



Manufacturing and analysis of a LIGA heat exchanger for the surface of a cylinder: a cooling simulation of the leading edge region of a turbine blade

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ABSTRACT

The presence of a pin fins array in a channel has the ability to enhance heat transfer greatly. That concept is already used in the internal cooling channel present in the trailing edge of some turbine blades. The reasons why fins enhance heat transfer are numerous: i) their presence increases the wetted surface area available to heat transfer ii) they promote higher turbulence levels by breaking up boundary layers which causes mixing and creates high convective thermal coefficients iii) the wetted surface area associated with the fins is characterized by high convective heat transfer coefficients associated with the cylinder in cross flow configuration.

The interest of this study is to use our LIGA experience to build a micro heat exchanger (a shroud supported by micro pin fins) around a cylinder, as a simulation of the leading edge region of a turbine blade. Such a heat exchanger can be an alternative to the existing techniques in use for turbine blade cooling.

A parallel micro heat exchanger with a staggered array of pin fins (Figure 1) was manufactured and is being tested in order to measure the performance with respect to the Reynolds number of the coolant. The heat exchanger is a simple 2 x 2 inch flat channel heat exchanger with a staggered array of micro pin fins 500 μm high, 500 μm diameter and 1250 μm apart in the downstream direction made using a LIGA process. This pure Nickel heat exchanger is tested using an apparatus allowing a uniform heat flux on the top plate and an air coolant flow between the plates. The Reynolds number of the coolant ranges from 5000 to 20000. A similar experiment with a smooth channel (parallel plates with a gap of 500 μm) is also performed in order to validate the testing apparatus.

The comparison of the results to a parallel plate heat exchanger without pin fins can demonstrate the expected benefits of the micro heat exchanger.

The heat exchanger was customized to fit the shape of a cylinder where the flow conditions approximate those at the

leading edge of a turbine blade. A new modified LIGA process was developed to build a shroud around a $\frac{3}{4}$ inch cylinder (Figure 2). The shroud is supported by an array with dimensions similar to those used for the flat heat exchanger. This heat exchanger and a testing facility were built. In the testing procedure, the heat exchanger is exposed to burner rig high temperature gases while internal cooling airflow is provided. The performance versus the Reynolds number is determined. The micro heat exchanger can be compared to other turbine blade cooling schemes.

Experimental results are not available at the present time but will be shown on the day of the conference.

FIGURES

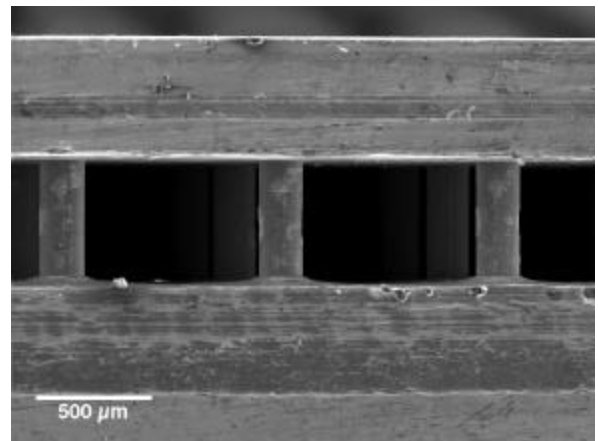


Figure 1. SEM of the completed heat exchanger

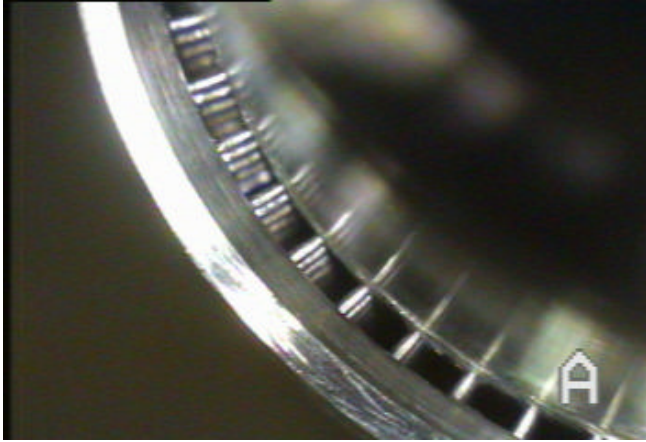


Figure 2: Cross section of heat exchanger on stainless steel tube

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