

# **Flow Structures and Interactions of a Hybrid ‘Fail-Safe’ Actuator**

by

Wasif Khan

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Approved:

Dr. Michael Amitay, Thesis Adviser

Rensselaer Polytechnic Institute

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## ABSTRACT

Vortex generators have been used for more than 50 years on airplane wings to manipulate the boundary layer that is about to separate. Vortex generators are passive devices that enhance mixing, encourage flow reattachment but cause significant drag penalties at off design conditions. Micro vanes implement the same basic idea of vortex generators but their physical dimensions are much smaller. To achieve the same effect on the flow field, micro vanes are usually combined with an active flow control device, so their net effect is comparable to that of vortex generators when the active device is energized. As a result of their small size, micro vanes have significantly less drag penalty at off design conditions. This concept of ‘dual-action’ is the reason why such actuation is commonly called hybrid ‘fail-safe’ actuation. The present study explored experimentally the flow interaction of a pair of side-by-side synthetic-jets with a micro vane in a zero pressure gradient flow over a flat plate. Using the Stereoscopic Particle Image Velocimetry technique the effects of the micro vane height and its angle with respect to the free stream, as well as the synthetic jets blowing ratios were studied. When a pair of side-by-side synthetic jets, incorporated with the micro vane, was tested, the effect of the synthetic jets on the vortex produced by the micro vane was significant for the tall micro vane, whereas for the small micro vane cases the effect was minuscule. This shows that the distance between the synthetic jets and the micro vane used in this work (5.6 time the boundary layer thickness) works better for the taller micro vane than it does for the smaller micro vane. In all the cases due to the jet vectoring, a strong counter clockwise vortex is observed and a weak clockwise vortex associated with synthetic jets can be seen. Total circulation calculation showed that the  $1.6\delta$  micro vane produced the most circulation, and as the angle of attack was increased, increased in the circulation was observe