Chapter 1

Introduction

1.1 Background and Statement of Problem

As well known, consumption of energy is increasing every day. Most of the present energy sources are petroleum, natural gas and coal. The production and consumption of these fuels create a lot of environmental problems. Moreover, the high consumption rate will cause insufficient energy for future use. Solar energy, which is clean and abundant, is among one of alternative energy sources. It is widely exploited to useful energy in the form of heat and electricity. In the case of heat energy, solar water heating is investigated for many years. Most of the solar water heaters fall into two categories: (a) collection and storage in separate units and (b) collection and storage in the same unit. Solar water heaters can also be classified by the difference of operation, that is the active or passive system. The active system operates with force circulation using an electric pump. The passive system operates with natural circulation and is often called the thermosyphon system. The collection and storage in separate units is considered as the conventional type of solar water heater since it has been used for a long time and is still widely used. The collection and storage in the same unit has recently been received great interest due to its lower initial cost. It is known in several names such as a built-in-storage type solar water heater, an integrated-collector- storage (ICS) type solar water heater, an integral compact solar water heater, a collection-cum-storage solar water heater, or sometimes a low cost solar water heater.

The development of built-in-storage solar water heating system has been received great attention from many researchers because its configuration is simple, hence easy to construct, and less materials are used in construction. A simple system may mainly consist of an inclined tank, in which the walls of the tank are thermally insulated, except the front wall, which is painted with black matte from outside and covered with a glass sheet (Sodha et al., 1979; Ecevit et al., 1989). Most of the tanks are either a rectangular or trapezoidal shape. Different developments are suggested by many researchers to improve the performance of built-in-storage solar water heaters. An insulation cover during night-

time is place on the front side to prevent heat losses at night (Gary and Rani, 1982; Kaushik et. al., 1994). A transparent insulation is used to reduce heat losses with a light reduction in solar transmission (Goetzberger and Rommel, 1987; Prakash and Carnevale, 1987; Schmidt et al., 1988; Prakash et al., 1994; Alulanantham et al., 1998). Another modification is the use reflectors to minimize solar radiation losses (Ali, 1984; Yun Fei, 1987; Tripanagnostopoulos and Yianoulis, 1992; Kalogirou, 1997; Triwari et al., 1998). A baffle plate that separated between collector and storage tank is also proposed to reduce heat losses mainly pass through the aperture area (Prakash et al., 1985; Vaxman and Sokolov, 1985; Siddiqui and Kimambo, 1994; Kaushik et al., 1995; Kaptan and Kilic, 1996). To prevent heat losses during the night due to the reverse circulation, a light plastic as a thermal diode is then used to fix on the insulated baffle plate of the system trapezoidal cross section tank (A.A Mohamad, 1997).

As far as manufacturing is concerned, the trapezoidal cross section tank might be difficult to construct. Also, a light plastic plate using as a thermal diode is not easy to construct and change. A simpler geometry of the built-in-storage solar water heater as a rectangular tank with a commercial check-valve, the compressing spring of which is removed, should be better and easier to construct and maintain. The main objective of this study is, therefore, to develop and construct such a built-in-storage type of solar water heater and to conduct experimental tests in order to obtain its thermal performance in comparison with a commercial conventional solar water heater. The proposed built-in-storage solar water heater is aimed at reducing the night losses, which is the main drawback of this type of solar water heater.

1.2 Objectives of the Study

1.2.1 To develop and construct a newly designed model of built-in-storage solar water heater which can reduce high heat losses from reverse circulation at night.

1.2.2 To investigate its outdoor performance characteristics and compare with those obtained from a conventional solar water heater, the collector of which is separated from storage tank.

1.2.3 To develop a simple mathematical model to predict the system thermal performance under varied weather conditions.

1.3 Scope of Study

The size of the built-in-storage solar water heater to be developed is approximately about the same as the normal conventional solar water heater, i.e. the aperture area for collecting the solar radiation is about 2 m^2.

1.4 Methodology

The steps of this study are organized as shown in Fig. 1.1 and can be explained as follows:

1.4.1 Make a literature review on various types of built-in-storage type solar water heater. Their advantages and disadvantages are discussed and taken into account in the development of the new model of built-in-storage type solar water heater. Details obtained from this study are given in Chapter 2.

1.4.2 Develop a new design of built-in-storage type solar water heater based on the conclusive considerations resulted from the reviews and construct the conclusive model.

1.4.3 Formulate a mathematical model for predicting the thermal performance of the new designed built-in-storage type solar water heater.

1.4.4 Procure necessary equipment and instrument and establish an experimental setup for comparative testing on both solar water heaters.

1.4.5 Conduct experimental tests on both the newly developed system and a conventional system, and discuss the results.

1.4.6 Compare the simulation results from the mathematical model with experimental results and discuss.

1.4.7 Make conclusions from the study.

1.4.8 Write up the thesis report.

1.5 Organization of the Study

The reason and objective of the study are described in Chapter 1. A literature survey of the previous researches on the built-in-storage (BIS) solar water heater systems is summarized in Chapter 2. The formulation of the thermal model for determining the performance parameters of the BIS system is expressed in Chapter 3. Chapter 4 shows the

establishment of the experimental setup and the details of several tests run to be performed on the built-in-storage solar water heater in a comparison with the conventional solar water heater. Chapter 5 presents the simulation results in predicting the system performance of the built-in-storage solar water heater under the actual climate conditions in comparison with those observed from the experiments. Finally, the conclusions for the study are given in the last chapter. The recommendations for the further investigations to improve the design of the system and to improve the simulation model are also mentioned.

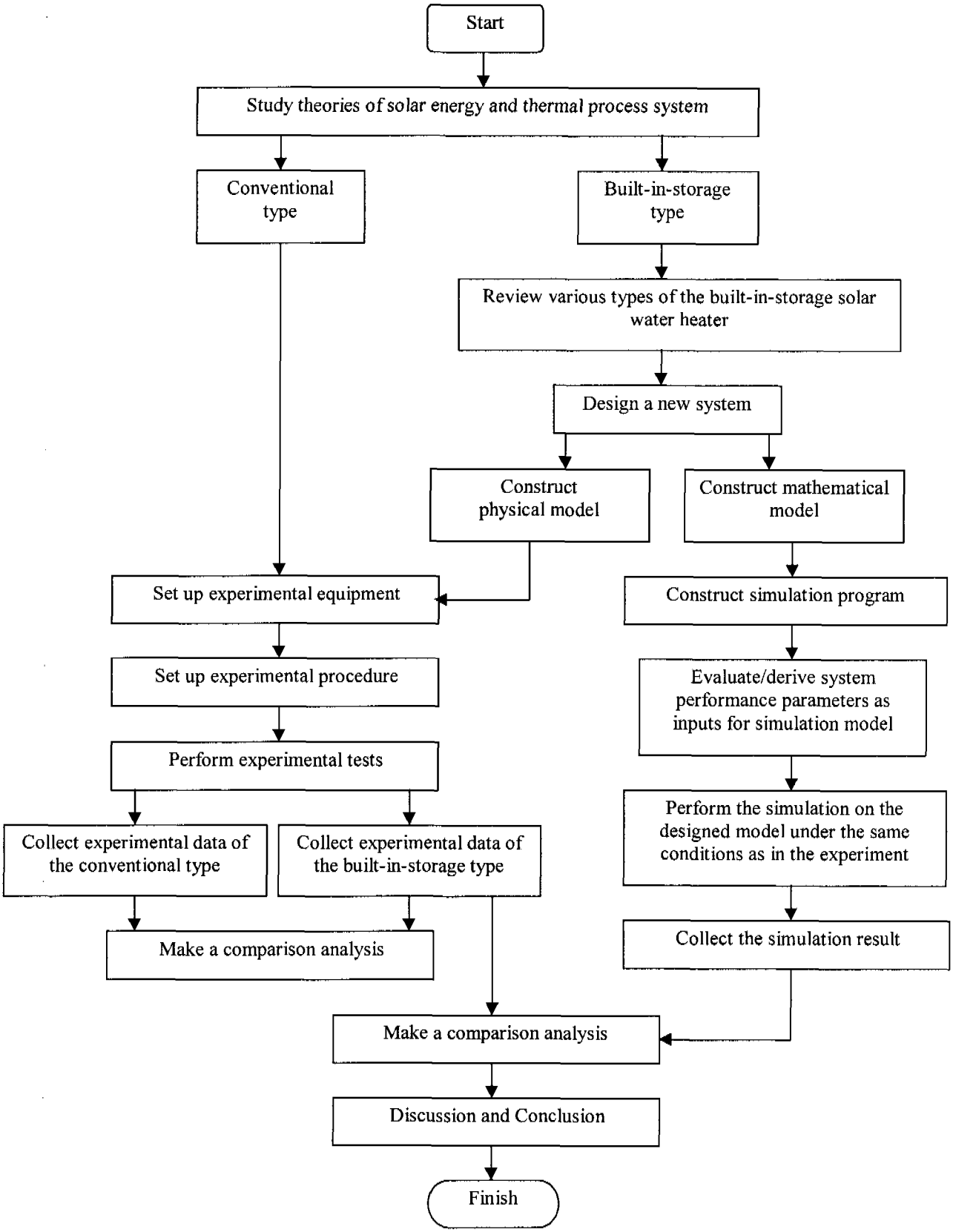

Fig. 1.1 Flow diagram of the study