A REVIEW OF TRIPLE CONCENTRIC HEAT EXCHANGER

[1]Krishn Chand Dwivedee, [2]Dr. Rajeev Arya, [3]Dr. NileshDiwakar, [4]Prof. Amit Khare
[1]M.Tech Scholar, Department of Mechanical Engineering
Truba Institute of Engineering & information Technology, Bhopal

ABSTRACT
To study the triple concentric tube heat exchanger and analyze the same for the better understanding of this heat exchanger. Overview and basic concepts of triple concentric tube heat exchanger is presented which helps to contemplate over the evaluation of different aspects of triple concentric tube heat exchanger. Triple concentric tube heat exchanger consists of 3 tubes of various diameters connected concentrically. Triple concentric tube heat exchanger performs higher than double concentric tube heat exchanger. The Triple concentric Tube heat exchanger is to be evaluated by experimentation for temperature variation on its length. CFD analysis is employed to validate the analytical design.
Keywords: Triple concentric tube heat exchanger; CFD analysis, Triple Tube

1. INTRODUCTION

Heat exchanger may be a device that transfers thermal energy from hot fluid to cold fluid with most rate and minimum investment and running cost. Concentric tube plays a very important role in food business. The most common concentric tube sort is double pipe heat exchanger.

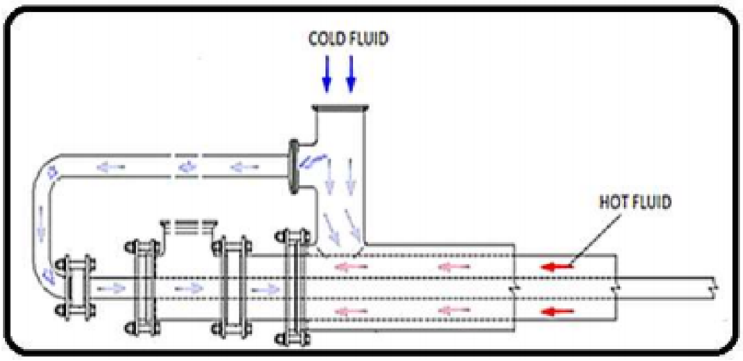

Fig.1 Triple concentric tube heat exchanger

Introducing an intermediate pipe to double pipe heat exchanger that performs higher than double pipe heat exchanger and it referred to as triple concentric pipe heat exchanger shown in Figure 1. The chief perform of third pipe is to enhance the heat transfer rate through a further flow passage and bigger transfer per unit exchanger length. In triple concentric tube heat exchanger thermal fluid (hot fluid) contacts with heat transfer fluid (hot fluid) from both sides, therefore, it provides larger heat transfer area and increases heat transfer rate. Generally, there are two types of fluid used which are cold and hot. In this arrangement, cold fluids flow from inner tube and outer annulus and hot fluid from inner annulus as shown in Figure 1. The technical and economic advantages that are ensured by the use of triple concentric tube heat exchanger in comparison to the double pipe heat exchanger are represented by the higher heat transfer area per unit length and higher velocity due to presence of annular space. Replacing the double pipe heat exchanger with triple pipe heat exchanger application of triple concentric pipe heat exchanger is principally in food industries like pasteurization, sterilization, drying, cooling, freezing, evaporation, refrigeration etc.
Different product use Triple concentric-tube heat exchangers. Most liquid product are often

pasteurized through one in all these heat exchangers. Samples of such product are milk, cream, pulpy orange juice, mashes, eggs, etc. Triple concentric-tube heat exchangers improve the heat transfer.

Basically a triple concentric tube heat exchanger consists of 3 tubes concentrically placed inside one another. Thus, we have referred to as these tubes as-inner tube, intermediate tube and outer tube. The Heat exchanger consists of inner tube space, inner annular space and outer annular space.

The efficiency that a triple tube heat exchanger offers is higher to it of a double tube heat exchanger. Heat exchangers are used for air conditioning, heating applications, power production, waste heat recovery, and chemical processing. Further, heat exchangers are used for pasteurization sterilization, drying, and evaporation, cooling, and freeze functions. Heat exchangers are classified supported flow directions (parallel-flow, cross-flow and counter-flow), construction of the heat exchanger (tubular or plate heat exchangers), on the idea of contact between the fluids (direct/indirect contact type). The sort of heat exchanger to be used is set by the method and therefore the product specifications. Numerous physical characteristics of the material/fluid influence the performance of the heat exchanger.

2. LITERATURE SURVEY

G.A. Quadir et al.[1]observed that the crossover purpose occurs between hot and traditional water for insulated also as non-insulated conditions under N–H–C arrangement. The crossover purpose is seen once rate of hot water is same or slightly but that of different 2 flu-ids flow rates. The crossover purpose appears early on the length of heat exchange r once the outer annulus is exposed to close having higher temperature than that of the fluid in outer annulus. The heat transferred from hot water to fluid in outer annulus is higher in N–H–C arrangement whereas it's almost same for each the flu-ids in C–H–N arrangement.

Patel Dharmik A et al.[2]

- For triple concentric tube heat exchanger factors which affect the performance ought to be relation in sizes or radius of inner tube, inner annulus and outer annulus, mass flow rate, material of tube.
- With the increase in inner tube diameter heat transfer rates of hot fluid, inner cold fluid and outer cold fluid increased, heat transfer coefficient of hot fluid was increased and heat transfer coefficient of inner cold fluid was decreased. Heat transfer coefficient of outer cold fluid remains constant.
- Overall heat transfer coefficient based on inner diameter of inner annulus and effectiveness was increased with the increase in inner tube diameter.
- With the increase in inner annulus diameter heat transfer rate of hot fluid and inner cold fluid increased up to 26 mm after that it decreased due to decrease in temperature difference and flow became laminar. Heat transfer coefficient of hot fluid decreased whereas heat transfer coefficient of outer cold fluid was increased.
- Overall heat transfer coefficient based on inner diameter of inner annulus was also improved. Effectiveness of triple concentric tube heat exchanger was increased up to 26 mm and after that it was decreased.

Mr. Ganesh V. Wafelkar et al.[3]Following conclusions were observed during these experimentation:

1. It is found that for the equivalent Reynolds number efficiency of triple tube heat exchanger is 60% more than double tube heat exchanger.
2. From the experimental data we found that Nusselt number is 1.25 times of predicted Nusselt number.
3. Increasing effectiveness from 0.27 to 0.5 with respect to varying mass flow rate of cold water at same range of ‘Re’ varies from 1500 to 4500 .
4. Friction factor on hot fluid side is decreases as ‘Re’ increases and hence pumping power is reduced.

Hence from the above discussion we conclude that triple tube HEX is suitable for all industrial as well as automotive vehicles (it depends on temperature range).

Dilpak Saurabh P et al.[4]Subsequent conclusions can be drawn from our current study.

1) Study of the experimentation was complete and the procedure of experimentation was briefed here.

2) Experimentation was carried out for both flow arrangements, but here we mainly focused

on two conditions, Vn=Vh=Vc = 35l/min and Vh=20l/min; Vn=Vc=35l/min.

3) The flow analyzed was co present parallel flow with N-H-C arrangement (Normal water in the inmost tube, Hot in the intermediate and Cold at the outermost tube)

4) When the flow rate is decreased in the hot tube there is decrease in the temperature rise of the normal and cold fluids

5) Results are presented in graphical as well as tabular form

6) Tolerating small difference, CFD results are close to the experimental results.

Pierre Peigné et al.[5]the TCTHE-NI is a static element which permits coupling a RSWPS with a MVHR unit in command to distribute heat power in the complete house and attain a better thermal comfort while ensuring occupants safety, indoor air quality and improving the combustion efficiency of the wood-burning appliance. This combined system is installed in two monitored low energy houses with a living area of 100 m² since September 2010 and first results presented and discussed evaluate its possibility and performance as well as inhabitant's satisfaction. In addition, a comparison between energy consumption of apartments equipped with the proposed system and another without will be carrying out including control of the system. This will be the subject of another article. Finally, since experimental and numerical results are during a sensible agreement, following step can consist to implement the mathematical model of the TCTHE-NI within a dynamic thermal simulation code for buildings.

AchourTouatit et al.[6]The technical-economic calculation is required for the design of economic hydrogen engine. The computer program developed in FORTRAN language provides us the optimal diameter corresponding to the minimum total cost of the heat exchanger (production and pumping costs to overcome pressure drops) for the same transferred thermal power. The obtained temperature fields help us to choose the desired temperatures. The effectiveness of the heat exchanger increases proportionally with the central tube radius. The developed model are often a superb tool to optimize the efficiency of triple concentric tube heat exchangers, and so the consumption of energy and matter. We have one optimum diameter, unlike previous studies, where they had two different optimal diameters, the first corresponds to the maximal heat exchanger efficiency and the last one to the minimal energy consumption required overcoming the pressure drop in the heat exchanger.

MaulikPancholi et al.[7]Triple concentric tube heat exchanger performs better in counter flow arrangement then in parallel flow arrangements. C-H-N arrangement ha higher heat exchange rate then N-H-C arrangement. For higher mass flow rate, heat transfer rate is higher. Overall steady state counter flow arrangement for C-H-N arrangement with insulation with higher RE number is the best possible flow configuration for the triple concentric tube heat exchanger.

Dilpak Saurabh P et al.[8] The errors we get in CFD analysis with respect to analytical calculations are 6.7%. The errors in experimental investigation with respect to analytical calculations are 5.45%. These errors are tolerable as the assumptions considered are not practically achievable. From the present study, we can conclude that CFD results and the Experimental results were very much in agreement with the analytical calculations and our design is a success. Thus, use of CFD is very helpful in fabrication of heat transfer related equipment.

3. TRIPLE CONCENTRIC TUBE HEAT EXCHANGER (TCTHE)

First and foremost, the TCTHE developed in this study is a static component integrated into the chimney of a RSWPS (Room Sealed Wood Pellet Stove) in order to warm up all of part of the ventilation air which is supplied in the house by a MVHR(Mechanical Ventilation Heat Recovery).

As shown in Figure 2, the chimney of a RSWPS is commonly composed of concentric parts that guarantee each flue gases evacuation and combustion air admission. Thus, flue gases are exhausted through the inner tube and also the combustion air is brought down through the annular area between the inner tube and also the outer tube of diameter 80 mm and 130 mm severally. Consequently, the sealing of construction is preserved and also the ventilation system isn't disturbed. In addition, the combustion air is heated in the annular space along the entire length of the chimney and so combustion efficiency can be improved by around 10% and carbon emissions are reduced thanks to better combustion.

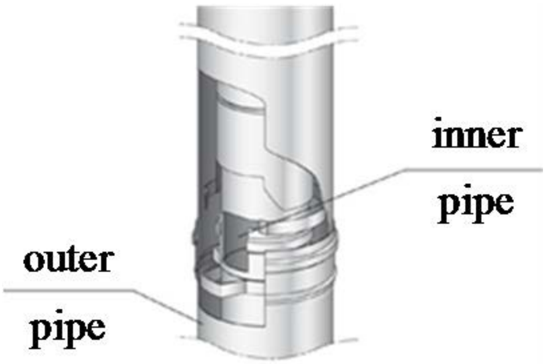

Fig.2 Diagram of a concentric element of the chimney of the wood pellet stove

As pictured in Figure 3, the TCTHE consists of 2 elements, every having a aspect opening of 125 millimeter diameter for either the entry or exit of the ventilation air. During this study, the recess and outlet of the ventilation air are located on the higher half and lower a part of the heat exchanger severally. By this manner, flue gases and vent air are during a counter-current flow arrangement, so a most of heat is transferred. Of course, the inlet and outlet of the ventilation air might be reversed if necessary.

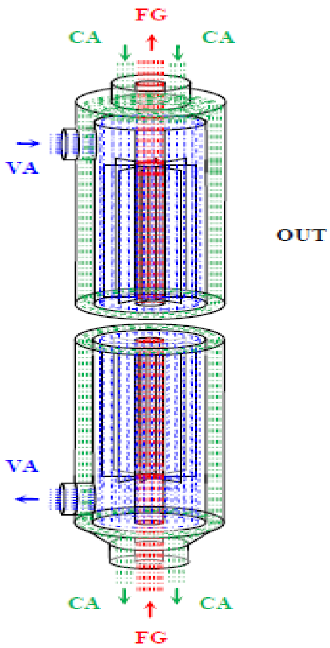

Fig.3 Diagram of the TCTHE

To clarify the flow pattern of the 3 gases inside the TCTHE, the flue gases (FG) are exhausted through the inner tube, the ventilation air (VA) is heated from high to bottom between the tubing and therefore the intermediate tube, and therefore the combustion air (CA) that ensures the proper operation of the wood pellet stove is brought down between the intermediate tube and therefore the outer tube. As a consequence, the flue gases and ventilation air are during a counter-flow arrangement, whereas the ventilation air and combustion air are during a parallel-flow arrangement. It should also be noted that this component is not insulated from the outside (OUT). Thus, heat transfer also occurs between combustion air and ambient air.

With a complete height of 1945 mm, the TCTHE is formed of 3 concentric stainless steel tubes of 0.4 millimeter thickness. The diameters of the 3 tubes are 80 millimeter, 180 millimeter and 230 millimeter, severally.

While limiting the scale of the installation, these dimensions permit to integrate the heat exchanger with the concentric components forming the chimney, however additionally to lead to minimum head losses for every fluid. Indeed, tests were conducted to quantify the pressure drop in annular flow areas. Thus, the head losses in the ventilation flow area air are below 50 Pa for a flow rate of 250 m3/h and the values obtained in the combustion air flow area remain below 5 Pa for a flow rate of 30 m3/h.

Then, eight stainless steel fins of 1280 mm height, 45 mm width and 0.4 mm thick, are welded outside the inner tube to enhance the exchange on the ventilation air side. Thermal joints are used to seal perfectly the upper and lower parts of the heat exchanger. Moreover, as ventilation air is pulsed into the heat exchanger, any risk of discharge of flue gases or combustion air in the ventilation air flow area is avoided.

Nevertheless, leak tests were performed on the TCTHE for the three flow areas of fluids. The measured leak rate corresponds to the amount of compressed air being supplied to maintain a differential pressure of 200 Pa between the inlet and outlet of the tested area. The results obtained are 0.7, 1.8 and 40.0 L/h respectively for the flue gases, the ventilation air and the combustion air.

Leakage rates achieved for flue gases and ventilation air are very low and mirror the nice tightness of the primary 2 concentric tubes. The leak rate measured for the combustion air is more important because the outer wall of the exchanger consists of several parts welded together. Nevertheless, the depression in the combustion air flow area is only about 10 Pa in actual conditions. Moreover, it ought to be emphasized that the system works by processing ventilation air within the triple concentric tube device, therefore there's no risk of system malfunction or contamination of ventilation air.

4. CONCLUSION

Based on the review study has carried on the research breakthrough to the Basic Review on Triple Concentric Tube Heat Exchanger. In this paper various research papers are studied related to the Triple Concentric Tube Heat Exchanger. The present work involves CFD analysis of triple concentric tube heat exchanger by using previous research’s mathematical model, experimental model and correlation. Most of the previous studies used 2 fluids for various arrangements. Cold fluids result inner tube and outer annulus and hot fluid from inner annulus. Different parameters were found which affect performance of triple concentric tube heat exchanger.

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