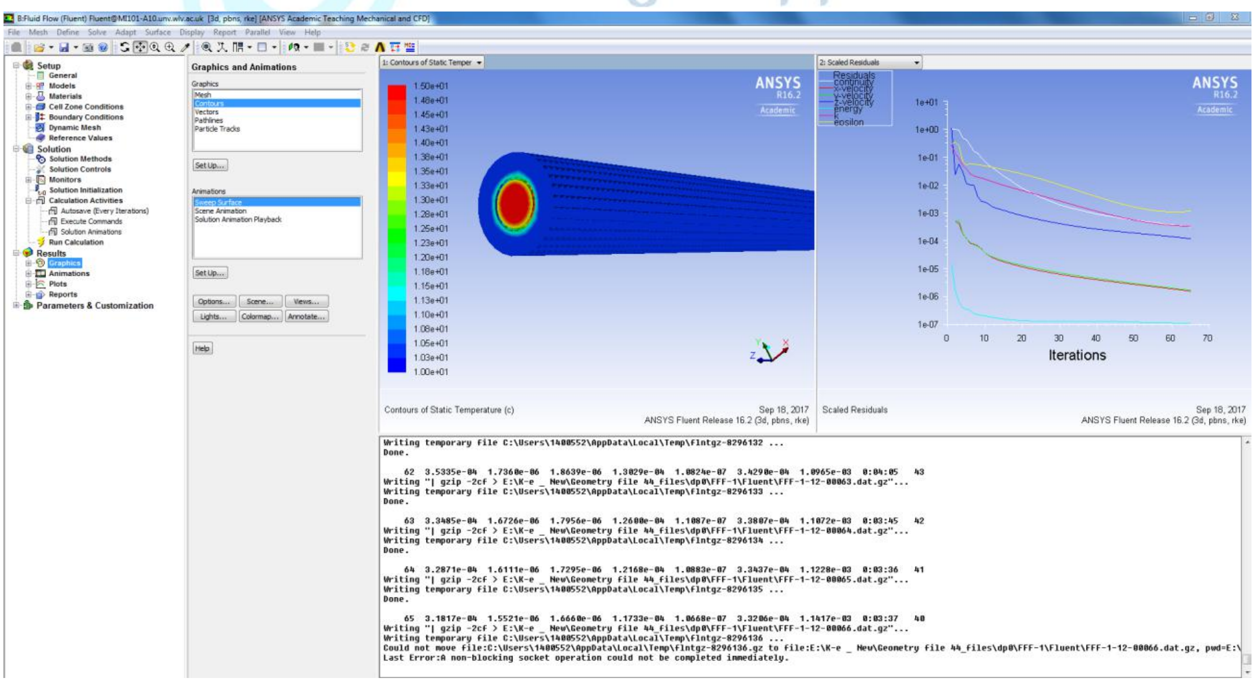

Figure 4.1.12: Contours of Static Temperature - K-e Realiable

(Source: ANSYS)

Thus different contours are obtained on basis of static temperature, a density of the working fluid inside the inner tubes, velocity, turbulent kinetic energy and static pressure. From the temperature contour, the corresponding outlet temperature is obtained. Different temperatures are shown in this model. According to the given model, the working fluid is taken to be very hot and heat is transferred to the colder heat exchanger fluid through certain separating wall between two fluids. There is a temperature slope in inlet and outlet of the heat exchanger due to a temperature difference (Labat *et al*. 2014).

From the density contour and molecular viscosity contour, change in density of two different fluids and change and value of molecular viscosity is obtained differently in different parts of the fluids flow. From the kinetic energy contour, a value of kinetic energy in turbulent flow is obtained. From the pressure contour and temperature contour, a position of maximum thermal stress and shear stress can be identified, and thus the design of the heat exchanger will be done accordingly. Maximum stressed areas are thickened to increase the durability of the heat exchanger. Several alloy materials are used in; order to resistance huge stress incorporated with a thermal gradient (Cullin *et al.* 2015).

Flow analysis is done in order to evaluate the overall efficiency of this particular considered heat exchanger model. From the flow analysis, different static pressures are used for calculation of the respective internal energy, change in temperature and enthalpy of the working fluid. And the best possible consideration is taken into account for preparing an accurate design of a concentric heat exchanger.

From the temperature distribution, it is seen that effectiveness of this type of heat exchanger is moderate in comparison to other types of heat exchangers. Due to a smoothness of the inner wall of the heat exchanger, it is suitable in case of fluid flow causing fouling. Robustness of this kind of heat exchanger helps in withstanding some operating conditions like high pressure. From the turbulent kinetic energy contours, it can be stated that this heat exchanger can create turbulent conditions at comparatively low flow rate with a high heat transfer coefficient. Due to its simple structural design, this kind of heat exchanger is easy to dismantle in case of maintenance work. From the proper analysis, stainless steel can be considered as the material of the structural wall of the heat exchanger body and for maintaining concentricity; spacers are included within the structure. In this heat exchanger, counterflow and parallel flow both are possible, but the cross flow is not possible as there is no baffling system present.

4.2 Summary

This research analysis describes data analysis and evaluation in details. An initial consideration is done in order to prepare respective pre analysis to start up. Dimensional values of a sample design are taken in order to start a respective analysis. Analysis can be done taking different wall materials of a specific tube like structures of this kind of heat exchanger in order to identify the most suitable material for this purpose. Stainless steel is found to be most suitable. From different contours of respective ANSYS model, an analysis is done on a basis of variables related to fluid dynamics, flow property, and thermodynamic states. With help of some governing equation of conservation of mass, flow rates, efficiency is deduced for further calculation. Thus, from this simple empirical analysis, and CFD analysis, involves in correlating the models of heat transfer. Heat transfer takes place in conductive method through the wall and in convective method through the fluid particles. So a conductive analysis is done for the solid structure and a convective analysis is done for working fluid and heat exchanger fluid.

Chapter 5: Conclusion and recommendation

5.0 Conclusion

In this current research study, a researcher focused on a special kind of concentric heat exchanger along with its implementation and importance in modern science. These heat exchangers can be used in both heating and cooling purpose in various manufacturing, automobile industry. Size and other specification of this kind of heat exchanger depending on the place of the application, type of working fluid, nature, and phase of working fluid, temperature, some properties (density, viscosity, chemical composition) of working fluid, thermodynamic state of certain portions of the place of application. Selection of the right specification for certain purpose requires enough knowledge of heat exchanger parts and its allowable mechanical strength, tolerance and other mechanical properties along with its competence of required mechanical characteristics associated with a particular application. In this present study, an analysis is done for a virtual sample of single flow concentric heat exchanger. A portion of maximum thermal stress, mechanical stress, thrust are identified in order to prepare a proper design of that heat exchanger considering all the issues that affect its durability of it. Initial conditions have to be considered according to a certain application. Efficiency, effectiveness, heat transfer rate, heat flow rate of this heat exchanger are to be analyzed and a heat exchanger is used in a suitable application according to respective requirements. This is a type of shell and tube heat exchanger in one of the simplest form and design.

5.1 Objective linking

1. **To identify some specifications regarding the single flow concentric pipe:** Single flow concentric type heat exchanger is one of the simplest forms of a heat exchanger with a very simple design. Specifications state certain characteristics of this type of heat exchanger according to different working condition and requirement. This kind of heat exchanger can be specified according to the code of material used for manufacturing respective solid structure and walls of it. This is to be selected according to the working conditions, and chemical & physical property of certain working fluid, as this fluid must not do any molecular interaction with respective walls of this heat exchanger. Other dimensional measurements also can be specified and according to the requirement, a specific type of this heat exchanger is taken for consideration.

2. **To evaluate the importance of single flow concentric heat exchanger in an industry and daily life:** Single flow heat exchangers can be used in daily life applications as well as in industries of a different realm. Importance of heat exchanger is evaluated in this research study. To complete a cycle regarding refrigeration or heat pump, these types of a heat exchanger is needed to maintain the continuous flow within the cycle. In power plant industry, coolant devices work on heat transfer without shell and tube like heat transfer. In single flow, a continuous supply of heat exchanger fluid is to be maintained in order to obtain required work output without any break.

3. **To access and examine the contribution of single flow concentric heat exchanger towards the applications in modern science:** In an application of modern science in the different realm of industries, heat exchangers play an important role. Heat exchangers are important in containing different heat cycle and maintain its flow. Wherever there is a need of cold fluid or hot fluid on a continuous basis, heat exchanger plays a particular role of doing it on regular basis. In single flow concentric heat exchanger, two different fluid of different temperature flows inside and outside of the inner tube structured into the heat exchanger. The continuous flow of fluid within it helps it serve effectively and with a larger heat transfer rate with the help of conduction and convection.

4. **To recommend a different way to improve heat exchanging techniques for the benefits of the society:** With the help of proper analysis of the design of a typical single flow concentric heat exchanger, some limitations and problems are identified. Formulation of efficiency and effectiveness of a heat exchanger helps in evaluating and making further of some external accessories and modification to increase its working ability and efficiency.

5.2 Recommendation

Recommendation 1: Implementation of alloying materials instead of raw metals as a structural element.

Specific	Alloying materials have produced to have greater mechanical strength and for this reason use of alloying material give the structure of heat exchanger better rigidity, robustness and durability and better thermal property like conductivity.
Measurable	Mechanical properties of an alloying material are measured by some experiments like Brinell or Rockwell hardness test, impact loading test (fatigue test).

Attainable	Alloying materials are easily attainable due to huge advancement in material science, and according to requirements regarding mechanical properties, an alloy material is taken into consideration.
Realistic	Implementation of alloying material is very much convenient and realistic in order to have an efficient performance from a heat exchanger.
Timely	Research on the alloying materials takes two weeks.

Table 5.2.1: Implementation of alloying materials

(Source: Self created)

Action plan

1st week	Analysis of different alloying material is done in accordance with the requirements.
2nd week	Selection of different allowing material is done.

Table 5.2.2: Action plan for implementation of alloying materials

(Source: Self created)

Recommendation 2: Observation of the work environment is done to obtain proper design.

Specific	A Proper understanding of the working environment is needed in order to realize particular requirements.
Measurable	Different working environments and its spatial characteristics (temperature, pressure) are measurable.
Attainable	Realization of certain working conditions is attainable by inspecting respective working space minutely and accurately.
Realistic	This is a very much realistic process which is required to be done before selection of the structural material of concentric heat exchanger.
Timely	Inspection needs almost two weeks

Table 5.2.3: Observation of work environment

(Source: Self created)

Action plan

1st week	A proper team for inspection is made.
2nd week	Inspection is done.

Table 5.2.4: Action plan for observation of work environment

(Source: Self created)

5.3 Research limitation:

Research work is done only for single flow concentric heat exchanger model. There are certain limitations regarding this kind of heat exchanger. Maximum attainable heat transfer efficiency is not so high for this type of heat exchanger. Maintenance cost is very much high and a large space is needed in order to place the entire heat exchanger unit. In this research study, one of the simplest structure of concentric heat exchanger with the single flow is considered and analyzed. From this model actual design of the entire unit is not very much convenient due to an absence of all the design parameters. This research study can provide an overall idea of the heat issues and strength issues of the structure in the simplest form of ANSYS model. Due to lack of scope, this project does not give any detailed idea about the fluid mechanics section related to the flow of fluid in different temperature state. Different factors affecting conductive and convective heat transfer should be considered in order to obtain more accurate and realistic design.

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5.4 Future scopes of study

Current research study provides data and brief idea about ANSYS diagrams of a single flow concentric heat exchanger which is the simplest form of a heat exchanger. There is a lot of scope of modification in this simplest form in order to attain higher efficiency and effectiveness. Parallel or counter flow can be achieved in this type heat exchanger. An additional provision of the baffling system inside the tubular sections of this heat exchanger would introduce a cross flow of the working fluid increasing surface area of contact, which helps in increasing net heat transfer rate. Thinner wall of the tubular section will produce better heat transfer rate. Lots of innovative ideas regarding a material selection of structure, improvement of convective heat transfer coefficient, structural design of the units are yet to be considered in the future project works regarding heat exchanger.

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Appendices

Appendix 1: Functioning of heat exchanger

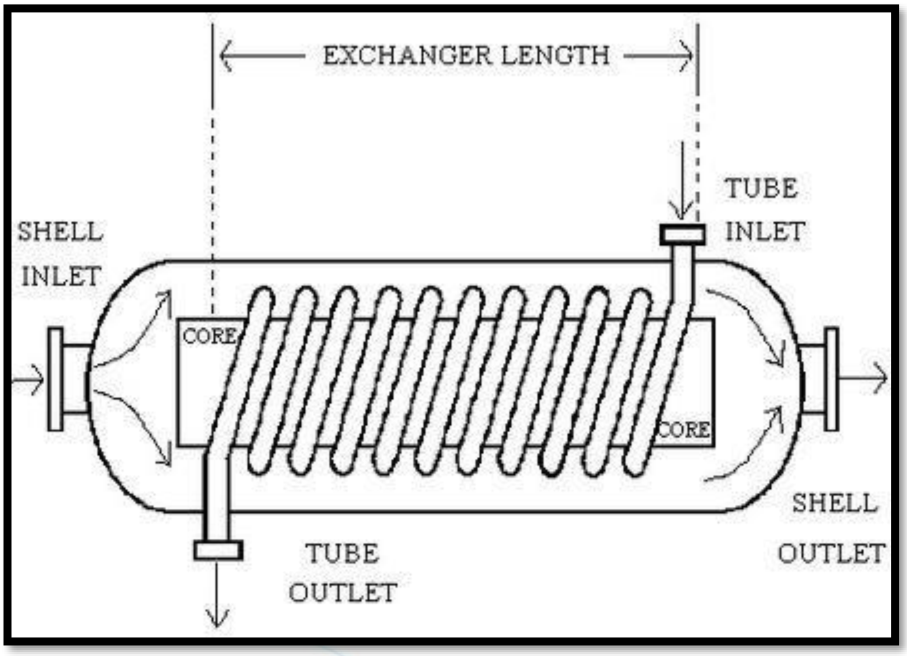

Figure 1: Functioning of heat exchanger

Appendix 2: Straight tube heat exchanger

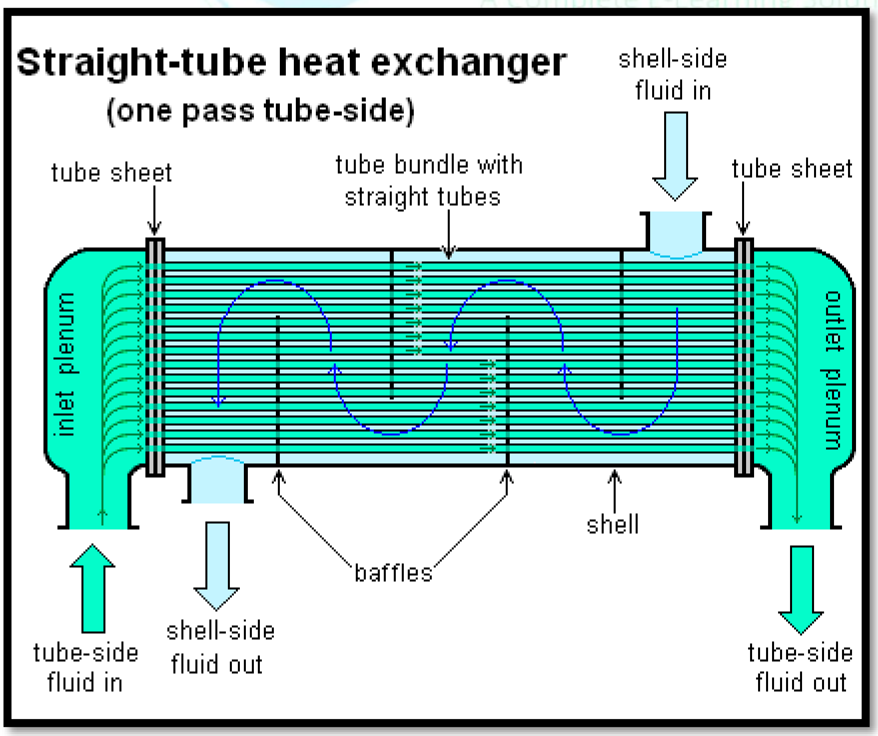

Figure 2: Straight tube heat exchanger

Appendix 3

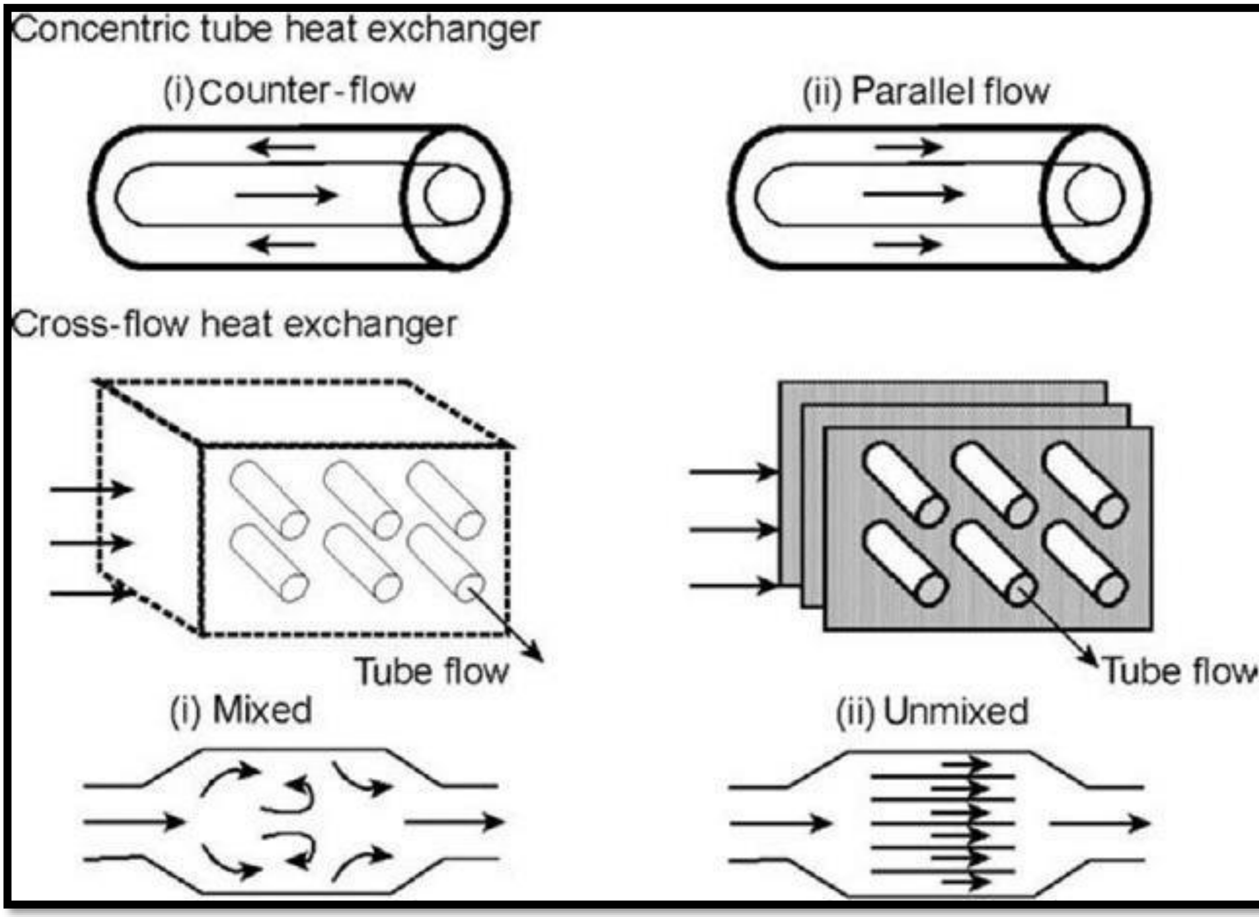

Figure 3: Types of flow in concentric heat exchanger tubes