Outline

• Team Members
• Compressor Flow Control Overview
• Flow Control Actuation Systems & Experimental Results
• Fluidic Actuators
• High Temperature Shape Memory Alloy Actuators
Team Members

Dennis Culley  Controls & Dynamics Branch
Randy Thomas  Controls & Dynamics Branch
Jon DeCastro  Arctic Slope Regional Corp (ASRC)
Doug Feikema  Combustion & Reacting Systems Branch
Suleyman Gokoglu  Combustion & Reacting Systems Branch

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Compressor Separation

Suction surface separation is inferred from changes in wake width and depth

- Induce separation via blade stagger change and reduced flow coefficient
- Quantify separation by surveying total pressure ($P_t$) downstream of blades

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Solenoid Actuation System

External Air Supply

Massflow Controller / Meter

Accumulator

Valve

Controller

Interleaved valve signal

TIP

HUB

$u_{jet1}$

$U_1$

Solenoids with rapid prototype stator vane

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Steady vs. Unsteady Injection

Total Pressure Coefficient, $C_{pt}$

Vane Pitch (%)

Baseline
Unsteady
Steady

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Impulsive Injection in Compressor Stator

50% Duty Cycle
Impulsive Injection Effectiveness

<table>
<thead>
<tr>
<th>% Core Mass Flow</th>
<th>Change in Baseline Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00%</td>
<td>5%</td>
</tr>
<tr>
<td>0.04%</td>
<td>0%</td>
</tr>
<tr>
<td>0.08%</td>
<td>-5%</td>
</tr>
<tr>
<td>0.12%</td>
<td>-10%</td>
</tr>
</tbody>
</table>

Legend:
- ▲ 1.95  800
- ▼ 1.71  700
- ■ 1.34  550
- □ 1.22  500
- × 0.98  400
- ○ 0.67  275

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Flow Control References


Active Flow Separation Control of a Stator Vane Using Embedded Injection in a Multistage Compressor Experiment, Culley, Dennis E. (NASA Glenn Research Center); Bright, Michelle M.; Prahst, Patricia S.; Strazisar, Anthony J. Source: Journal of Turbomachinery, v 126, n 1, January, 2004, p 24-34
Actively Controlled Fluidic Actuators

Rapid prototyped fluidic actuators with solenoid operators

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Current Efforts

SFW Turbomachinery Flow Control task experiments and analytical & computational models

Plasma controlled fluidic actuator

Modeling of the transient switching performance of the fluidic actuator

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High Temperature Shape Memory Alloy Actuators

Dynamic response of SMA actuators

HTSMA actuator developed for T700 engine

HTSMA actuator installed in T700 engine

SBIR success story
Miga Motors

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Active Flow Control Actuation Research & Development

Component Rig & Wind Tunnel Test
- Separation Control
- Stability Control

Innovation Design Test

Voiced Coil
Rotary
Solenoid
Passive Fluidic
High Temperature Shape Memory Alloy
Variable Frequency Plasma-Fluidic
Rapid Prototyping

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Actuator References


Opportunities for Collaboration

SFW Funded Opportunities
Currently there are no funded opportunities within SFW

Collaborative Opportunities
Fabrication and micro-machining
Materials development
Electronic circuit development and miniaturization
Electric and magnetic field analysis
Computational fluid dynamics (CFD) model development
Experimental applications and testing

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Future Plans

Continue the effort to develop, expand, and refine techniques for active flow control in aero-engine applications through multi-disciplinary collaboration.

Goals

• Through improved understanding, develop the design tools which will enable the practicable use of flow control in a wider breadth of aero-engine applications.

• Deliver realistic and reliable actuation technologies for embedded, point-of-use flow control in the aero-engine environment.