A performance and technoeconomic study of different geometrical designs of compact single-pass cross-matrix solar air collector with square-tube absorbers

A.A.Razak[a], Z.A.A.Majid[b], F.Basrawi[c], A.F.Sharol[a], M.H.Ruslan[d], K.Sopian[d]

[a]Faculty of Engineering Technology, Universiti Malaysia Pahang, Pahang, Malaysia
[b]Kulliyyah of Allied Health Sciences, International Islamic University of Malaysia, Pahang, Malaysia
[c]Energy Sustainability Focus Group (ESFG), Faculty of Mechanical Engineering, Universiti Malaysia Pahang, Pahang, Malaysia
[d]Solar Energy Research Institute, Universiti Kebangsaan Malaysia, Bangi, Malaysia

ABSTRACT

This manuscript presents a performance study on a forced convection single-pass solar air heater channel with compact cross-matrix absorber (CMA) incorporating metal hollow square-tube absorbers. Four different geometries of CMA (Type I, II, III and IV) were investigated experimentally to evaluate their efficiency, pressure drops and heat transfer parameters. The experiments were conducted with uniform heat flux (indoor) and outdoor solar radiation as heat source. The air mass flow rates used were between 0.0142 kg/s and 0.0360 kg/s. Techno-economic feasibility studies were conducted using cost-benefit ratio (AC/AEG) method. Thermal efficiency of the CMA obtained by Type I with 76%, being the highest. CMA Type I also exhibited the highest temperature elevation than other configurations with 15.3 °C and thermal capacity of 38.7 kJ. Maximum pressure drop obtained was 1.33 Pa in turbulent condition with Reynolds number of 50,794. Type I has the advantage of high performance CMA and has comparatively lower cost-benefit ratio (AC/AEG) of 0.15 RM/kWh than other type of thermal absorbers.

Keywords: Solar air collector; Cross-matrix absorber; Thermal absorber design

DOI: https://doi.org/10.1016/j.solener.2018.12.010

Acknowledgement

The authors gratefully acknowledge Universiti Malaysia Pahang, Malaysia for the financial support under project RDU1703137, and Ministry of Higher Education Malaysia for the provision of the grant TRGS/1/2014/UKM/01/11/4.