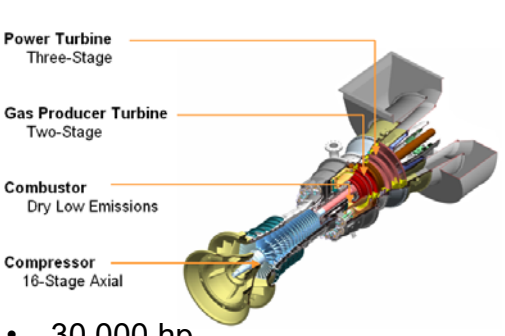
www.iagtcommittee.com October 23rd - 25th, 2017, Banff, Alberta

TITAN 250 GAS TURBINE DEVELOPMENT

By
Rainer Kurz, Mark Knodle, Carlos Aylwin and Jim Raeside
Solar Turbines Incorporated

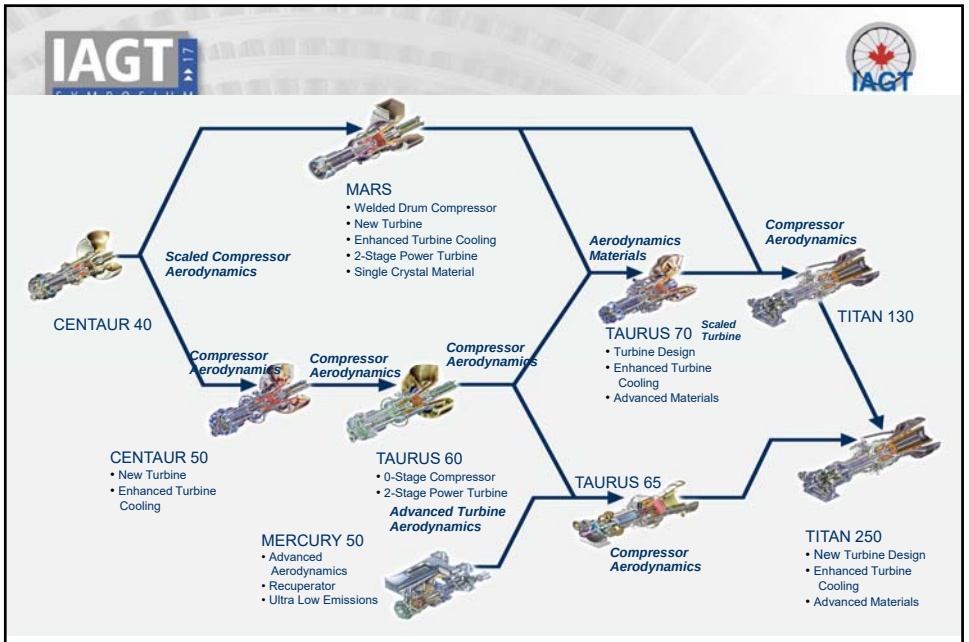
Presented at the 2017 Symposium on Industrial Application of Gas Turbines (IAGT)
Banff, Alberta, Canada - October 2017

Titan 250

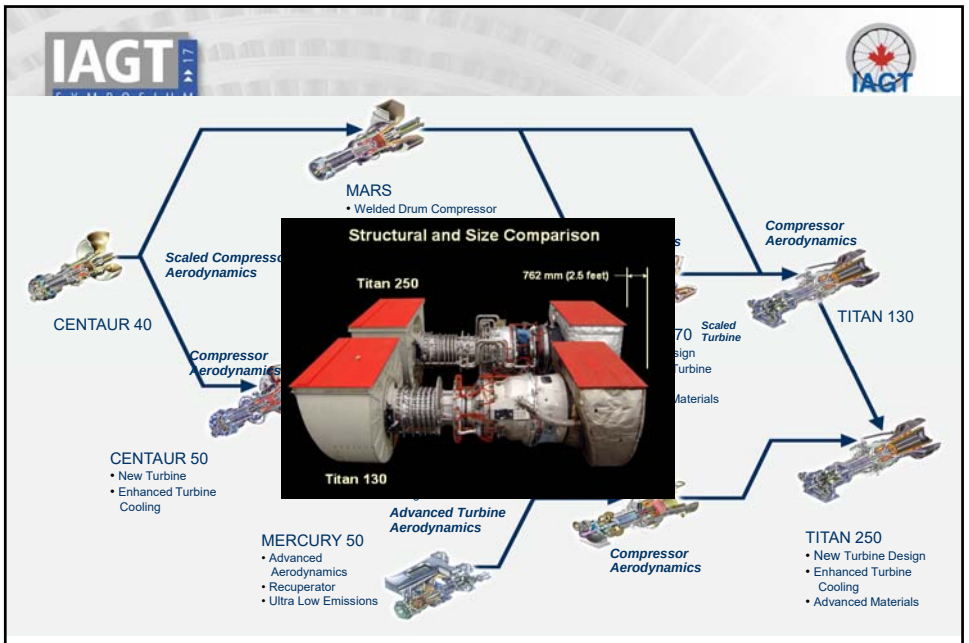


- 30,000 hp
- 40% Thermal Efficiency

Titan 250 driving
a C85 pipeline compressor



Titan 250 Heritage



Titan 250 Heritage

Overview

- Requirements
- Trade-Offs
- Heat Transfer and Cooling
- Experimental Methods
- Stress
- Fuel Capability
- Conclusions

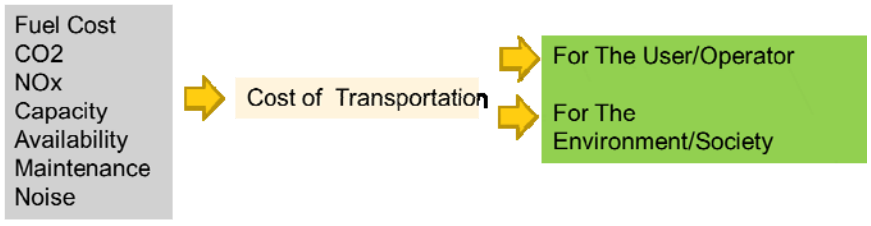
Overview

- Requirements
- Trade-Offs
- Heat Transfer and Cooling
- Experimental Methods
- Stress
- Fuel Capability
- Conclusions

For a given size, the goal is to provide a product offering to potential users that make their operation successful. This includes features that allow for:

- High Reliability and Availability
- Low Emissions
- High Efficiency
- High Power Density
- Attractive first cost and operating cost
- High operational flexibility
- Life cycle support

A wider definition of efficiency



Overview

- Requirements
- Trade-Offs
- Heat Transfer and Cooling
- Experimental Methods
- Stress
- Fuel Capability
- Conclusions

Trade-Offs

Increased efficiency
increased power density

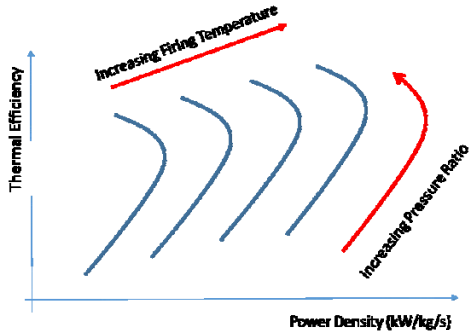
Higher Firing Temperatures
As Little Cooling as Possible

Engine Life and Reliability

Computational Fluid Dynamics (CFD)
Advance Measurement Technologies: irradiated Crystal Sensor Method

Material Science
Improved Knowledge of Local Temperatures in the hot section under actual operating conditions

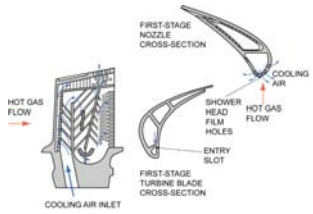
Temperature and Pressure Ratio



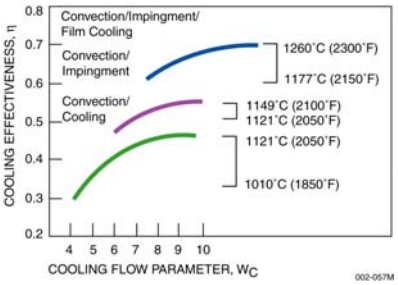
Overview

- Requirements
- Trade-Offs
- Heat Transfer and Cooling
- Experimental Methods
- Stress
- Fuel Capability
- Conclusions

Heat Transfer and Cooling

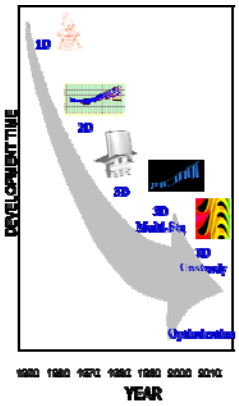


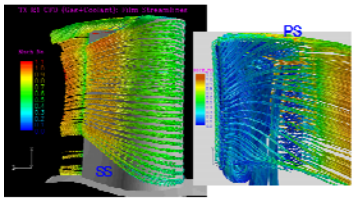
Practical Examples of Blade Cooling Concepts: Convection/Impingement Cooling (left), and film cooling (right)

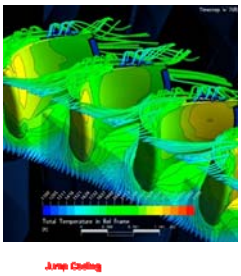


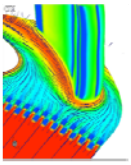
Blade Cooling Effectiveness

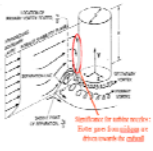
CFD Application



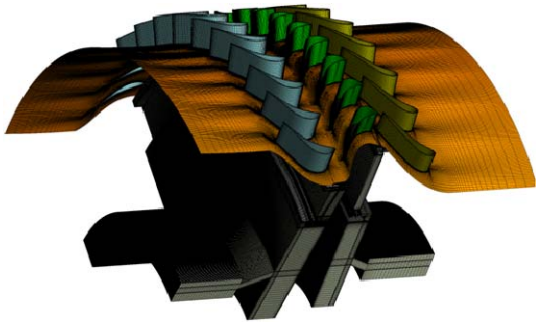




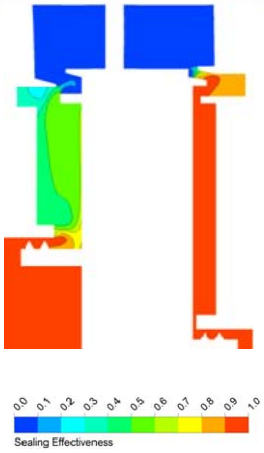




CFD Simulation of Disk Cavity Ingress



90 Degree Sector Model



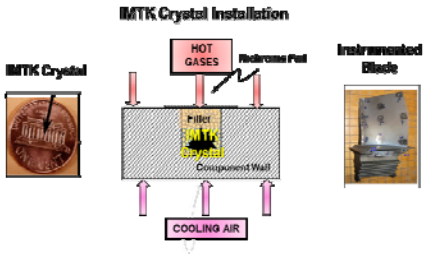
17

Overview

- Requirements
- Trade-Offs
- Heat Transfer and Cooling
- Experimental Methods
- Stress
- Fuel Capability
- Conclusions

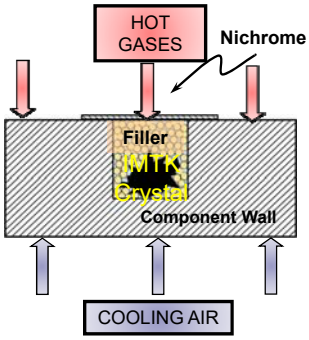
Experimental Methods

- Thermal paint
- Temperature Plugs
- Pyrometers
- IMTK Crystals



IMTK Crystal Installation

IMTK Crystal



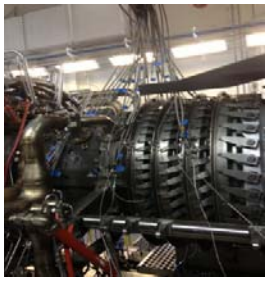
Instrumented Blade

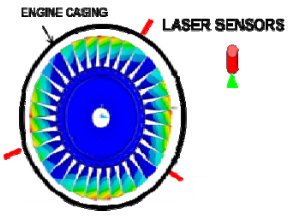
20

Overview

- Requirements
- Trade-Offs
- Heat Transfer and Cooling
- Experimental Methods
- Stress
- Fuel Capability
- Conclusions

Non-Intrusive Stress Measurement System

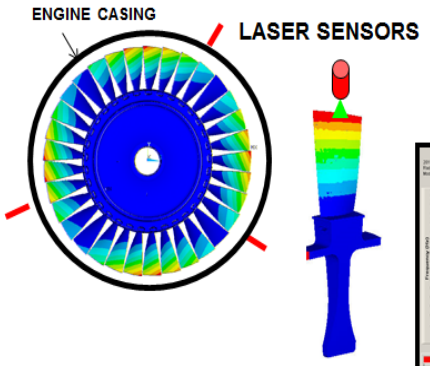


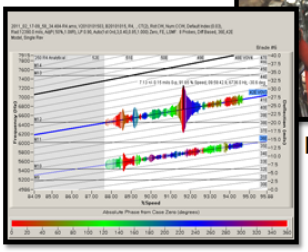


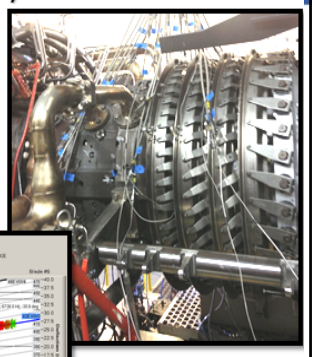
Product Testing and Validation

Non-Intrusive Stress Measurement System (NSMS)

- *Measures Blade Deflections in Engine Real-time*
- *Evaluate Rotor Modal Response and Blade Stresses Levels*







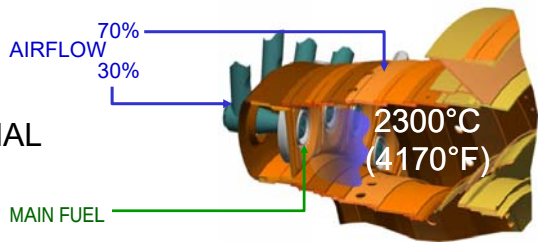
Monitors All Blades, Every Rotation

Overview

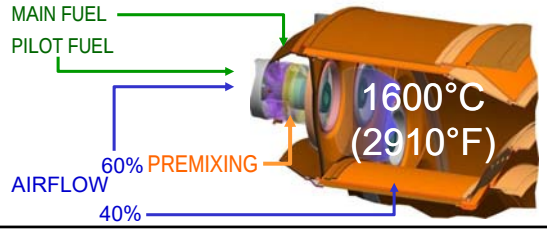
- Requirements
- Trade-Offs
- Heat Transfer and Cooling
- Experimental Methods
- Stress
- Fuel Capability
- Conclusions

Combustion Systems

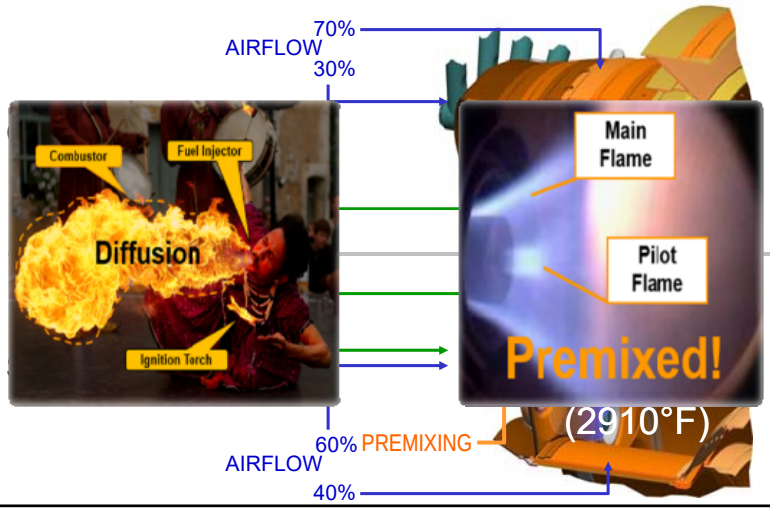
CONVENTIONAL



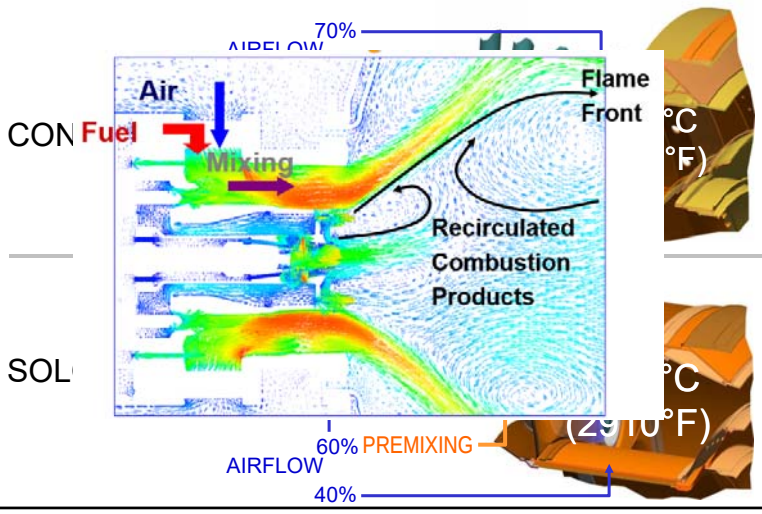
SOLONOX



Combustion Systems



Combustion Systems



Overview

- Requirements
- Trade-Offs
- Heat Transfer and Cooling
- Experimental Methods
- Stress
- Fuel Capability
- Conclusions

Conclusions

- Ultimately, any product is only successful if it adds to the success of its users. Any technology advance has to be judged by this criteria.
- **What do the technologies described offer the gas turbine operator?**
- If the emissions levels don't meet the regulators requirement, the engine cannot be operated.
- Low fuel consumption, high power density, high availability and reliability, and low maintenance costs all add to the economic success of compression projects.
- In a broader sense, in an increasingly competitive marketplace, user acceptance of gas turbine systems will be under increased scrutiny for economic and environmental benefit.
- **Technology advances create user benefits**