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Experimental Investigations on a Double Pass Solar Air Heater having Combination of Broken Arc and Staggered Ribs

Sumit Joshi
P.G. Scholar, Mechanical Engineering Department,
G.B.P.U.A.T Pantnagar, Uttarakhand, India

L. Varshney
Professor, Mechanical Engineering Department,
G.B.P.U.A.T, Pantnagar, Uttarakhand, India

Abstract

In the present work experimental study is done on a Double Pass Solar Air Heater (DPSAH) with combination of broken arc and staggered ribs as a artificial roughness for enhancing the thermo-hydraulic performance parameter (THPP) of the collector. Reynolds number (*Re*) was taken from 3000 to 12000, relative gap position (b'/b) was taken from 0.3 to 0.9 and relative roughness pitch (*p/e*) was taken as 10. Other parameters like relative roughness height (*e/D*) of 0.0354, arc angle (α) of 30°, relative staggered rib size (*r/e*) of 2.5 and Relative staggered rib position (p'/p) of 0.2 are kept constant. From the experimental results it is concluded that the value of (THPP) is higher for combination of broken arc and staggered ribs as compared to that for a continuous arc shaped ribs. It was found that (THPP) is highest in case of (b'/b) as 0.6 which ranges from 2.09 to 2.46 for a (*Re*) of 3000 to 12000 respectively. Enhancement in (THPP) is estimated to be 33% higher for combination of broken arc and staggered ribsas compared with continuous arc shaped rib roughness.

Keywords: Solar, heat transfer, friction factor, Nusselt number, thermo-hydraulic performance parameter.

Introduction

A fundamental approach for transforming solar energy into thermal energy for heating purpose of fluids is by solar powered collectors. A solar air heater (SAH) is a device that heats up the air by utilizing the solar irradiance incident on the device. (SAHs) are widely used for drying and curing of crops, space heating, timber seasoning, curing of plastic etc. The conventional SAH has a low value of convective heat transfer coefficient which lead to poor thermal and hydraulic performance of the collector. The reason behind the low performance of SAH is the development of laminar sub-layer on the vicinity of the absorber plate. In order to enhance the performance of SAH various researchers have used different roughness geometries on the rear side of the absorber plate. The roughness tends to breakdown the laminar sub-layer. However increment in pumping losses occurs by providing roughness in a absorber plate. So, the objective of researchers has been to increase the heat transfer capacity by providing the new design and geometries along with least pumping losses. Prasad and Mullick [1] experimentally studied the implementation of roughness on the rear side of the absorber plate to enhance the thermal efficiency of SAH for drying purposes. The increment in efficiency of a SAH having roughened absorber plate are 0·63 to 0·72 times of the conventional SAH. Saini et al. [2] experimentally investigated the effect of a arc shaped roughness on thermal performance of SAH in rectangular duct. Considerable augmentation in *Nu* was reported in case of roughened SAH as compared to smooth solar powered collector. A study on SAH having a arc ribs with gap combined with staggered ribs was investigated by Gill et al. [3]. The experimental study was carried for a relative gap size varied from 0.5 to 2.5 and constant value of (b'/b) as 0.65, (*r/e*) size as 2.0, (*p/e*) as 10 and (α) as 30^0. It was obtained that *Nu* and *f* are highest when relative gap width and rib height were equal.
To improve the THPP of SAHs collectors packed bed were used. Varshney et al. [4] performed outdoor experimental study on the performance of solar collector having packed bed. It was reported that geometrical parameters of packing element played an important role in the performance of SAH. Verma and Varshney [5] perform an analytical study on a packed bed SAH to investigate the THPP of the system. A comparative study performed between low porosity matrix and high porosity matrix. It was found that, in case of high porosity, the value of effective efficiency is higher than low porosity matrix. DPSAH is a design modification in SAH to improve the heat transfer capability as it have more heat transfer area of absorber plate and it also reduces the top losses.
Satcunanathan and Deonarine [6] studied the concept of counter flow in DPSAH and around 11% increase in thermal performance of the DPSAH was obtained as compared with SPSAH. Wijeysundera et al. [7] studied the effect of two transparent covers in DPSAH in which an absorber plate is used to create a passage between entry and exit sections for air flow and 10 to 15 % increase in efficiency was obtained for DPSAH as compared to SPSAH system.An experimental study on DPSAH having artificial roughness applied to both end of the absorber plate was conducted by Sharma et al. [8]. The values of *Nu* and *f* were evaluated for distinct roughness parameters and compared with the values of smooth one. Maximum enhancement in *Nu* and *f* was obtained to be 1.7 and 1.9 times as compared to DPSAH without roughness. Ravi et al. [9] conducted experiment on DPSAH having multi-V ribs in combination with staggered ribs as roughness geometry on both