ANALYSIS OF THE HEAT TRANSFER DURING ENERGY STORAGE IN A TRIPLEX CONCENTRIC TUBE USING PCM

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Abstract:- *This paper addresses a heat transfer investigation of a thermal energy storage unit involving PCM process dominated by heat physical phenomenon. The thermal energy storage unit involves a triplex concentric tube with phase change material (PCM) filling in the middle channel, with hot heat transfer fluid (HHTF) flowing outer channel during charging process and cold heat transfer fluid (CHTF) flowing inner channel during discharging process. The main objective of this work is to check the impact of the water temperature and also the flow of warmth transfer fluid (HTF, as well as HHTF and CHTF) on the thermal energy storage has been studied. Heat transfer coefficient, heat transfer rate and skin friction coefficient for the triplex concentric tube heat exchanger. 3D modeling is done by using creo2.0 and simulation is done with help of CFD in ANSYS.*

Keywords: triplex concentric tube, creo 2.0 and CFD

1. Introduction to heat exchanger

Heat exchanger is a procedure hardware intended for the powerful exchange of warmth vitality between two liquids. For the warmth move to happen two liquids must be at various temperatures and they should come warm contact. Warmth trade include convection in every liquid and conduction through the isolating divider. Warmth can stream just from more sweltering to cooler liquids, according to the second law of thermodynamics.

Fig 1.1:- Heat exchangers

1.2 Thermal energy storage:

Energy resources on the earth will be exhausted one day if they are used in an unchecked way. This will cause serious problems and even crisis and jeopardize the survival of mankind. In China, with the rapid development of economy and the much improvement of people's living standard, the problem of energy shortage becomes serious. Especially after early morning until midnight, this problem becomes more serious for more power consumption of industrial, commercial and residential activities during that period of time.

There are two different ways to alleviate this significant circumstance somewhat. One is to move power utilization from pinnacle periods to off pinnacle periods. The other is to recoup the vitality which is utilized to be catapulted legitimately to the earth as squandered warmth, for example, the launched out warmth from the condenser of forced air system, or to gather and use the diurnally fluctuating warm vitality, for example, the sun based vitality. Regardless, a vitality stockpiling framework ought to be vital. Because of overall vitality deficiency, the advancement of productive and practical warm capacity framework has gotten significant consideration because of the approaching lack and expanding cost of vitality assets (Hamada, 2003). A warm capacity framework is relied upon to give to convenient and complete vitality the board by intemperate warm vitality at vitality rich periods to use it atenergy-poor periods. The principle errand of the vitality stockpiling is then to beat the errors between vitality supply and vitality request. There are three primary strategies for warm vitality putting away: reasonable, inactive and warm compound warmth stockpiling. An inactive warm vitality stockpiling framework, with strong fluid stage change, has gotten an impressive consideration because of its favorable circumstances, for example, putting away a lot of vitality in a little volume i.e., high stockpiling thickness also, heat charging/releasing at an almost consistent temperature, which result in a more noteworthy adaptability and more smallness of the PCM stockpiling framework in picking an area for the capacity framework (Setterwall, 1996).

1.3. Classification of PCMs:

There are an enormous number of natural, inorganic and eutectic materials, which can be Recognized as PCM from the perspective of dissolving temperature and idle warmth of combination. As no single material can have all the required properties for a perfect warm can have all the required properties for a perfect warm capacity media, one needs to utilize the accessible materials and they to compensate for the poor physical property by a sufficient framework structure.

For instance metallic balances can be utilized to expand the expansion the warm conductivity of PCMs, super cooling might be smothered by presenting a nucleating operator in the capacity material and incongruent softening can be hindered by utilization of appropriate thickness. For their altogether different warm and synthetic conduct, the properties of each sub gathering, which influences and fluid gas frameworks are of constrained utility as a result of the huge volumes required for such frameworks.

1.5. PHASE CHANGE MATERIALS [PCMs]:

Unlike the sensible thermal storage methods, PCMs provide much higher energy storage densities and the heat is stored and released at an almost constant temperature. PCMs can be used in active and passive in building materials such as concrete, gypsum wallboard in the ceiling or floor to increase their thermal storage capacity.

They can either capture solar energy or thermal energy through natural convection of space heating and cooling, yet at present there are limited systems in use. The design of latent heat storage systems using PCMs of that sub group.

1.7. Criteria of Selection of PCMs

The criteria of selection of PCMs mainly depends upon

- Latent heat of fusion
- Thermal conductivity
- Recyclability and chemical stability
- Melting/ Transition temperature
- Non-Flammability

LITERATURE SURVEY

Jegadheeswaran and Pohekar [1] and Fan and Khodadadi [2]. Sparrow et al. [3] performed an experimental investigation of a finned tube using four fins, and concluded that the use of fins could delay the natural convection during the solidification process. According to the authors, the presence of fins could delay or interrupt the solidification process, and hence, was deemed undesirable. Sparrow et al. [4] investigated the freezing of a finned vertical tube, when either conduction in the solid or natural convection in the liquid controlled the heat transfer, using n-eicosane paraffin as a PCM. The authors concluded that the presence of fins brought an enhancement of freezing heat transfer on the tube surface between the fins. Padmanabhan and Krishna Murthy [5] studied the phase change process occurring in a cylindrical annulus, in which rectangular, uniformly spaced axial fins spanning the annulus are attached to the inner isothermal tube, while the outer tube is made adiabatic. They performed the parametric analysis, and based on the results, they suggested a working formula to obtain the volume fraction solidified at any time for this fin configuration.

Velraj et al. [6] performed an experimental and numerical analysis of the enhancement of heat transfer in a PCM storage system, consisting of a cylindrical vertical tube with an internal longitudinal fin arrangement. A theoretical model that also accounts for the circumferential heat flow through the tube wall was developed, using the enthalpy formulation, and employed in conjunction with the fully implicit finite difference method, to solve the solidification problem in a convectively cooled vertical tube. The numerical model was validated with the experimental data. Lacroix and Benmadda [7] noticed that the onset of natural convection was gradually prevented during the melting of the PCM, as the distance between the fins was decreased. It was concluded that natural convection would occur, if less number of fins were used. They also found that too large a distance between the fins led to a reduction in the total heat transfer surface area, and hence, they optimized the number of fins for a fixed size of the module. Ismail and Melo [8] developed a two-dimensional axi-symmetrical model for the formulation of the problem of the fusion of PCM around a vertical cylinder in the presence of natural convection. The model was extended to produce charts and correlations for the mean heat transfer rate, total solidification (or fusion) time in terms of the geometrical parameter, and the modified Rayleigh and Stefan numbers.

PART MODELING

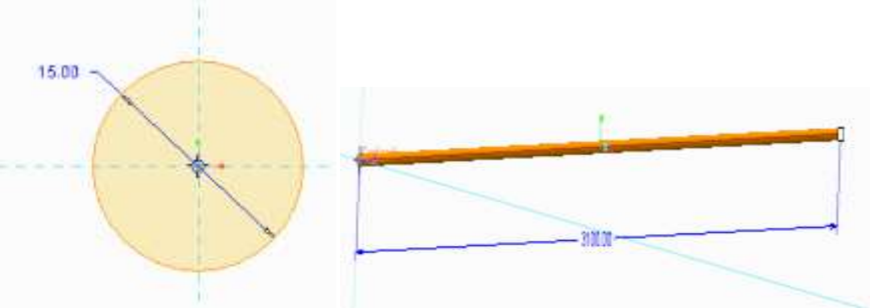


Fig:- inner fluid diameter and its length to flow

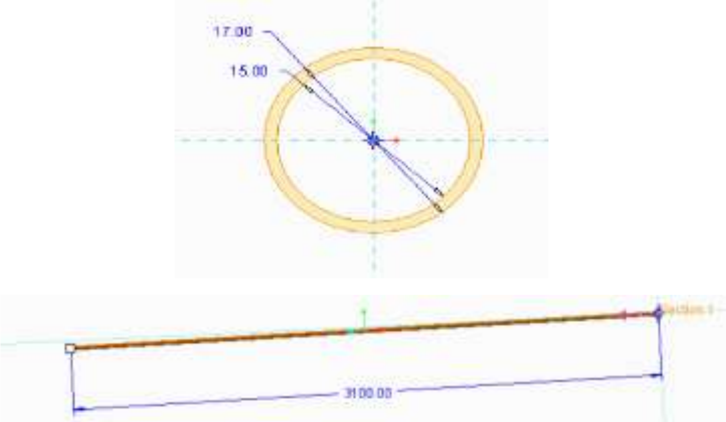


Fig:- cold water flow pipe made with copper

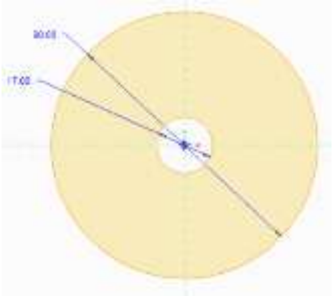


Fig:- PCM material with length of 3000mm

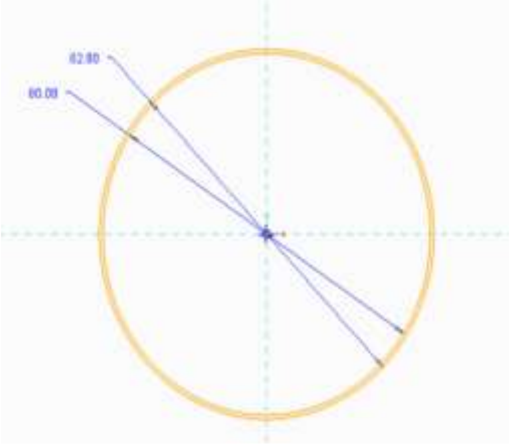


Fig:- cross section of the pipe which can placed outside of PCM

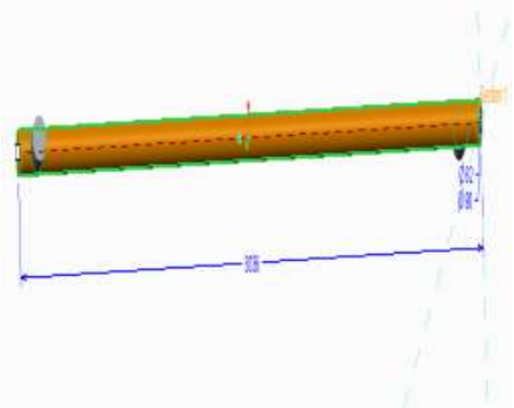


Fig:- hot water fluid flow region

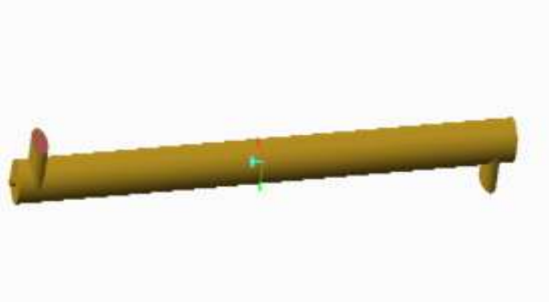


Fig:- Final assembly

Boundary conditions

PCM Material is n-octosane

Mass flow rate : 0.009, 0.01, 0.011 and 0.012 kg/sec

Cold water temperature: - 23, 25, 27 and 29^{0}C

Hot water temperature: 59, 61, 63 and 65^{0}C

CFD SIMULATION FOR PARALLEL FLOW

Case 1:- COLD INLET 23^{0}C & HOT INLET 59^{0}C

Condition 1: Mass flow rate 0.09 kg/sec

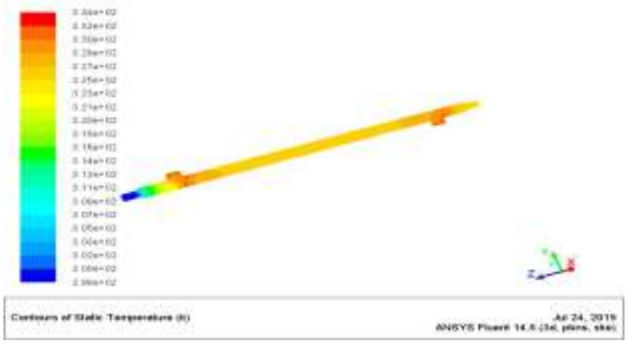


Fig:- temperature

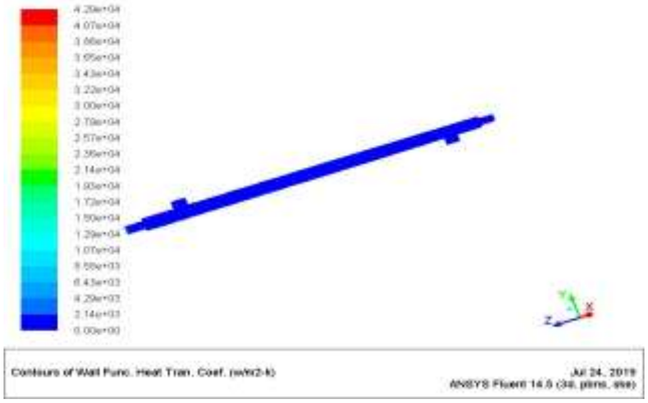


Fig:- wall function heat transfer coefficient

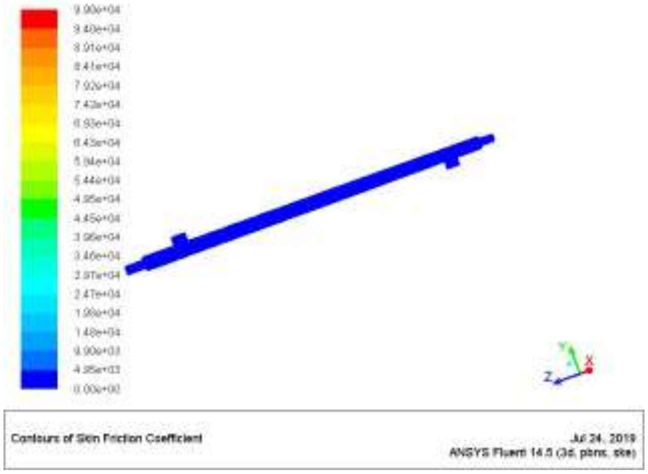
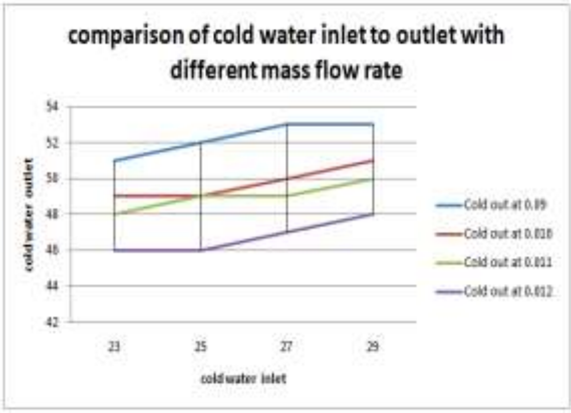
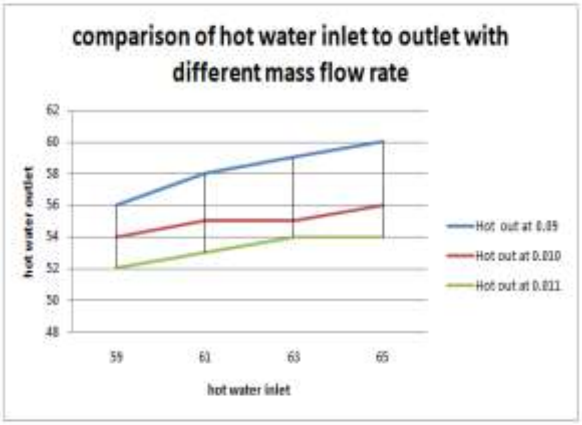
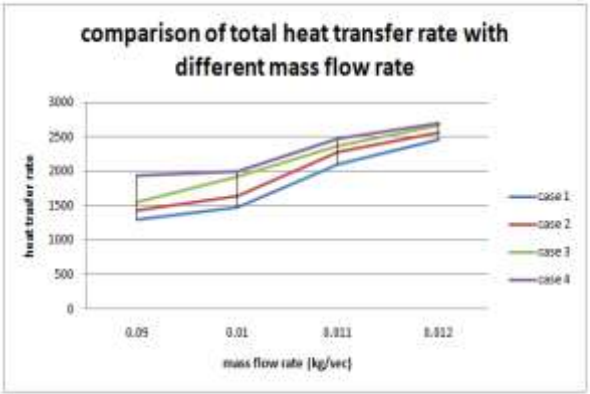


Fig:- skin friction coefficient

RESULTS AND DISCUSSIONS







CONCLUSIONS

The main objective of this work is to check the impact of the water temperature and also the flow of heat transfer fluid (HTF, as well as HHTF and CHTF) on the thermal energy storage has been studied. Heat transfer coefficient, heat transfer rate and skin friction coefficient for the triplex concentric tube heat exchanger. 3D modeling is done by using creo2.0 and simulation is done with help of CFD in ANSYS.

By observing above results

- By utilization of PCM, the temperature is increment observed in counter flow while compared to parallel flow.
- The total heat transfer rate high for the counter flow direction.
- Similarly, the heat transfer coefficient is also observed for the both parallel and counter flow of triplex concentric tube heat exchanger

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