Vortex Generator Model Developed for Turbomachinery

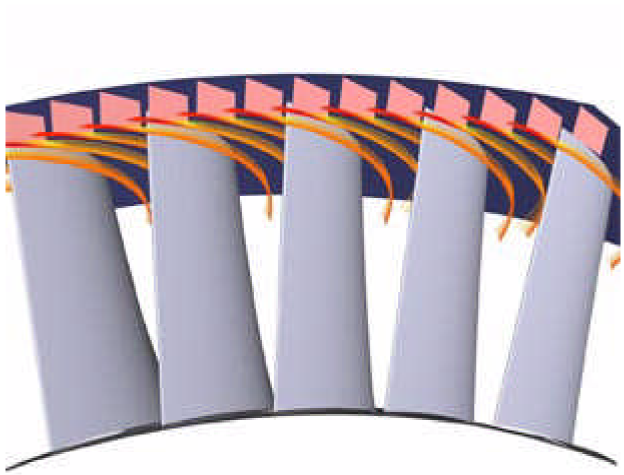
A computational model was developed at the NASA Glenn Research Center to investigate possible uses of vortex generators (VG's) for improving the performance of turbomachinery. A vortex generator is a small, winglike device that generates vortices at its tip. The vortices mix high-speed core flow with low-speed boundary layer flow and, thus, can be used to delay flow separation. VG's also turn the flow near the walls and, thus, can be used to control flow incidence into a turbomachinery blade row or to control secondary flows.

The model was implemented in a multiblock turbomachinery analysis code called SWIFT that uses an explicit finite-difference method to solve the Navier-Stokes equations. The model uses body force terms to produce the effects of VG's on the flow, without the difficulties of gridding and solving the flow around the VG's directly. Two-dimensional calculations of VG blades were used to calibrate the model, and a full three-dimensional calculation was used to validate it.

The VG model was used to simulate three possible applications of VG's in turbomachinery. The first application used VG's as part-span splitters ahead of a transonic stator. Tall VG's (10 percent of the stator span) were used to help direct the swirling flow from an upstream rotor into the stator passage. The figure shows a segment of a stator blade row with three VG's attached to the casing just ahead of each stator passage. The stator flow field was solved in detail, but the VG's were modeled by applying body force terms on the colored areas. The particle traces show how the upstream flow is turned into the stator passage.

The second application used smaller VG's (about 2 percent of the rotor span) to improve the boundary layer and to turn the flow on the casing ahead of a rotor. Both preswirl and counterswirl configurations were investigated. The preswirl configuration increased the stall margin of the rotor, whereas the counterswirl configuration decreased the stall margin. Neither configuration had a significant effect on the efficiency.

The third application used extremely small VG's (0.014 in. or 0.36 mm high) to modify the secondary flows on the suction surface of a stator. These VG's were intended to reduce the spanwise migration of flow near the surface. They reduced the losses at midspan but increased the losses near the endwalls, such that the overall loss was slightly increased.



Computed particle traces from simulated vortex generators ahead of a transonic stator. Long description: A segment of a stator blade row is shown. Three small vortex generator blades are attached to the casing between each pair of stator blades. Particles released at the tips of the vortex generators roll up into vortices that convect through the stator passages

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Turbomachinery analysis codes http://www.grc.nasa.gov/WWW/5810/rvc/
SWIFT multistage
thttp://www.grc.nasa.gov/WWW/RT1996/2000/2760c.htmurbomachinery analysis code

Reference

1. Chima, Rodrick V.: Calculation of Multistage Turbomachinery Flow Using Steady Characteristic Boundary Conditions. AIAA Paper 98-0968, Jan. 1998. (NASA/TM-1998-206613), 1998.

Glenn contact: Dr. Rodrick V. Chima, 216-433-5919, Rodrick.V.Chima@grc.nasa.gov
Author: Dr. Rodrick V. Chima

Headquarters program office: OAT
Programs/Projects: UEET