# COMPUTATIONAL AND EXPERIMENTAL INVESTIGATION OF GAS TURBINE BLADE COOLING


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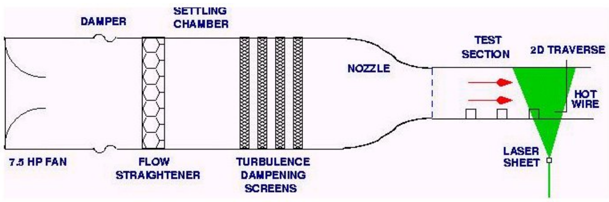
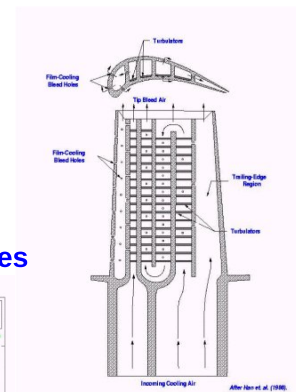
***Current turbine inlet temperatures in gas turbine engines are beyond the melting point of the turbine blade material. To prevent the blades from melting, turbine blade cooling methods are applied to the first turbine stages. Since convectively cooled flow fields and temperature fields are coupled and interact strongly, it is necessary to understand the flow physics in order to accurately predict how cooling will behave. In case of the rotating turbine blades, the effects of rotation also influence the flow. Centrifugal forces as well as the Coriolis force have to be included in the analysis. The present research project is an experimental and computational investigation of the flow through internal turbine blade cooling passages. In the first phase, the flow in a straight, stationary cooling channel is observed. Pressure measurements as well as hot–wire and PIV measurements are used to determine efficacy of different turbulator geometries. In the phase 2, the flow in a rotating cooling channel with an 180° bend will be investigated using PIV.***

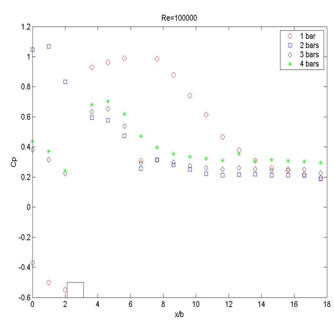
## Wind Tunnel Setup




***Right: A typical convection cooling channel in a gas turbine blade is shown. In addition to complex passage geometry, the channel has turbulators to trip the boundary layer and increase convection cooling coefficients.***

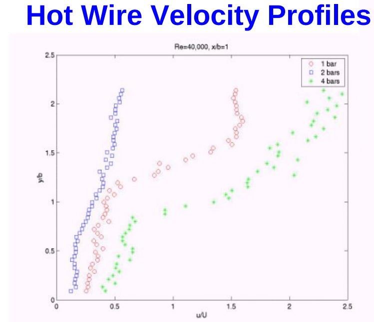


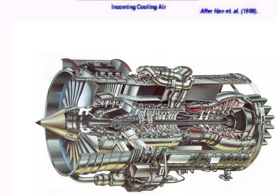
## Pressure Measurements




***Pressure and single component hot wire measurements at different Reynolds numbers were taken in a straight channel. The number of turbulators was varied from 1 to 4. It was found that the pressure coefficient shows the same behavior for 3 and 4 bars. In the case of one bar, a large separation bubble behind the bar is observed. In contrast to the 1–, 3– and 4–bar configuration, a high value of Cp is measured before the last bar. Figure shows the velocity profiles obtained from the unsteady hot wire data. Measurements were taken from 1 to 8 barsizes behind the last bar with a step size of one barsize at Reynolds numbers of 40,000 and 100,000.***

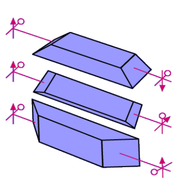
## Hot Wire Velocity Profiles

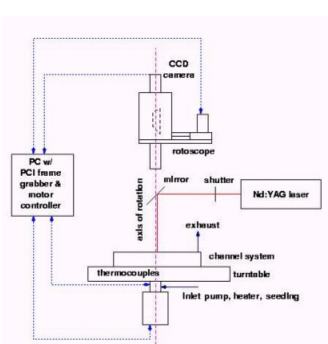


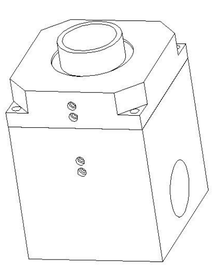



***The computational portion of the research is focused on developing tools to accurately predict the random behavior of the turbulent channel flow using non–linear dynamical systems sub–grid scale models. Using chaotic maps, the behavior of the flow can be accurately represented using experimental data as input.***

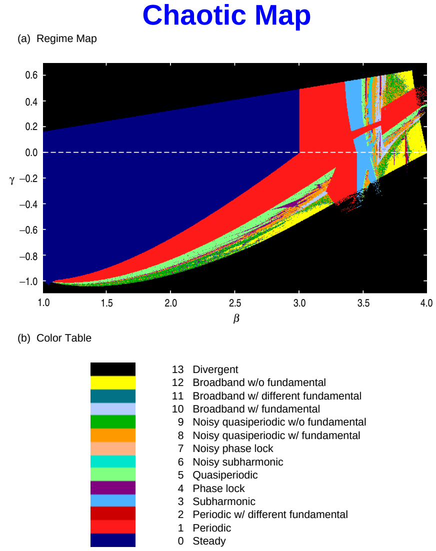
***In the rotating system, the flow is observed by means of a dove prism. Rotating the dove prism at exactly half the speed of the rotating cooling channel, a stationary image is obtained. The flow can be examined in the blade's reference frame and instantaneous flow field data can be obtained.***



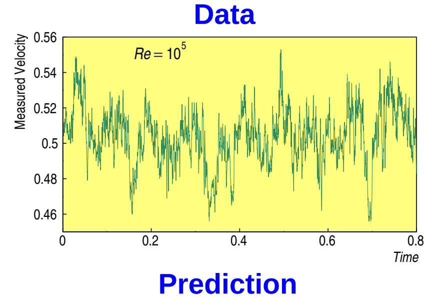


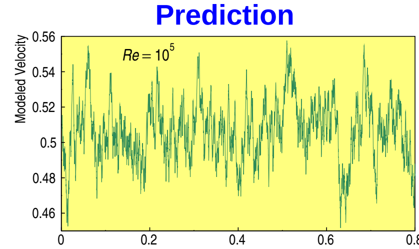
## Chaotic Map




## Data




## Prediction





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