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Dynamic Modeling of Solar Air Collector with Thermal Storage Material

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Abstract. The investigation of solar air heater using SIMULINK tool to predict the transient state of solar thermal collector is presented in this article. The modeling is primarily centered on the solar crop drying system for small and medium scale farmers. Double transparent walls and sensible heat storage rocks were used in the modeling to aid the performance efficiency of the flat plate solar collector. The simulation was run with variable steps solver of relative tolerance of 0.001 using Dormand-Prince technique. The outcome of this investigation revealed the time trend of solar irradiance, effects of laminar forced convection on thermal coefficient, and early performance efficiency ratio. However, the model required improvement for it to accurately predict the system efficiency ratio after long period of operation.

Introduction

Solar energy drying system is growing in acceptability since last decade. This is not unconnected with the concern of all on global warming and the effort of government of nations in creating awareness on use of sustainable energy sources that are environmental friendly. This eventually opened some challenges on efficient and effective transient modeling of solar air heater.

Renewable energy specialists were challenged to let 1.3 billion people gain access to green energy and provide other 2 billion people who are using fossil fuels with alternative sources that are ecofriendly [1]. The United Nations has projected renewable energy for all by 2050; it was therefore a pride for specialists to see the ground breaking achievements target towards this noble goal [2].

The existence of computer system has reduced time consuming analytical procedure by simulation techniques that are effective in investigating dynamic situations [3]. Numerical approach would be a better modeling option for crop dryer based on its robustness and easier means of solving complex functions [4]. SIMULINK solves dynamic system modeling with numerical integration techniques in which each of them work perfectly in a specific application and the integrator remains the basic block for continuous system in this package [5]. The subsystem in SIMULINK defines equation for a particular purpose in one block. Hence, it simplifies network of connections of the block diagram [6]. The modeling of solar energy systems was underscored as an approach of estimating the parameters of the system, complex situations are simplified with clear understanding of components interaction and operation [7]. There is need for more researchers of solar energy systems to employ SIMULINK as their preferred modeling tool based on its robustness like other counterparts in dynamics, control, mechatronics etc. [8].

Porous matrix was used to store sensible heat that its performance was based on change in temperature and thermal capacity. It was established that porous material experiences a positive temperature gradient at charging and negative gradient at discharging period [9]. Pebble bed energy storage extends the drying period of any solar drying system with improvement in overall performance efficiency [10,11]. The presence of porous material in a collector was reported to improve the air heater efficiency by 10% or more [12]

Series of software programs such as WATSUN, Polysun, TRNSYS, F-Chart, Engineering Equation Solver etc. have been used for modeling of solar thermal system that its operation depends on solar illumination [13,14]. However, each of these tools is with its own peculiar limitations in usage to replicate real life situation. Hence, this investigation is to use the SIMULINK software to

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