Gas Turbine Blade Cooling and Heat Transfer

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Gas turbine engines are a vital machine in today's industrialized society. They are relied on for land-based power generation, aircraft propulsion, marine propulsion, and a variety of other specific industrial applications. With these engines generating power throughout the world, it is imperative they operate as efficiently as possible. The efficiency of the engine is directly related to the temperature of the mainstream gases exiting the combustion chamber and entering the turbine: increasing this turbine inlet temperature increases the efficiency of the engine. Increasing the temperature of the working gas must be done cautiously, as the majority of the turbine components are metallic. Therefore, they cannot withstand prolonged exposure to extremely high temperatures. To increase the life of the turbine blades and vanes, they must be cooled. These components are cooled by extracting gas from the engine's compressor, and circulating this "coolant" gas through the hollow airfoils. The coolant gas removes heat from the walls of the blades and vanes, so they can survive in the engine. The heat transfer from the blade wall to the coolant can be enhanced with the use of turbulators within the cooling channels. The turbulators coupled with the rotation induced Coriolis and buoyancy forces result in non-uniform levels of heat transfer enhancement in the cooling channels. As the coolant passes through the internal cooling channels, a portion of the coolant is extracted through small holes. This extracted coolant forms a protective film on the outer surface of the airfoils; thus the external surface of the blade is protected via film cooling. Film cooling is utilized on both the blade surface as well as the platform of the blade. With the blade platform comprising a large portion of the surface area exposed to the hot gas, this area must be adequately protected. A number of experimental techniques have been tested to obtain accurate film cooling effectiveness measurements on the blade platform. Both internal and external turbine blade cooling will be discussed. The effect of rotation on the heat transfer distributions of the cooling passages will be considered, along with the measurement of the film cooling effectiveness on the turbine blade platform.