HEAT TRANSFER AND PRESSURE DROP CHARACTERISTICS OF THERMAL ENERGY STORAGE SYSTEM WITH ALUMINIUM OXIDE

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Abstract - *This chapter presents a review of work done in the field of thermal energy storage and nanofluid. There is a need of energy storage systems due to increasing demand of energy. In the case where the supply or consumption of energy varies with time energy storage is essential there. Thermal energy storage has been main topic in research for last 20 years. Many researcher doing lot of research for finding advanced heat transfer fluid with significantly higher thermal conductivity in thermal energy storage to overcome the disadvantage of low thermal conductivity of heat transfer fluids.*

Key Words: **Nanofluid. Al_2O_3, heat transfer, Thermal Storage, Reynolds number**

1.INTRODUCTION

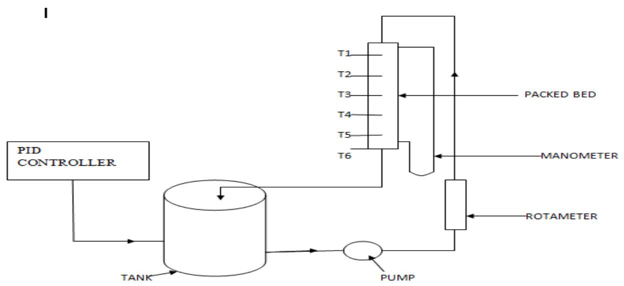
The continuous emission of green house gases and rise in capital prices are the main reason for different source of renewable energy. In various places solar radiation is available to be one of the most useful sources of energy. The researchers are trying to find of new source of energy storage in direction of renewable energy sources. One of the methods is developing new resources of energy as energy storage devices. Now in present days, its problem for researcher to convert the store energy into useful forms. To reduce the gap between energy supply and demand have to store energy into desired form. Energy storage improves the performance and durability of energy storage system. There are different types of energy storage methods.

2.EXPERIMENTAL SETUP

Experimental setup include:

1. Thermal Storage System-test section
2. Hot water storage tank
3. Rotameter
4. PID Controller
5. Temprature sensor
6. Manometer
7. Magnetic pump

3.LINE DIAGRAM



4.Procedure

1. Switched on the electrical heater in tank to heat up the heat transfer fluid up to desired temperature.
2. After desired temperature pump is operated and flow of heat transfer fluid is controlled by rotameter.
3. Heat transfer fluid flows from main tank to test section and heat transfer to steel sphere.
4. The temperature of heat transfer fluid decrease and steel sphere increase.
5. To attain the thermal equilibrium the charging process should be continue.
6. Temperature is measured by thermocouples and pressure drop is measured by U-tube manometer.

5.Technical specification.

Product	As shown in schematic diagram
Test section	Copper pipe with 7cm diameter and 60cm length fitted with six thermocouple PT-100
Hot water tank	Made of ceramic steel insulated with fiber
Manometer	U-tube manometer measure pressure drop across the packed bed
Temperature sensor	RTD PT-100
Rotameter	Water flow measurement
Control panel	Digital temperature controller(0-199°C) for hot water tank
Pump	Hot water circulation

6.FORMULAS

Flow rate= LPM

Pressure drop in centimeter of manometric fluid

Bed porosity= ϵ

Spherecity= 1

Cross sectional area of bed = $\pi d^2/4$

Diameter of steel sphere= 8.4mm

Mass flow rate= m°

Pressure drop $\Delta P= \Delta h\rho g$

$f_p= 150\ (1-\epsilon)/QR + 1.75$

Volume of steel sphere= $4/3\times \pi\times r^3\times n$

n= no. of steel sphere

Geometrical bed volume= $\pi \times r^2 \times L_{bed}$

V volume fluid in voids= Geometrical bed volume- volume of spherical balls

Void fraction(ϵ)= Ratio of volume of fluid to volume of bed

$m_{b=}$ mass of steel sphere

$c_{b=}$ specific heat capacity

ΔT= temperature difference

$\rho_{b=}$ density of steel sphere

V_b= volume of steel sphere

Thermal energy store by water in the voids between spheres

$Q_{wv}= mc_p\Delta T$

$m_w= p_w\times v_w$

$v_w=\pi \times r^2\times L\times \epsilon$

c_p= specific heat of water

Energy with the fluid leaving the bed

$Q_f=m\times c_f \times\Delta T$

Total energy storage= steel sphere + energy store by water in voids between the steel sphere + energy with fluid leaving the bed.

7.GRAPHS AND CALULATIONS

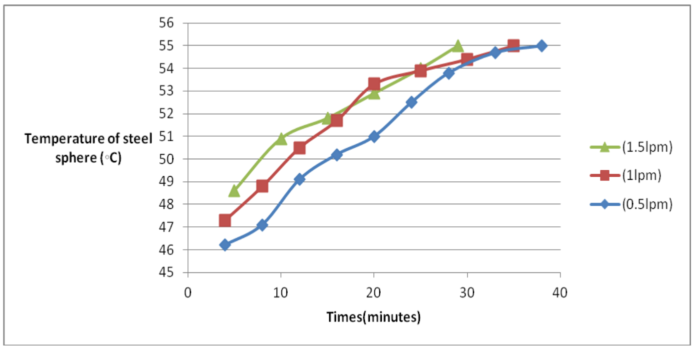


Figure 1. Temperature of steel sphere v/s time at different flow rate with water

Figure 1. represent the temperature variation of steel sphere during charging process for different mass flow rate .5LPM, 1LPM, 1.5 LPM. The initial temperature of steel sphere is 34 ˚C. Its seen from the figure that initial temperature of steel sphere increase gradually during the charging process and remains nearly constant around 55˚C. The measuring charging time for different mass flow rate .5LPM, 1LPM, 1.5 LPM are 38, 35, 29 minutes. The figure5.1 shows that mass flow rate increase charging time decrease.

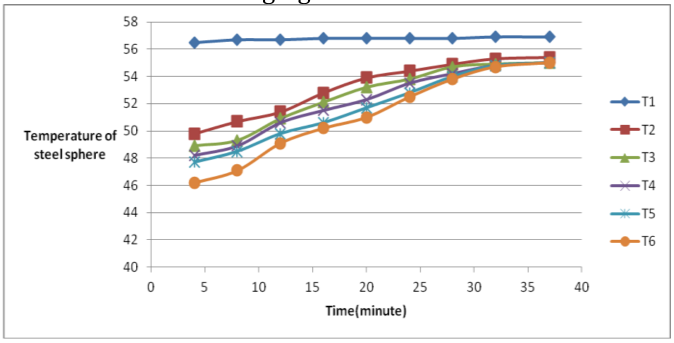


Figure 2. Temperature v/s time at different section of packed bed

As shown in figure 2. near inlet temperature of steel sphere become in equilibrium in shortest time as we move further time increase with length of test section.

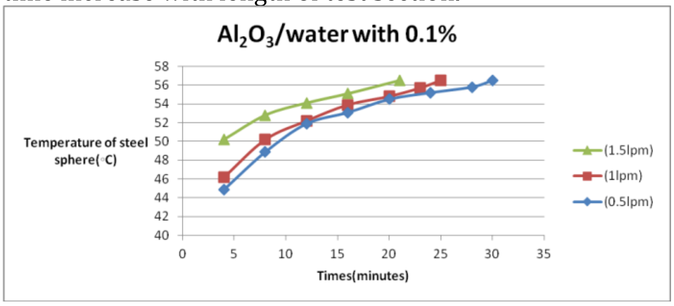


Figure 3. Temperature of steel sphere v/s time at different flow rate with Al_2O_3 with .1% concentration.

Figure 3. represent the variation of temperature with different mass flow rate .5LPM, 1LPM, 1.5LPM. The initial temperature of steel sphere is 40˚C its seen from the figure3. that steel sphere temperature increase gradually at the beginning of charging period, remain nearly constant at 57.0˚C. Charging time taken by nanofluid Al_2O_3 (.1%) at .5LPM, 1LPM, 1.5LPM are 30, 25 and 21 minutes and equilibrium temperature are 56.5˚C.Nanofluid takes less charging time as compare to water to reach equilibrium state. The figure shows that charging time decrease with increasing mass flow rate.

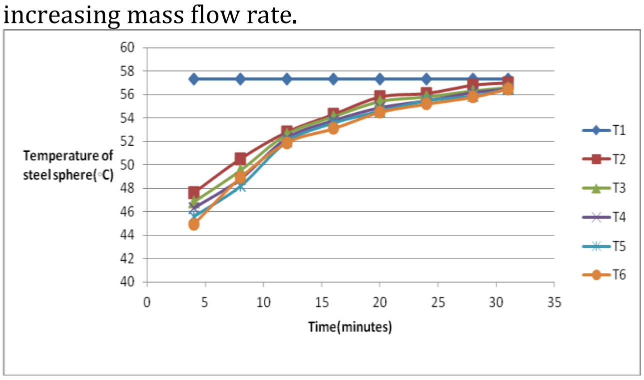


Figure 4. Variation of temperature v/s time at different segment of bed with Al_2O_3/water (0.1 % concentration)

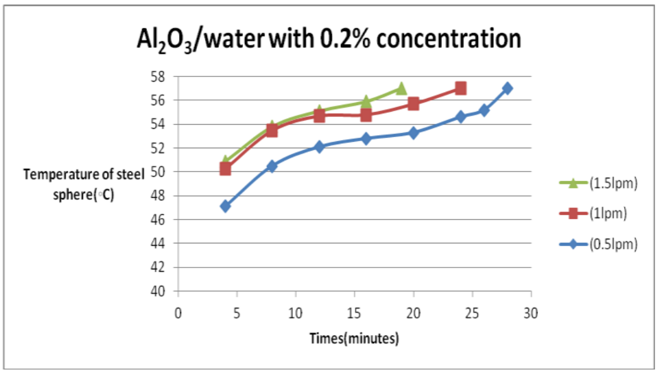


Figure 5. Temperature of steel sphere v/s time at different mass flow rate with Al_2O_3/water (0.2% concentration)

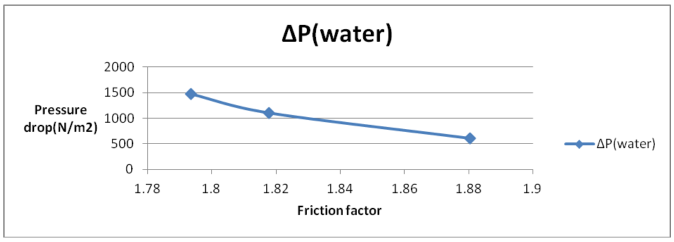


Figure 6.variation of pressure drop v/s Reynolds number with Al_2O_3/water (0.1% concentration)

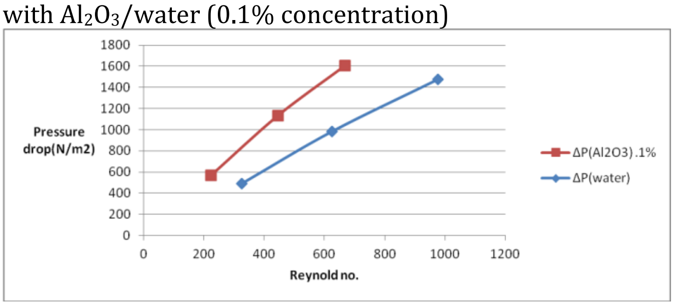


TABLE 1

Material	Density(kg/m^2)	Specific heat(j/kg.k)	Thermal conductivity(W/m.k)
Steel	8085	480	54
Al_2O_3	3880	773	36
TiO_2	4175	692	8.4
Water	998.9	4181	0.613

3. CONCLUSIONS

1. Increasing mass flow rate of fluid increase the temperature of storage unit until the equilibrium state achieved and gives pressure drop. Nanofluids (Al_2O_3 with 0.2% concentration) are more efficient than water in case of charging process and have high pressure drop than water.
2. Increasing mass flow rate increases the pressure drop across the packed bed.
3. Reynolds number is directly proportional with mass flow rate of fluid.
4. Near inlet the temperature of steel sphere becomes in steady state in shortest time as we move further time increase with length of packed bed.

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