Experiment On A Finned Tube Heat: Exchanger For Thermal Energy Storage

Abstract— this experiment conducted on thermal energy storage with annular shell and tub heat exchanger, the experiment is conduct on both plane tube as well as finned tube. And check what the effect of fin on heat transfer rate is. KNO3 is used as thermal storage material which as specific capacity 0f 1.21 KJ/Kg K and water is used as heat transfer fluid which as specific capacity 4.187 KJ/Kg K.in this experiment only sensible heat is stored and check effect number of fin on heat energy. And while in charging mode water inlet temperature is taken 60°C. And flow rate will set constant 80 lit per hr. through the experiment. We had calculated effect of fin on time while charging and discharging. From this experiment it will show that as goes increase the number of fin the heat rate also increases.

Keywords— thermal energy storage, finned tube, non-phase change material, heat transfer fluid, charging, discharging.

I. Introduction

Thermal energy storage is latest and advanced trending technology for storage of both sensible heat energy and latent heat energy. There are mainly two type of material used for heat energy storage, one is phase change material and another non phase change material. Thermal storage technology is still not practical because it’s difficult to find proper thermal storage material and they are possesses certain desirable thermodynamic, mechanical, chemical, technical properties and should be economic characteristics, and also had good thermal conductivity, large latent heat, low super cooling and good stability are the most key point to selection of storage material. The thermal storage system of the solar thermal power plant is necessary for the power plant stability and reducing rate of mismatch between energy demand and supply [1] to increase the heat transfer rate as well as thermal efficiency there are many way of heat exchanger like helical coiled heat exchanger, plate type, and compact surface type, many more. In this project we used finned tube shell and tube heat exchanger which has better efficiency value compare to bared tube.in this experiment I taken effect of number of fin on heat transfer rate and heat recovery efficiency. First experiment is conduct on the five finned stainless tube then ten finned stainless tube both finned tube are compared to the bared stainless tube and on technical data there is more efficient as goes on increasing number of fin. All tube is as same dimension and mild steel is used for fin material of same size. These fins are welded on tube and shell is made up of stainless steel on both side plunge will be welded for closing and opening of shell. Experiment will be conducted on and non-phage change material like salt material in salt material we can save sensible heat energy and it does not change phase while heating process with different finned tube compare it for which is suitable for thermal energy storage. In this experiment KNO3 salt is taken as non-phase change material. Which has good thermal as well chemical properties [2] and physically and chemically equilibrium also low cost material and it is easily available in market. The overall experiment setup had low cost and all materials are easily available.

II. Design And Concept.

There are many type of heat exchanger are available but for better efficiency of heat transfer I had tested on finned tube heat exchanger. Because in many heat exchanger industries try to increase the efficiency of heat transfer rate on shell and tube or double pipe heat exchanger. Therefore finned tube with shell heat exchanger will give way to increase the heat transfer rate. And also heat exchanger is major part in thermal energy storage. In this experiment consist of energy storage and extract the heat energy from storage material by using shell and finned tube heat exchanger.

SL No component Material used

1. Corrugated tube stainless steel
2. shell stainless steel
3. Baffle plates mild steel

Fig 1 and 2 shows the shell and tube which are made up of steel material and fins are welded on tube with gas welding and similar type shell tube designed and fabricated table 1 and 2 show detail of data of shell and tube arrangement.

III. Experiment Procedure.

A) Component required

To complete the experimental set up major following component are required and explained below.

- Shell and tube set up

This is main device which consist of shell of 5cm diameter pipe and thermal storage material is placed inside the shell. And 2.5cm corrugated stainless steel pipe on which finned are welded as shown in figure and heat transfer fluid or hot fluid is flowing inside this pipe.

- Thermometer

Digital thermometer is used to measure the temperature of inlet and outlet HTF T1 T2 and also measure the thermal storage material temperature as T3.

- HTF storage tank

A steel tank of 10 litre capacity is taken as HTF storage tank, in that water is placed and is heated externally by electric heater as shown in fig.

- HTF collecting tank

After out coming cold water collected in another tank which is also made up of steel of 10 lit capacity.

- Valve

In this experiment ball valve is used of 1cm diameter, it consist ball inside the valve and is used for control flow rate of working fluid.

- Flow measurement

In this experiment I am taken gravity type flow. According to that adjustment of flow rate is controlled by ball valve.

SL No PARAMETER DIMENSSION

1. Type of heat exchanger horizontal
2. Shell diameter 0.1m
3. Shell length 0.5m
4. Tube diameter 0.05m
5. Tube length 0.45m
6. Tube thickness .001m
7. Number of baffle 5
8. Baffle spacing 0.08m

1. HTF Storage tank.
2. Ball valve.
3. Inlet temperature.
4. NPCM temperature.
5. Outlet temperature.
6. HTF collecting tank.

- Pipe

Hose pipe is used to connect water tank and prototype. Which is made up of plastic with high withstand temperature about range of 100 to

120°C.

B) Standard Procedure.

There are mainly 2 steps involved and they are given below.

1. Charging.

First arrange all components as shown in figure. Next collect water in heat transfer fluid storage tank and heat it up to 60°C, and maintain it constant throughout charging process. Set flow rate at 80ltr/hr. constant level by using ball valve which is attached to hose pipe. Attach digital thermometer as required position to measure the temperature as shown in fig. Allow to flow water by opening valve then at every 45 second note down temperature of NPCM material and outlet temperature of water. Repeat the procedure up to NPCM temperature will attend 60°C. And corresponding outlet temperature should be note down.

2. Discharging.

After achieving NPCM temperature at 60°C stop the experiment Then fill HTF as cold water in storage tank. Then measure initial temperature of water at tabulates it. Then again with same flow rate the cold water will allow to flow in heat exchanger setup. And measure NPCM temperature and HTF outlet temperature then note down it. Repeat the experiment up to NPCM temperature will attend room temperature. Then by using data calculate the heat transfer rate of both charging and discharging.

IV. Result And Discussion

A) Charging.

Charging is process of continuous addition of heat to non-phage change material (NPCM) .when water is used as heat transfer fluid HTF which is constant set to 60°C. and fist set up will arrange with plane tube as shown in fig and continue experiment according to procedure. From above the blue line which is shows the variation of temperature with respect to time as goes on increasing the time the NPCM temperature also increases and finally it will approach 60°C temperature at 2500 sec or 45 minute. Similarly for five finned tube will take 34 minute to attend 60°C temperature. The brown line shows five finned tube reading in above graph. and finally for 10 finned tube it will take only 25 minute to approach 60°C temperature of the NPCM material. From above data and graph shows that when rate of temperature increasing is depend upon fin. As increasing number of fins it will take less time to attend 60°C temperature because the heat transfer rate is increases as increasing the number of fins. There is conduction heat transfer takes place between hot pipe and KNO3 salt (NPCM) material. And there is maximum temperature at depth of bed.

B) Discharging.

The figure shows the temperature variations in the storage unit during discharging with an HTF flow rate of 80 LPH. Significant temperature drop at beginning of the discharging process due to sensible energy loss. When zero finned pipe there is decreases Fig 5 variation of temperature vs. time. In temperature takes place slowly because there is less heat transfer rate and finally it will take time 50 minute to reduce temperature from 60°C to room temperature. And simultaneously HTF fluid temperature also decreases parallel to NPCM temperature. And for plane tube the blue line indicated in above graph. Similarly for five finned tube it will take 40 minute to reduce to room temperature, compare to plane tube there is slight faster reduces takes place because of the heat transfer rate is slightly more due to fins, the brown line shows variation of five finned tube. And finally the green line shown ten finned tube in that reduction of temperature takes place little bit faster than five finned tube because heat transfer rate is more as increasing number of fins. And it will take 34 minute to come to room temperature. From above three lines at beginning there is sudden decrease takes place due to low heat capacity and as goes on time the reduction rate come slowly and normally parallel to HTF temperature.

C) Effect of heat transfer rate.

From Eq. 1 we have to calculate heat transfer rate while charging mode and variation with time which is shown in above figure 5.5.as we seen in graph there is continuously reduction in heat transfer rate of all three line because the temperature difference continuously reduced at each reading. And ten finned tube which get faster rate compare to the five and zero finned tube.

V. Conclusion

From this experiment we can conclude as this is advance experiment for checking the thermal energy storage. Overall experiment show at 80 lit per hr. while charging mode the zero finned tube consume more time to achieve the 60°C temperature of material 45 minute to achieve temperature. But five finned tube will take 34 minute and ten finned tube took 25 minute to attend 60°C temperature. While in dis charging mode zero finned tube took 50 minute to reduce room temperature of material and other side five finned tube will take 40 minute, while ten finned tube took 35 minute to attain room temperature of material from above date shows as goes on increasing the no. of fins the heat transfer rate also increases.

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