Heat transfer characteristics of thermal energy storage system with titanium oxide

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***Abstract*—As we know that the need of a suitable and efficient TES is as one of the main challenge facing the world today to reach the target for energy transition. In various installations such as boiler, solar collector, heat exchanger and electronic device forced convection process is employed. Because of low warm conductivity of warmth exchange liquid, for example, stage change material oil, water, and ethylene glycol blend is burden for enhancing their execution. That is purpose for it to create warm exchange liquids with fundamentally higher conductivity to beat this constraint. It is based on experimental result that thermal conductivity of fluid can be improved by suspending nanosize solid particle in base fluid.**

Keywords*— Nanofluid. Al2O3, heat transfer, Thermal Storage, Reynolds number

XV. INTRODUCTION

In the past various studies have been made on warm conduct of suspensions of strong molecule in fluid. For example, poor suspension, soundness and subsequently channel stopping up which are especially genuine for frameworks utilizing smaller than normal or potentially miniaturized scale diverts if there should arise an occurrence of suspension of millimeter or micrometer estimated molecules. Nanotechnologies have discovered a advance category of fluid named as nanofluid. Nanofluid are liquid suspensions include particles that are smaller than 100nm and have high thermal conductivity than the base liquid. There are various type of material used for nanoparticles.

XVI. EXPERIMENTAL SETUP

A. Experimental setup includes:

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

XVII. LINE DIAGRAM

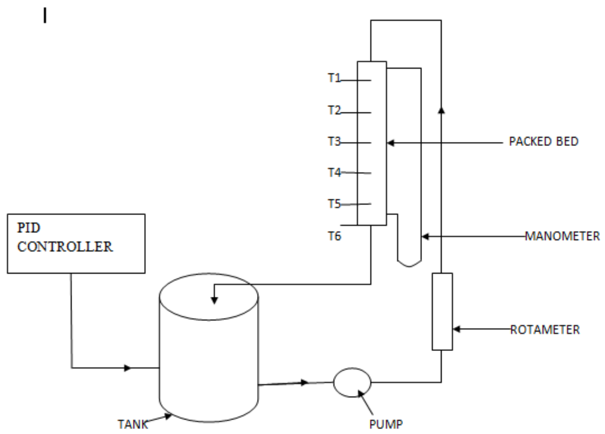

Fig 1 Line diagram

XVIII. 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.

XIX. TECHNICAL SPECIFICATION

Table1 Technical Specifications

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

XX. FORMULAS

Flow rate= LPM
Pressure drop in centimeter of manometric fluid
Bed porosity= ϵ
Sphercity= 1
Cross sectional area of bed = πd2 4
Diameter of steel sphere= 8.4mm
Mass flow rate= m◦
Pressure drop ΔP= Δhρg
f_p= 150 (1-ϵ)/QR +1.75
Volume of steel sphere= 4/3× π× r3×n
n= no. of steel sphere
Geometrical bed volume= π × r2 × 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
ρ_b= density of steel sphere
V_b= volume of steel sphere
Thermal energy store by water in the voids between spheres
Q_{wv}= mcpΔT
m_w= pw×vw
v_w=π ×r2×L×ϵ
cp= specific heat of water
Energy with the fluid leaving the bed
Q_f=m× cf ×ΔT
Total energy storage= steel sphere + energy store by water in voids between the steel sphere + energy with fluid leaving the bed.

XXI. GRAPHS AND CALULATIONS

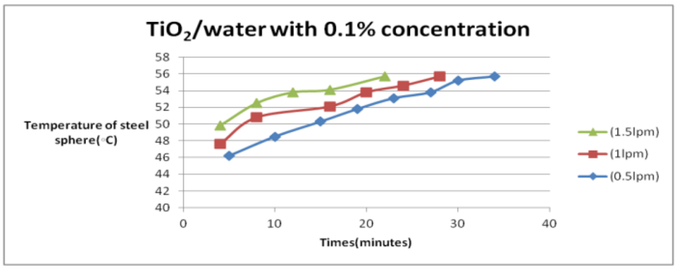

Fig 2 Temperature of steel sphere v/s time with TiO2 (0.1% concentration)

Figure1. represent temperature variation of steel sphere during the charging process for different mass flow rate 0.5LPM, 1LPM, 1.5LPM. Charging time for mass flow rate 0.5LPM, 1LPM, 1.5LPM are 34, 28, 22 minutes and equilibrium temperature are 55.7◦C.

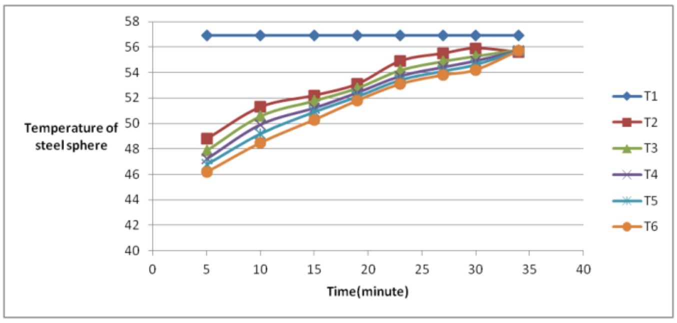

Fig 3 Variation of temperature v/s time at different section of packed bed with TiO2/water (0.1% concentrations)

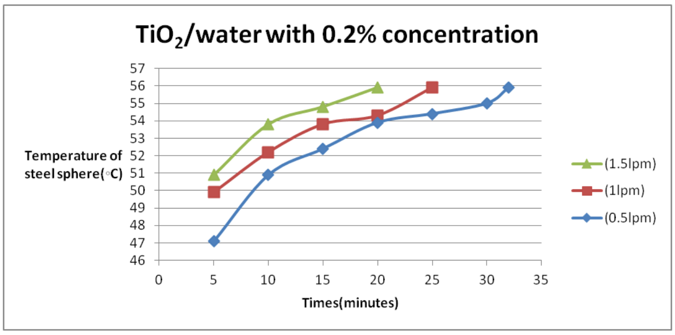

Fig 4 Temperature of steel sphere v/s time with TiO2/water nanofluids (0.2% concentration)

Figure 3. represent temperature variation of steel sphere during charging process for different mass flow rate 0.5LPM, 1LPM, 1.5LPM and equilibrium temperature are55.9◦C.

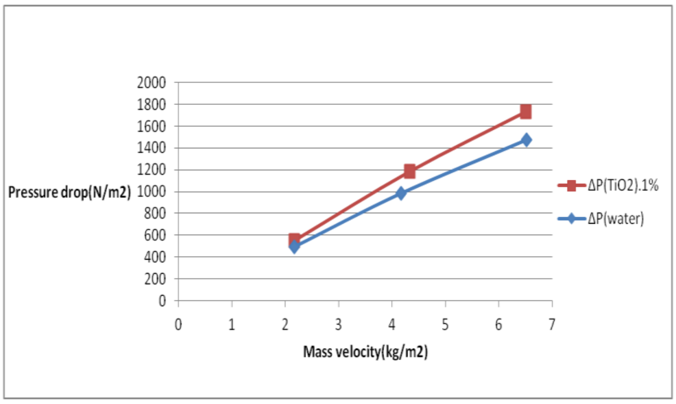

Fig 5 Pressure drop characteristic of TiO2 (0.1% concentration) nanofluid

Figure 4 shows that increase in mass velocity of fluid increase pressure drop across the bed. Graph shows that pressure drop is directly proportional to mass velocity. TiO2 has high pressure drop than water.

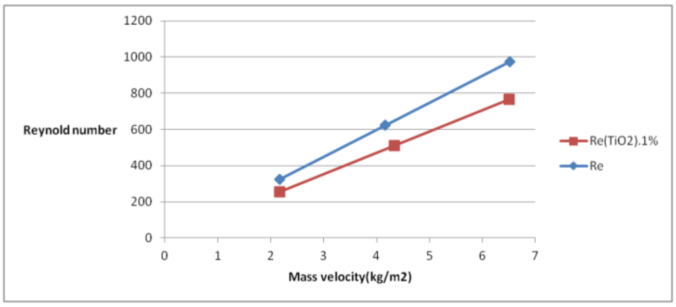

Fig 6 Reynolds number v/s Mass velocity

Figure5.shows that increase of mass velocity increase of fluid increase Reynolds numbers it indicates that Reynolds numbers is directly proportional to mass velocity.

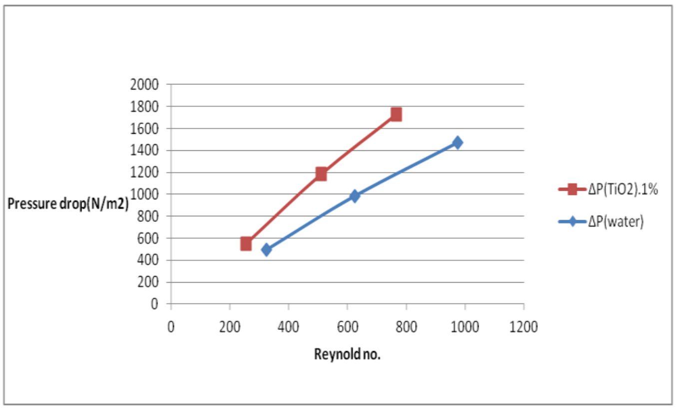

Fig 7 Pressure drop v/s Reynolds numbers

Figure6. Shows that increase in pressure drop across the packed bed Reynolds numbers also increase. It indicates that pressure drop is directly proportional to Reynolds numbers

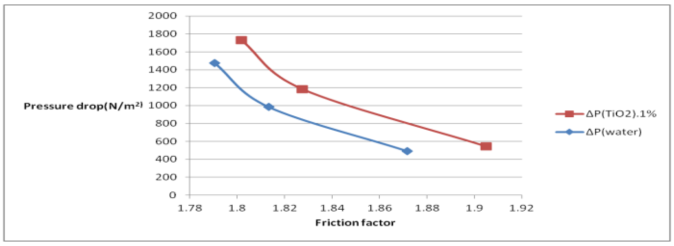

Fig 8 Pressure drop v/s Friction factor

Figure 7. Shows that friction factor of nanofluid are more than water. Friction factor increase with decrease in pressure drop.

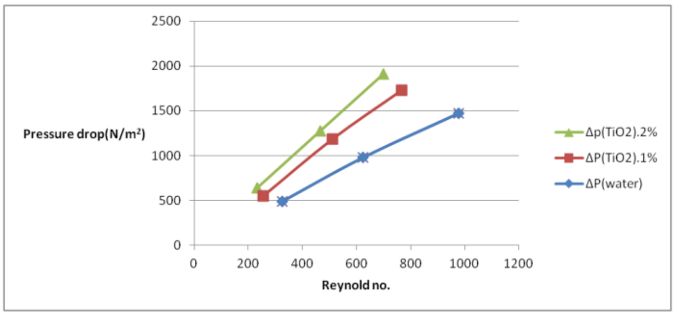

Fig 9 Pressures drop v/s Reynolds no.

Figure8. Shows that increase of pressure drop also increases Reynolds no. It indicates that Reynolds no. is directly proportional to pressure drop.

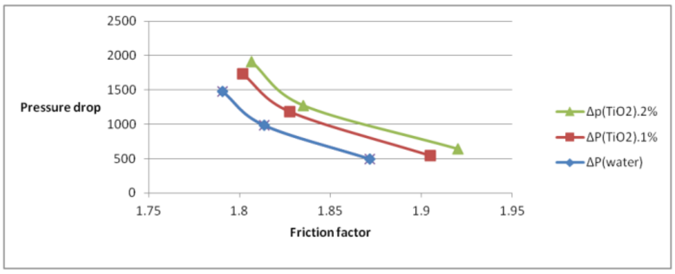

Fig 10 Pressure drop v/s Friction factor

Figure9. shows that friction factor increase with pressure drop. TiO2 (0.2% concentration) has highest friction factor than water about 22.8%.

CONCLUSIONS

1. Increasing mass flow rate of fluid increase the temperature of storage unit until the equilibrium state achieved and gives pressure drop. Nanofluids (Tio2 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.

References

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