CHAPTER 5

EXPERIMENTAL RESULTS FOR PLAIN TUBE COLLECTOR

This chapter discusses the experimental results for plain tube collector in natural circulation mode. The experimental Nusselt number and friction factor are compared with the fundamental equations and the deviations are found to be within the acceptable limits.

5.1 THERMOSYPHON SOLAR WATER HEATING SYSTEM

Thermosyphon system operates on the temperature difference between the hot and cold water in the storage tank that accelerates the driving force. Convective movement of the liquid starts when liquid in the loop is heated in the riser tube, causing it to expand and becomes less dense, and thus more buoyant than the cooler water in the bottom of the loop. Convection moves heated liquid upwards in the system as it is simultaneously replaced by cooler liquid returning by gravity. Ideally, the liquid flows easily because a good thermosyphon should have very little hydraulic resistance. The characteristics of this thermosyphon solar water heating system are as demonstrated below.

5.1.1 Characteristics of thermosyphon system

The characteristics of thermosyphon solar water heating system with plain tube, for typical sunny days are depicted in Fig.5.1. The solar radiation is found to increase gradually and reach a maximum at 1.00 p.m. and later decrease gradually till 4.00 p.m. Mass flow rate also exhibits a similar trend. Inlet and outlet temperature of water increases gradually until both the temperatures are equal. Since in the consecutive days in which the trials are
conducted, showed similar trend, the observation of this characteristic of the solar water heating system is divided into two phases; 9.00 a.m. to 1.00 p.m. is considered as Phase 1 and 1.00 p.m. to 4.00 p.m. is considered as Phase 2. The variation in heat transfer and friction factor characteristics in the collector loop depends on the Phase.

**Fig.5.1.a** Variation of Inlet/Outlet temperature with elapsed time

**Fig.5.1.b** Variation of Mass flow rate with elapsed time

**Fig.5.1** Characteristics of a thermosyphon solar water heater system
5.2 NUSSELT NUMBER DATA VERIFICATION

The theoretical Nusselt Number for plain tube collector is estimated from the Sieder-Tate equation (1936) for Phase 1 and Phase 2.

\[ \text{Nu} = 1.86 \left( \frac{Gz}{\mu/\mu_w} \right)^{0.14} \text{ for } Gz > 10 \]  

(5.1)

where Gz is the Graetz number which is the ratio of \( \frac{kCm}{p} \).

The experimental Nusselt number is fitted with the above equation for Phase 1 and Phase 2. The maximum deviation is found to be within ±11.3% as shown in Fig.5.2. Observations made from Fig.5.2.a indicate that due to gradual increase in the intensity of solar radiation in Phase 1, the temperature difference between inlet and outlet increases. This will induces the driving force and increase the mass flow rate and velocity of the fluid. Hence there is gradual increase in Reynolds number which in turn increases the Nusselt number.

In Phase 2, the intensity of solar radiation decreases from 01.00 pm. Hence the heat input to the collector is decreasing. The temperature difference between inlet and outlet decreases gradually which decreases the driving force. Hence the decreasing Reynolds number in Phase 2 reduces the heat transfer as shown in Fig.5.2.b. The experimental and theoretical values are given in Table A4.1 in Appendix 4.

5.3 FRICTION FACTOR DATA VERIFICATION

The experimental friction factor is fitted with the Fanning equation for Phase 1 and Phase 2 for plain tube collector as shown in Fig.5.3 and the maximum deviation falls within ±15.17%.
It is observed from Fig.5.3.a that the friction factor decreases with increase in Reynolds number in Phase 1 since the intensity of solar radiation increases gradually and maximizes the fluid flow. In Phase 2, the intensity of solar radiation decreases which would minimize the fluid flow and hence the friction factor increases with decrease in Reynolds number as shown in Fig.5.3.b. The experimental and theoretical values are given in Table A4.2 in Appendix 4.

![Graph showing Nusselt number data verification for plain tube collector](image)

**Fig.5.2 Nusselt number data verification for plain tube collector**
Fig. 5.3 Friction factor data verification for plain tube collector
5.4 REMARKS

The characteristics of thermosyphon solar water heater system is divided into two phases based on the trend observed in the intensity of solar radiation have been studied and presented. The experimental Nusselt number and friction factor are verified with the Sieder - Tate and Fanning equation. The deviation falls within ± 11.3% and ± 15.17% for Nusselt number and friction factor respectively.