Applied Thermal Engineering 49 (2012) 55–60

Contents lists available at ScienceDirect

Applied Thermal Engineering

journal homepage: www.elsevier.com/locate/apthermeng

Foam height effects on heat transfer performance of 20 ppi aluminum foams☆

Simone Mancin, Claudio Zilio, Luisa Rossetto*, Alberto Cavallini

Dipartimento di Fisica Tecnica, Università degli Studi di Padova, Via Venezia 1, 35131 Padova, Italy

ARTICLE INFO

Article history:
Received 29 October 2010
Accepted 9 May 2011
Available online 17 May 2011

Keywords:
Metal foams
Heat transfer
Pressure drops
Air flow

ABSTRACT

This paper investigates the heat transfer performance of two 20 *PPI* (pores per linear inch) aluminum foams with constant porosity (around 0.93) and different foam core height (20 mm and 40 mm). The aluminum foams are cellular structure materials that present a stochastic interconnected pores distribution mostly uniform in size and shape. Most commercially available metal foams are based on aluminum, copper, nickel and metal alloys. Metal foams have considerable applications in multifunctional heat exchangers, cryogenics, combustion chambers, cladding on buildings, strain isolation, petroleum reservoirs, compact heat exchangers for airborne equipment, air cooled condensers and compact heat sinks for power electronics. The experimental measurements of the heat transfer coefficient and pressure drop have been carried out in a test apparatus built at Dipartimento di Fisica Tecnica of the Università di Padova. The foam core height effects on the heat transfer performance have been studied imposing three constant specific heat fluxes at the bottom of the samples: 25.0, 32.5 and 40.0 kW m^{-2} and varying the frontal air velocity between 2.0 and 5.0 m s^{-1}. The experimental heat transfer coefficients and pressure gradients have been compared against the predictions obtained from two models recently suggested by present authors.

© 2011 Elsevier Ltd. All rights reserved.

1. Introduction

Metal foams are a class of cellular structured materials that present a stochastic interconnected pores distribution mostly uniform in size and shape. In the last decades, these porous media have been largely studied because of their interesting properties that cover several different technical fields. In fact, metal foams are lightweight, offering high strength, rigidity and high heat transfer surface area [1].

As shown in Fig. 1, metal foam consists of tortuous, irregularly shaped flow passages. The most important geometrical characteristics of the metal foams are the number of pores per inch (*PPI*) and the porosity. The first one is easily obtainable by counting the number of pores in 25.4 mm. The second one, the porosity ε, is defined as the ratio of total void volume to the total volume occupied by the solid matrix and void volumes. Several authors have studied the heat transfer and fluid flow characteristics of metal foams by varying the number of pores per linear inch and the porosity, among them: Boomsma and Poulikakos [2], Kim et al. [3], Liu et al. [4], Bhattacharya et al. [5], Calmidi and Mahajan [6] and Hsieh et al. [7].

In particular, Boomsma and Poulikakos [2] carried out several heat transfer and pressure drop measurements during liquid flow through 40 *PPI* aluminum foams with different porosities. The authors observed a great increasing of the pressure drops as the porosity decreased. Moreover, they found that the Nusselt number, defined on the hydraulic diameter of the empty channel with the heat transfer coefficient referred to the base area of the sample, increases with the compression ratio.

Kim et al. [3] studied the effects of porosity and of number of pores on the heat transfer, testing 6 different porous fins in a plate and fin heat exchanger. They found that at 20 *PPI*, the volumetric heat transfer coefficients referred to the total heat transfer area times the surface area efficiency, decrease with increasing porosity.

Liu et al. [4] investigated the fluid flow through seven different aluminum foams varying the number of pores per inch and the porosity. The authors suggested that the pressure drops increase with *PPI* while at 20 *PPI* the effects of porosity on the pressure gradient are negligible.

Bhattacharya et al. [5] proposed a model for the estimations of the permeability and inertia coefficient of aluminum metal foams regressed on a database which includes pressure drop measurements of 22 different porous media. Part of their database has been collected by Calmidi and Mahajan [6], that studied the air forced convection in high porosity metal foams, measuring the heat

☆ Paper presented at Thermal and Environmental Issues in Energy System Conference and selected by the scientific commission to be suggested for a possible publication in a special issue of the International Journal: *Applied Thermal Engineering*.

* Corresponding author. Tel.: +39 049 8276869; fax: +39 049 8276896.
E-mail addresses: simone.mancin@unipd.it (S. Mancin), claudio.zilio@unipd.it (C. Zilio), luisa.rossetto@unipd.it (L. Rossetto), alcav@unipd.it (A. Cavallini).

1359-4311/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.applthermaleng.2011.05.015