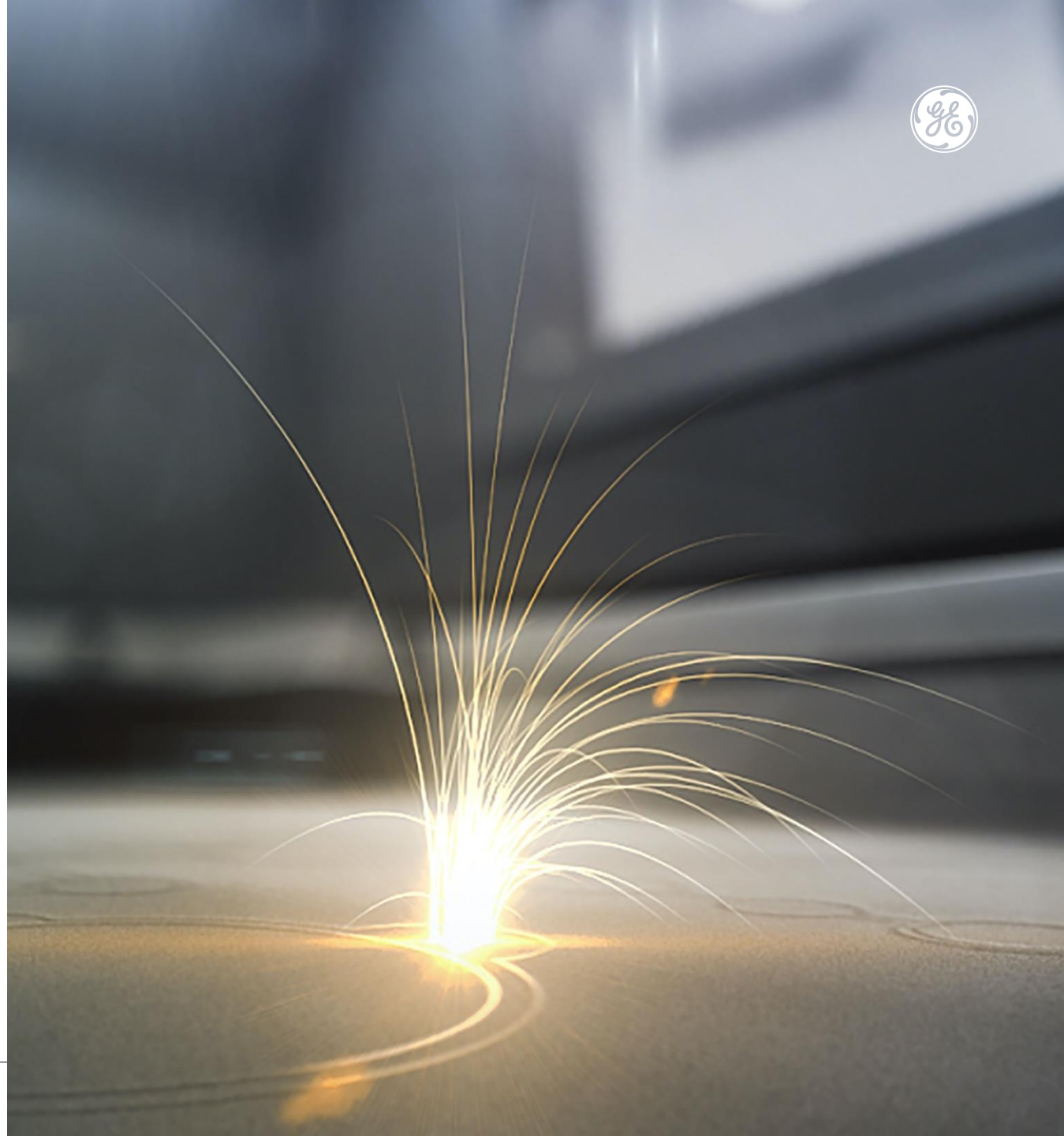
High Temperature Additive Architecture for 65% Efficiency

DE-FE0031611

GE Gas Power

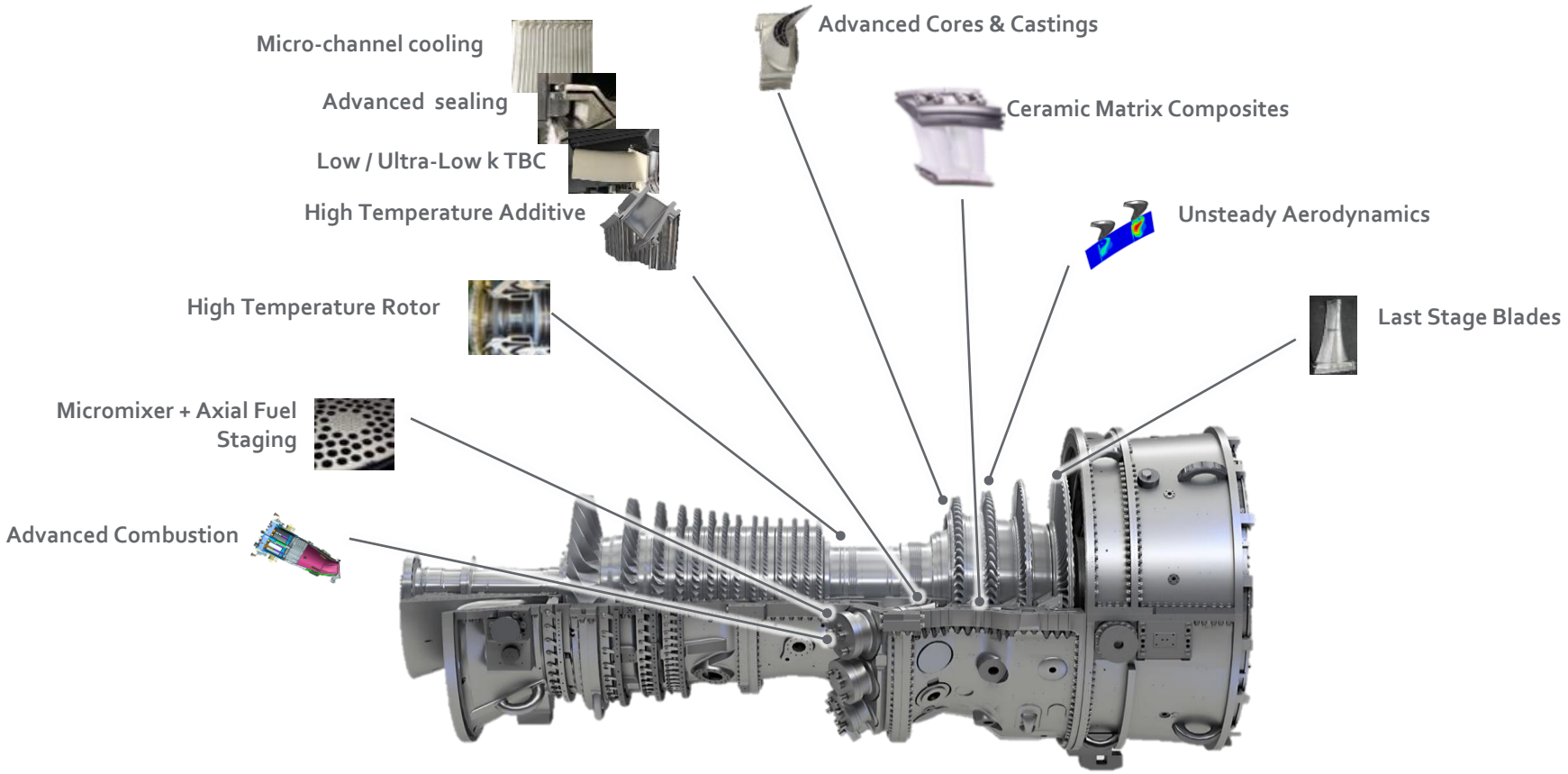
PI: Richard DiCintio
PM: Sharon Swede
Key Contributors: Ben Lacy, Srikanth Kottilingam, Brad VanTassel, Evan Dozier, Tim Moricca

UTSR Project Review Meeting
San Diego, CA
September, 2022



This material is based upon work supported by the Department of Energy under Award Number **DE-FE0031611**

Successful History of GE-NETL Partnership Leads to World Record Performance



57% to 64%+ Combined Cycle Efficiency in 15 years!

Agenda

- Impact of Additive at GE
- Industrial Gas Turbine Terminology
- Phase I Objectives
- Phase II Key Technology Activities
- Phase II Next Steps

Impact of Additive at GE

Performance

- Removes traditional mfg. constraints
- Enables “near surface” cooling & Cooling air reduction

Speed to Market

- Model to part directly
- Quick prototypes
- ~18 month cycle

Cost

- Eliminate casting tooling
- Metal only where needed
- Reduction of component counts

Improving state-of-the-art

Processing sciences

Alloys

Design

Advanced Manufacturing Works – Greenville, SC

Merging design and manufacturing technology to deliver better products

Additive

- >20,000 parts shipped
- 1st GT parts produced/fielded

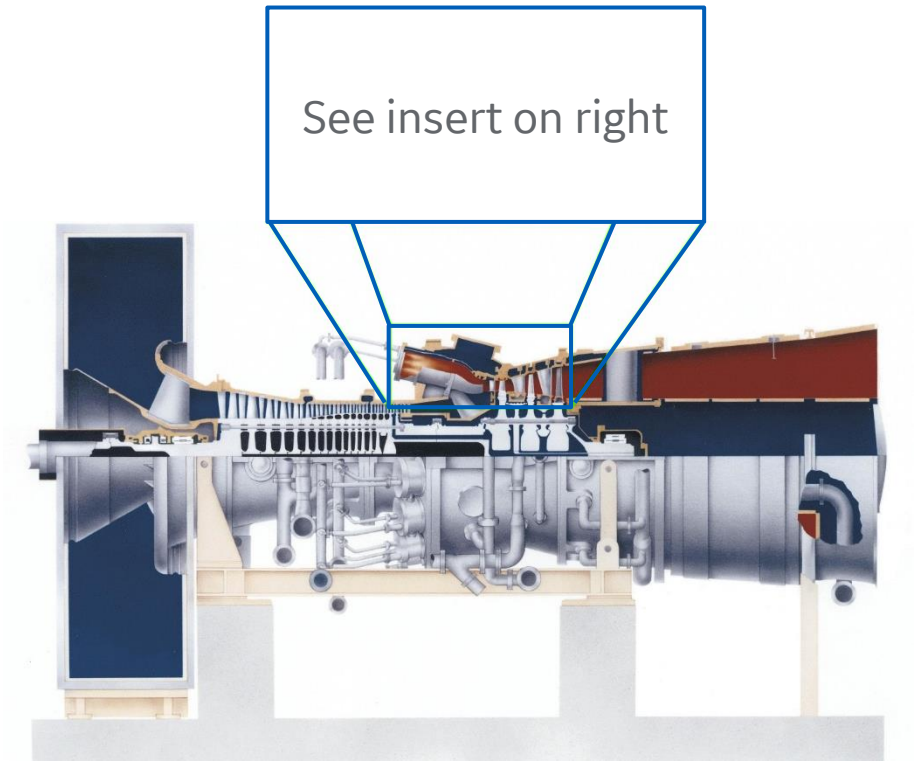
Ceramics

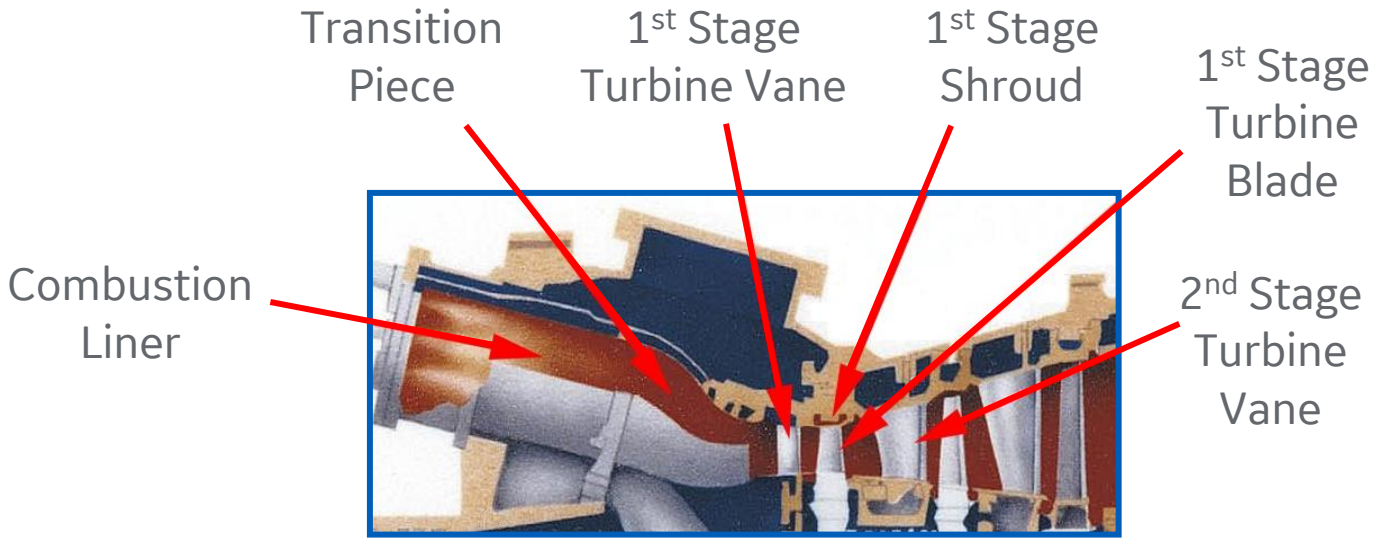
- 1st fielded CMCs
- Thermal coatings

Process optimization

- Automation/CMT/Digital
- HGP Special Processes
- Reduced cost and lead time

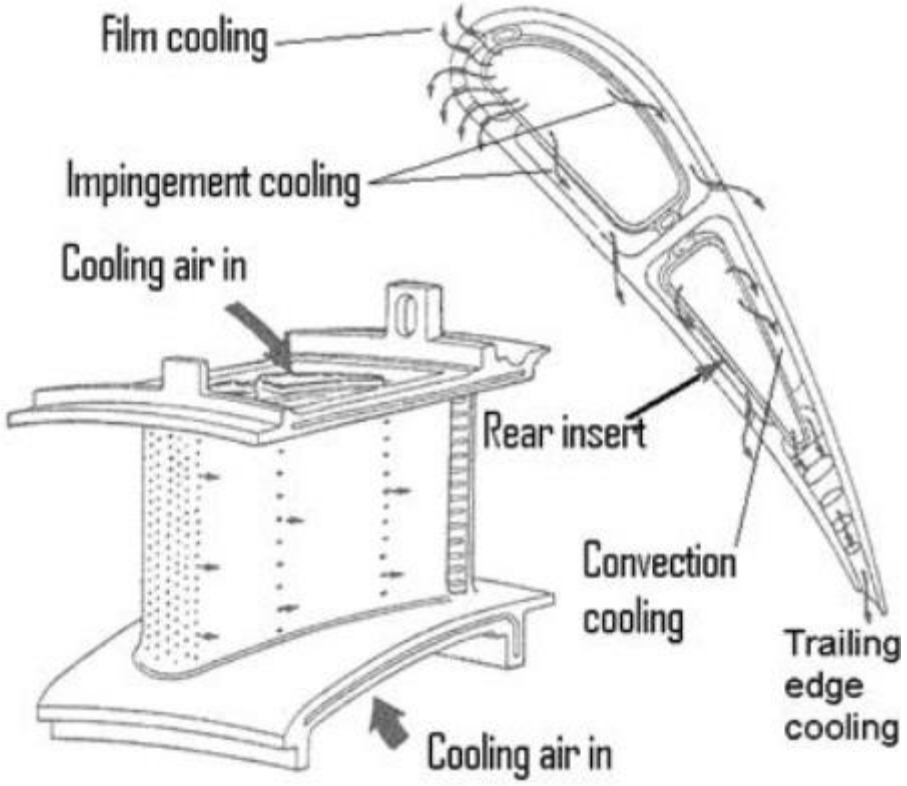
Industrial Gas Turbine Terminology



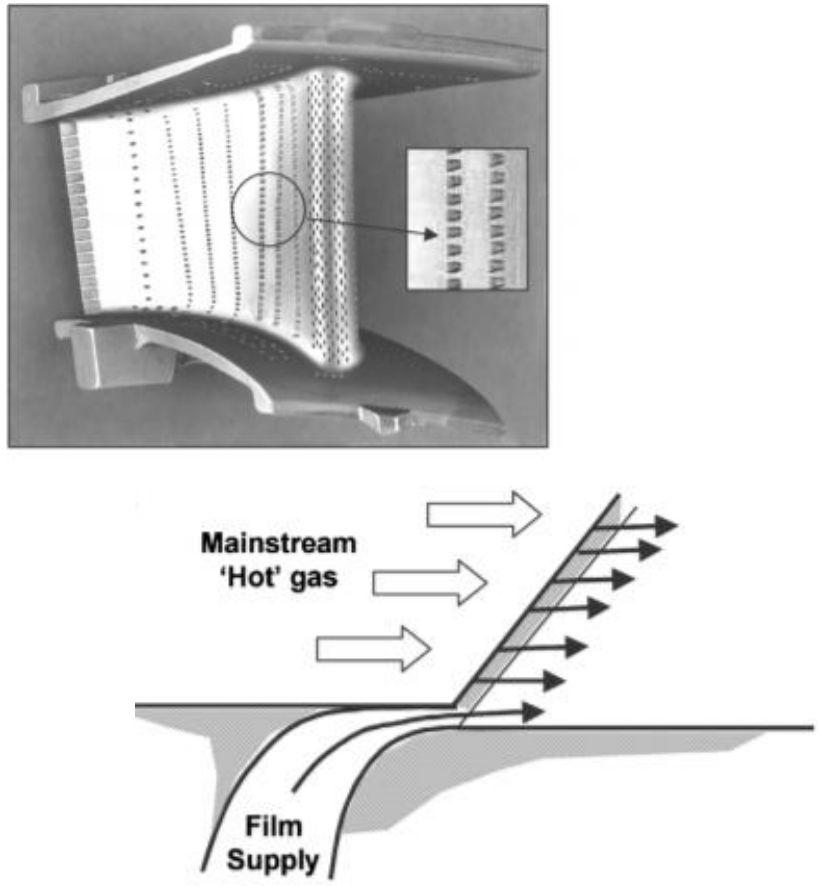


Turbine Vane Conventional Cooling Fundamentals

Internal Cooling Flow Circuit



Surface/External Film Cooling



Project Objectives & Technical Approach

Overall Objective

Develop a feasible conceptual design for advanced additive turbine inlet components that enable 65% CC efficiency through analytical methods and feature print trials.

Technical Approach

Phase I – Discovery (July 2018 – January 2020)

- Generate advanced wall architecture and airfoil concepts enabled by additive manufacturing
- Identify and evaluate additive methods and materials that enable desired geometry through coupon print trials
- Down select a primary concept and additive method/material plus a backup to carry forward into potential Phase II project
- Develop test plan for Phase II execution

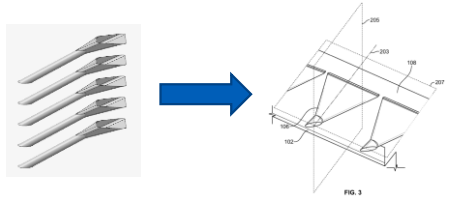
Phase II– Demonstration (January 2020 – Sept 2024)

- Generate high efficiency component design, enabled by additive manufacturing, using state of the art tools and methods
- Demonstrate manufacturing readiness level for additive manufacturing modalities through extensive print trials and post print inspection
- Validate individual wall architecture and cooling concepts with laboratory environment testing
- Demonstrate technology readiness level for component design at representative gas turbine conditions in combustion validation rig

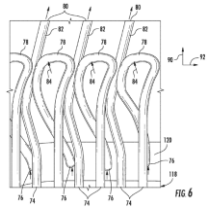
Program Objectives: Phase I – Discovery

Conceptual Design & Feasibility

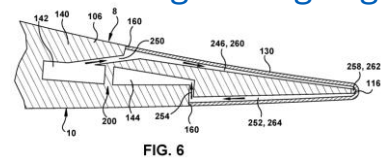
Advanced Film Shapes

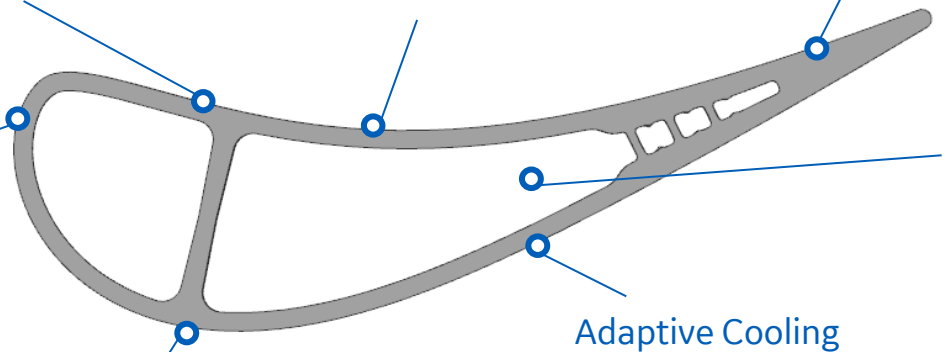


Near-wall Microchannels

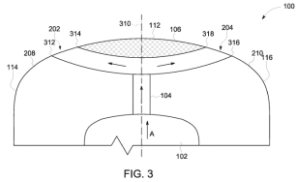


Recirculating Trailing Edge

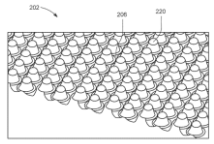




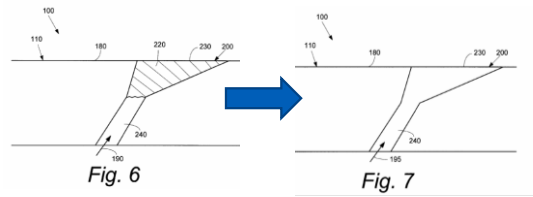
Axial Film Flow
for Leading Edge



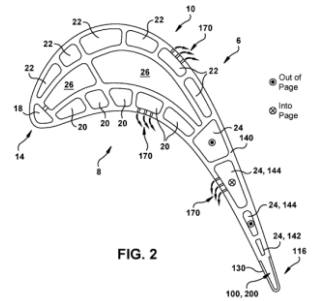
Advanced H-Bumps



Adaptive Cooling



Airfoil Compartmentalization
& Impingement Reuse



Program focus will be on high-temperature alloys, new additive modalities, geometry enabled by additive, and manufacturing capability

Phase II Key Technology Activities

Phase II Activities

1) Cooling Technology
   - ➢ Initial scope of thermal correlations for additive cooling features completed
   - ➢ Additional scope identified

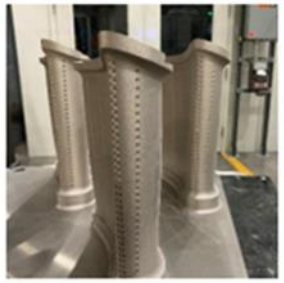
2. Wall Architecture Technology Bench Testing
   - ➢ Correlations of model to printed feature size for different additive modalities
   - ➢ Flow testing of cooling features, total and by feature

3. Additive Process Capability and Control
   - ➢ Powder removal demonstrated repeatedly on production viable designs
   - ➢ Progressing towards repeatability demonstration/ dimensional control

4. Additive Material Properties
   - ➢ Evaluating properties for several modalities

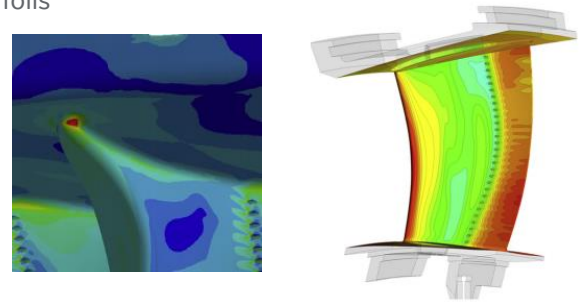
5. Detailed Design
   - ➢ Iterations on heat transfer and structural mechanical

Additively Printed Features



Additively Printed Airfoils

Additively Printed End walls



Detailed Design – Heat Transfer and Structural

Phase II Next Steps

Optimization for a Viable Commercial Product

- Demonstrated Manufacturing Repeatability of selected additive printing modalities and associated processes
- Completion of material property characterization including optimization of grain size
- High temperature validation of optimized design
  - Detailed design of rig underway to support testing in 2024
  - Numerous test samples to be tested

Questions?