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TRANSIENT MODELLING OF MULTI-PASS SOLAR THERMAL COLLECTOR WITH SENSIBLE ENERGY STORING MATRIX

M. W. Kareem[1], Khairul Habib[1], M. H. Ruslan[2] and Kashif Irshad[1]
[1]Department of Mechanical Engineering, UniversitiTeknologi Petronas, Seri Iskandar, Perak, Malaysia
[2]Solar Energy Research Institute, Universiti Kebangsaan Malaysia, Bangi, Selangor, Malaysia
E-Mail: kareem_g01949@utp.edu.my

ABSTRACT

Transient modelling of multi-pass solar hot air dryer as a physical system is presented in this present work. SIMSCAPE/SIMULINK tool was utilized for the theoretical study of hot air passing through transparent flat plates and anodized aluminium as solar thermal collector. Pebble bed made of granite was obtained locally to sever as the sensible heat reservoir. The thermal energy balance was resolved using lumped component technique. The parameters, variables and operating conditions of materials that constitute the thermal system forms the modelling input with available weather data collected in the Solar Research Site, Universiti Teknologi PETRONAS (4.385693^o N and 100.979203^o E). The model revealed improved on the multi-pass system performance efficiency by 12.4% and 10.1% when compared to the reported single pass and double pass solar air heaters. Closed loop control mechanism was imposed to achieve a steady heat flow 471.2 Js^{-1} to the drying compartment. A temperature gradient of 31.21 K was predicted which is suitable for the drying operation of many agricultural products. The theoretical result was in agreement with output obtained from the humidity controlled drying test system in the Solar Energy Laboratory, Universiti Kebangsaan Malaysia. However, there was need to improve the boundary condition accuracy and flexibility to accept various materials for system boundary.

Keywords: solar thermal collector, storing matrix, lumped component technique.

INTRODUCTION

The determination to achieve the United Nations target of green energy for all by 2050 is gaining momentum by contribution of researchers and other stakeholders in renewable energy sector. Every human being is becoming interested in energy that is economical and devoid of environmental pollution. Therefore, the green energy sector is now enjoying agencies and government supports on its research and development. A lot of approaches have been used in the past to dry farm products which are not eco-friendly such as burning of fossil fuel. A green active solar dryer was modelled as an alternative to unfriendly means of drying in our environment.

Numerical method has significant value in solving practical engineering challenges that other approach may be difficult to handle based on its iterative approach[1]. Numerical tool was used to investigate the effect of various sizes and operating variables on both flat and corrugated solar collector [2]. Flat absorber is the simplest, economical and the best thermal energy collector type for air heating applications [3]. The transient state in thermal conduction in solid material is usually aided by heat transfer by convection to or from liquid that form the solid material boundary [4], whereas Osório and Carvalho [5] affirmed that transient testing approach of solar absorber required less testing time when compared with other available solar collector testing techniques. Kong *et al.*[6] developed a transient method of solar collector testing by solving energy balance equations using Laplace transform technique.

Simulation of renewable energy system started in the second half of the twentieth century and hundreds of modelling software was used in the last two decades to solve solar energy related problems. However, each software is transient and has its peculiar vantage and limitation [3]. A heuristic solar collector model based on numerical approach was used to determine the absorber performance through variation in temperature [7].SIMSCAPE™ is a MATLAB oriented lumped object modelling tool and it is compliant with SIMULINK® environment [8].

Drying is the combination of thermal transfer from a solar collector or any other heat source to the crop to be dried and the mass transfer of water content of the crop from within to the atmosphere [9]. Solar drying is an economical means of preserving agricultural products with ease in transportation [10].

Many solar air heaters have been proposed and constructed. However, the statistic still revealed that many farmers are still using open drying mode of crop preservation[11]. This work is to achieve a theoretical investigation of crop dryer using robust SIMSCAPE modeling tool. A product that would be affordable to small and medium scale farmers with low system maintenance cost is predicted. Hence, a multi-pass collector that can generate hot air at a suitable temperature range[10, 12] for drying of crops and medicinal herbs under dynamic mode is the critical thrust of this work.