Abstract

Film cooling is incredibly important for gas turbines, like jet engines and power generating turbines, as the temperatures after combustion are hot enough to melt any metal in existence. Film cooling effectiveness is dependent on shape, orientation and arrangement of the holes and blowing ratio.

The results of film cooling performance analysis are reported here as adiabatic film effectiveness and heat transfer coefficients.

To study the efficiency of the film cooling, two holes rows with opposite direction jets, backward and forward jets, and stagger arrangements are investigated at three blowing ratios (0.5, 1.0 and 1.5). The forward holes are embedded in arc trench to estimate the cooling efficiency and to enhance the mechanical properties over that of existing designs (rectangular trench).

In the experimental test, warm air is blown through a tunnel, and cold air through the plenum chamber. When the warm air flows through the test section it heats everything downstream. Infrared camera is used to measure the temperature of the surfaces downstream to test rows.

Tensile test is also introduced to look at the effect of making trench of different configurations on the material alloy strength.

The results of the comparison between existing rectangular and present arc trenches for the same holes arrangements showed that the film cooling thermal performance for both cases are approximately very close with slight differences according to the values of blowing ratios. In which the present model has higher value of heat flux ratio (q/q_o) at BR=0.5 than that

of rectangular trench by (11, 72%), but at high blowing ratio BR=1.0 and BR=1.5 the present model shows relatively lower values of (q/q_o) than that of rectangular trench by (5, 9%) and (2, 5%) respectively.

The present results (with arc trench) are compared also with same model (without trench), in which value of (q/q_o) for the present model reduced at all BRs. At BR=0.5 the value of (q/q_o) is reduced by (1.7%), at BR=1.0 by (12.8%) and at BR=1.5 by (16.54%).

The CFD prediction shows that the forward holes row embedded in arc trench improve the thermal performance of film cooling especially at low blowing ratios in which the trench spread the air more evenly and film cooling process inefficiently produce layer of cold air over metal surfaces creating a barrier to the hot air.

Tensile test showed that arc trench enhanced the mechanical properties over that of rectangular trench; more likely enhanced the stress concentration factor by 10%.