Thermal performance investigation of metal foam heat exchanger for micro-gas turbine

Panagiota Chatzi

Antonia Antoniadou

Theofilos Efstathiadis

Anestis Kalfas

Department of Mechanical Engineering,

Aristotle University of Thessaloniki,

Thessaloniki, GR-54124, Greece

Abstract

Micro gas turbines require a compact recuperator with high effectiveness to achieve higher thermal efficiency. Porous media such as metal and ceramic foams are known to increase heat transfer and potentially can be incorporated in recuperators. This study presents an experimental monitoring of heat transfer performance of metal foams. The idea is to combine excellent thermal properties of metal foams with turbine gases heat fluxes exploitation, in order to elevate the temperature of compressed air before it enters the combustor. A novel facility was designed and developed for monitoring heat transfer mechanisms that occur in metal foams at steady and transient state. The study demonstrates that the application of foam materials may increase thermal efficiency achieving higher performance of micro-gas turbines.

introduction

A considerable amount of heat is lost when switching from gas turbines to micro gas turbines resulting in lower thermal performance. Heat management through combined cycles may improve this performance. However, complicated combined cycles increase the cost and industrial footprint of the system, making it more complex. The use of a compact recuperator makes the system much simpler and may achieve the required improvement in thermal efficiency. [1].

Metal and ceramic foams are already known for their exceptional mechanical and thermal properties and are widespread in the market for several applications [2, 3]. However, they have not debuted in the micro-GT market and their use is still not fully investigated in this area. It is necessary to understand the relation between metal foam geometry features and their thermal properties. Besides, a significant gap exists in the dynamic performance evaluation of porous media.

The measurement of temperature as a spectrum over the wall of the test section can be performed using thermochromic liquid crystals (TLC). TLCs are widely used in surface temperature measurements during heat transfer experiments. The colour change is reversible and repetitive, allowing the crystals to be used in many tests as well as for the continuous temperature surveillance in a variety of applications [4]. Their great advantage over conventional thermocouples is that they are more accurate in dynamic performance.

RESULTS and DISCUSSION

The results of the conducted experiments indicate the effects of metal foams on constant and dynamic thermal performance of a heat exchanger. The input variables monitored are fluids mass flow rates and input temperatures. During the experiment at transient and steady state, wall temperature distribution, local convection heat transfer coefficient as well as the local Nusselt number can be visualised. The visualisation of these quantities was achieved by the calibration of TLCs colour spectrum to 2-dimensional temperature distribution. Heat flux at the wall, and overall effectiveness of the component are also obtained.

|  |
| --- |
|  |
| **Figure 1: a) Section view of experimental set up b) temperature distribution colour visualisation.** |

# **References**

|  |  |
| --- | --- |
| [1] | C. F. McDonald, "Recuperator considerations for future higher efficiency microturbines," *Applied Thermal Engineering,* vol. 23, pp. 1463-1487, 2003. |
| [2] | N. Michailidis, F. Stergioudi and A. Tsouknidas, "Deformation and energy absorption properties of powder-metallurgy produced Al foams," *Materials Science and Engineering: A,* vol. 528, no. 24, pp. 7222-7227, 2011. |
| [3] | K. Boomsma and D. Poulikakos, "Metal foams as compact high performance heat exchangers," *Mechanics of Materials,* vol. 35, no. 12, pp. 1161-1176, 2003. |
| [4] | J. A. Stasiek and T. A. Kowalewski, "Thermochromic liquid crystals applied for heat transfer research," *OPTO-ELECTRONICS REVIEW,* vol. 10, no. 1, pp. 1-10, 2002. |