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Study on thermal-fluid effect of thermal energy storage tank design in solar energy applications

Tanti Ali[a], Rosli Abu Bakar[a,*], Billy Anak Sup[a], Mohd Farid Zainudin[a], Gan Leong Ming[a]

[a]*Faculty of Mechanical Engineering, Universiti Malaysia Pahang. Pekan 26000, Malaysia*

Abstract

The growth of technologies in energy storage has urged new proficiencies and application areas. Energy storage technologies can be varied from an electric battery to a flywheel that can results in deliverable power based on the application. These variations are a challenge to design a reliable and efficient energy storage system. The purpose of this paper is to study the thermal-fluid effect of thermal energy storage (TES) tank design. A three-dimensional modelling of TES tank was carried out using commercial computational fluid dynamics (CFD) code by differentiate the heat source temperature and heat transfer fluid (HTF) velocity. The results predict the thermal-fluid behaviour of TES tank. Since the HTF used is water, the expected outcome of the outlet temperature is in the range of 40 to 60°C.The outlet temperature of the TES tank is compared with the experimental data. It can conclude the TES tank thermal-fluid behaviour is affected by heat source temperature and velocity HTF. The results can be further used to design dependable TES system for green energy application

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Keywords: thermal energy storage; solar energy; thermal-fluid effect

1. Introduction

Energy sources can be divided into two categories; renewable energy and non-renewable. Since the fossil fuels world supply decreased, humans are keen towards green energy which is environmental friendly and affordable in

* Corresponding author. Tel.: +60-12-983 2631; fax: +60-9-424 2202.
E-mail address: rosli@ump.edu.my

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order to meet growing energy demands. Also, to attain the satisfaction of clean energy supplies is a significant societal challenge [1]. Thermal storage system is an energy saving device for later usage. The system is usually in a special designed tank and employed when encounter the inconsistency of energy supply and demand [2]. In solar energy development, an energy storage system is at optimal capacity not only considered economic and safe but it also depends on the loads of nature expected on the process, the solar radiation availability expected time dependence, the process of reliability, the manner of additional energy is supplied, the size of the solar thermal power system or solar-electric generator and the allowable capital cost allocated to storage [3].

2. TES description

Energy storage technologies are structured to be an industrial big challenge, with beneficial characteristics such as multiple cycles, duration and transportability. Meanwhile, there are indecisions in these technologies, from considering the performance and flexibility for applications; to in what way it fit within the structures, to what the outcomes and benefit of the investments. For solar energy application, the solar energy storage system can be classified as in Fig. 1. TES can be divided into three main groups; latent heat storage, sensible heat storage and chemical storage [1].

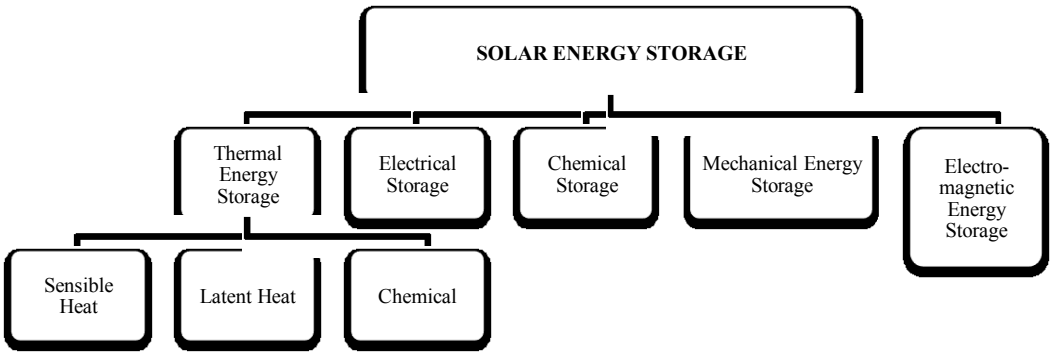

Fig. 1: Solar energy storage classification.

Sensible heat storage described that thermal energy can be stored in the change of temperatures of substances that experience a change in internal energy. Sensible heat occurred when the material released or absorbed energy as the temperature is varied [4]. Heat stored can be calculated based on the equation,

$$Q = \int_{T_i}^{T_f} mC_p dT \tag{1}$$

$$Q = \dot{m}C_p(T_f - T_i) \tag{2}$$

The characteristics of heat storage are storage medium has high specific heat capacity, long term stability under thermal cycling, and low thermal conductivity. The key element of energy storage is the storage material. The storage medium applied in the sensible heat storage system is rock, water, concrete, brick, engine oil, ethanol [1,3,4,5].

In this study analysed the effect of heat source temperature and HTF velocity on the TES tank thermal-fluid pattern. The TES tank showed in Fig. 2 is designed with the height of 0.425 m and diameter of 0.5 m. It is fabricated using Stainless Steel 304 and equipped with an inlet and outlet port for the HTF flow.