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Entitled

THERMAL EVALUATION OF ADVANCED LEADING EDGE FOR ROTATING GAS TURBINE BLADE: NUMERICAL AND EXPERIMENTAL INVESTIGATIONS

by

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Date & Venue

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Abstract

Gas turbine engines play a vital role in our life. Our power demand is significantly and continuously growing. The growing energy demand has led power industry to improve gas turbine engines' thermal efficiency. One approach to improve thermal efficiency in gas turbine engines requires a higher turbine inlet gas temperature. The material limitation of turbine blades constrains the use of higher inlet gas temperature; hence an innovative thermal management cooling is used to protect the turbine blade against high turbine inlet gas temperature. Advanced gas turbine engines operate at high temperatures, around 2000 K. Since operating at high temperatures may compromise the blade structure integrity, different cooling systems are used in a turbine blades to reduce the temperature of the blade and prolong the blade lifetime. One of the most efficient and aggressive cooling techniques is impingement cooling, mostly used in the leading edge of rotating airfoils. The leading edge experiences the highest temperature in the blade since it is exposed to the hottest gas coming from the combustion chamber. The rotating blade leading edge is well suited for impingement cooling because of the relatively thick local area of the blade. Researchers have studied different factors over the years to identify and optimize jets impingement on the leading edge of the blade. Nevertheless, publications on jets impingement under rotation are limited in the public literature. Hence, the objective of this study is to evaluate blade cooling via jets impingement on a rotating semi-circular internal channel. The study is initially carried out experimentally and numerically for validation purpose. After validation, a parametric numerical model is developed to understand the effect of series of internal jets impingement on a rotating leading edge cooling with higher range of Reynolds number and rotation numbers. The experimental and numerical validation studies are performed for an internal channel cooling that employ seven jets impinging inside a rotating semi-circular internal channel. The experimental study is performed for a jet Reynolds number of 7,500 and five rotating speeds ranging from 0 to 200 rpm. The numerical analysis is conducted using SST k-ω turbulence model with a properly analyzed mesh. By comparing the experimental results and the numerical results, all features of the temperature distribution over the target surface are precisely captured. A good agreement between the numerical analysis and the experimental measurements has been established. The parametric numerical model is used to test higher jet Reynolds numbers, varying between 7,500 to 30,000, and a higher rotating speed, ranging from 0 to 750 rpm. The results show that jets impingement with high Reynolds numbers is an efficient method of cooling a rotating leading edge. The jets impingement cooling performance is strongly influenced by the individual jet location, the crossflow from other jets, and the blade rotation speed. The effect of rotation is diminished at high jet Reynolds numbers. The cooling performance improves as jet Reynolds number increases and as rotating speed decreases.

Keywords: *Gas turbine engine; SST k-ω model; thermal efficiency; turbine inlet temperature; impingement cooling; turbine blade cooling; rotating leading-edge; crossflow; thermochromic liquid crystal.*