Additive Manufacturing of Fuel Injectors

Mahdi Jamshidinia[1], Shawn Kelly[1], Daniel Ryan[2]

[1]EWI, [2]Solar Turbines

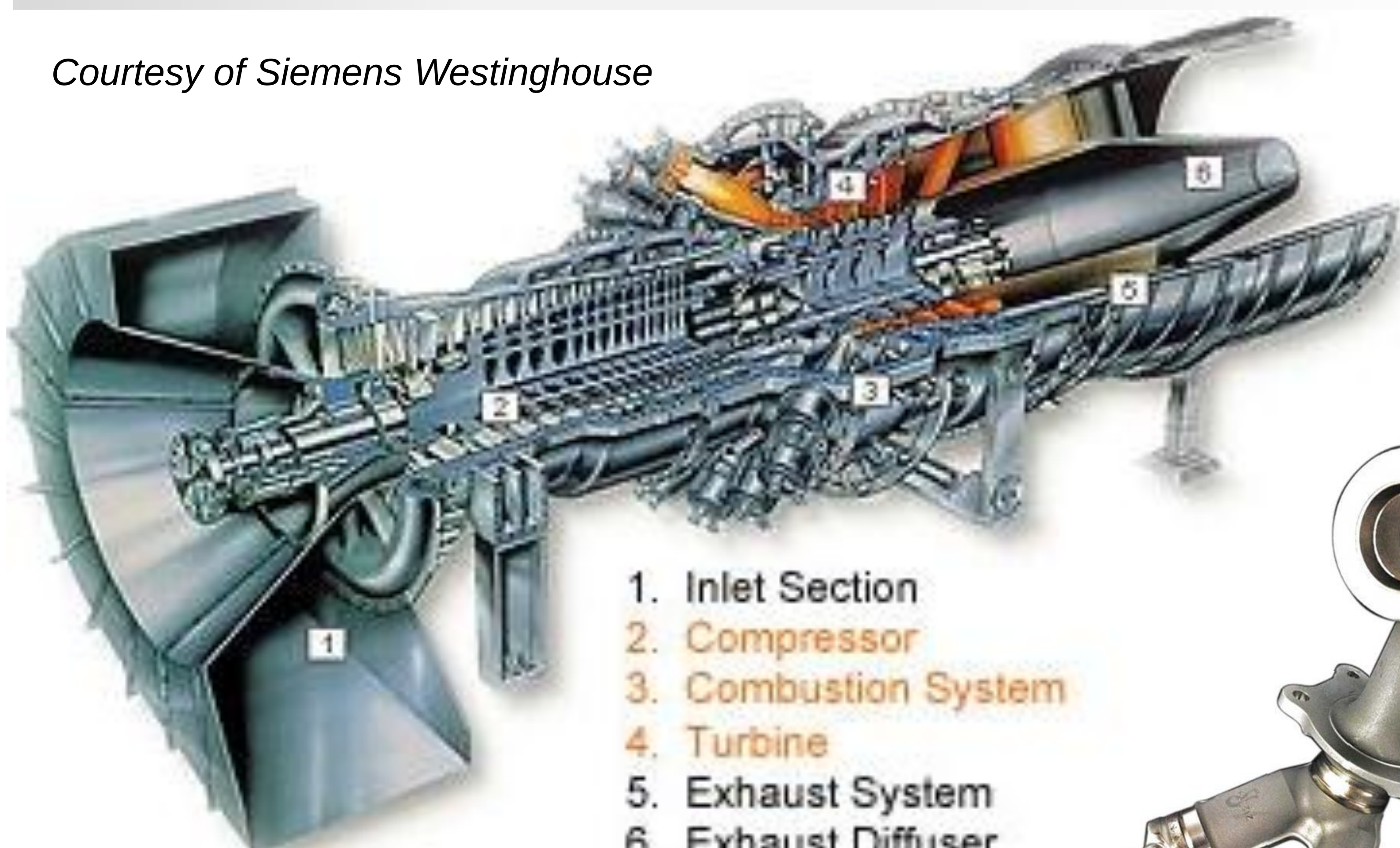
Technical background/motivation

- Gas turbine components require very specific design and material considerations.
- Fuel injector tip currently has a long lead time and is very difficult to cast.

Objective

- Evaluate the impact of several variables in additive manufacturing of a fuel injector.
  - Different types of powder material (Alloy X) from various suppliers
  - AM parameter
  - Post processing (heat treatment and surface finish)

Courtesy of Siemens Westinghouse

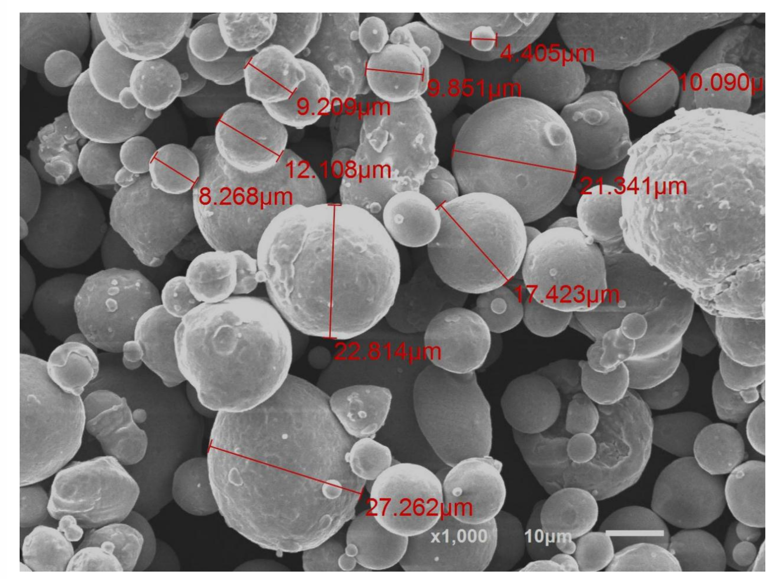


Courtesy of GE

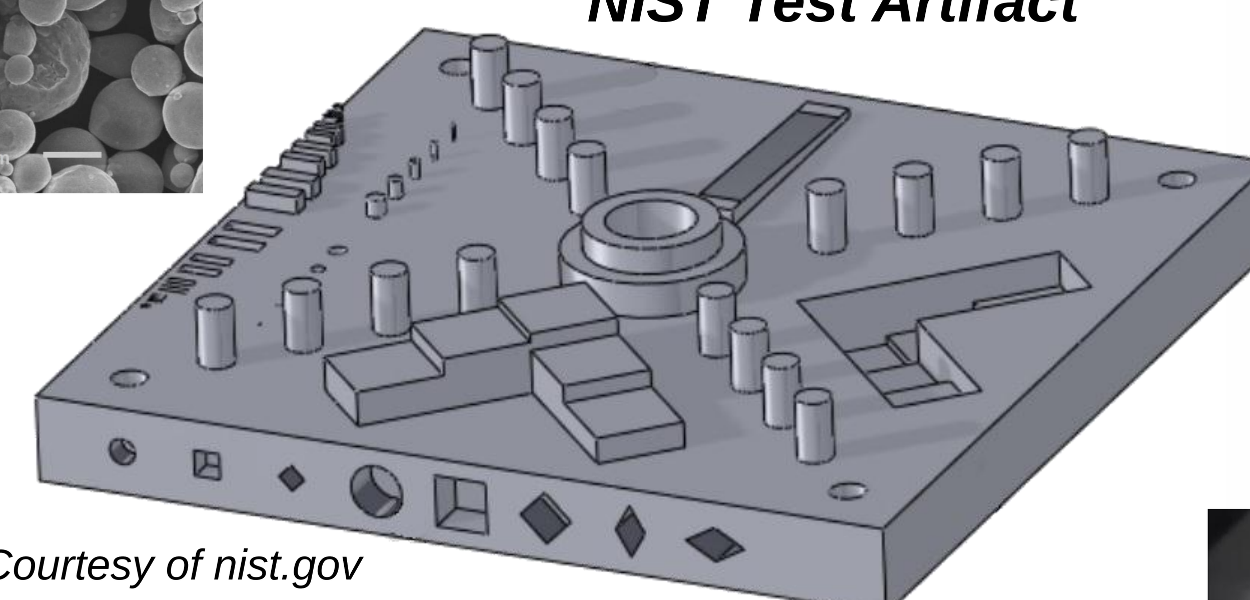
Milestones

- **Powder Sensitivity**
  - *Issue:* High occurrence of very fine particles (~1 to 10 μm)
  - *Objectives:* Effects of powder characteristics on material defects (metallography) and mechanical properties (mostly through tensile testing) will be evaluated.
  - *AM Process:* NIST test artifact will be fabricated to determine the effect of powder characteristics on surface finish and dimensional accuracy.
  - *Testing:* Tensile testing, Metallography, Full chemistry (ASTM B815), Heat Treatment and Low cycle fatigue (LCF).

- *Basis for Evaluation:* AM material defect distribution and AM material tensile properties.
- *Metrics:* Investment cast property minimum values.



NIST Test Artifact



Courtesy of nist.gov

- **Development of Optimal AM Process Profile**
  - *Objectives:* One powder will be down-selected to examine the effects of AM process variables such as build parameters, orientation, support structure, and post processing on component geometry, mechanical properties, and surface finish.
  - *Basis for Selection:* Powder cost and AM material quality (defects, tensile properties).
  - *Post Processing Finishing:* Grit blast, abrasive flow machining, and Microtek proprietary micromachining process.
  - *AM Process:* Fabrication of a representative IGT fuel injector geometry
    - Parameters to Study: Part orientation relative to the build axes, support structure, scanning parameters of the laser.
  - *Heat Treatment Development*
    - JMATPro Software: Select the proper post build heat treatment parameters.
    - Targets: Increase grain size, optimize carbide distribution for elevated temperature service.

- **Material properties**
  - Design Data Curves on tensile, creep and low cycle fatigue (LCF)
  - *Objective:* Improve ductility of the material produced using L-PBF process.
- **Specifications**
  - Powder Specifications
    - Input powder quality, morphology, production process route and particle size range.
  - Material and Process Specifications:
    - to produce a consistent outcome in a manufacturing context.
    - Degree of interconnectivity between the process and material produced is such that a combined material and process specification will be developed and refined during the project, particularly in Task 3.0, Component Geometry and Surface Finish and Task 4.0, Material Properties.

Potential significance of project

- **Assist in evaluating other turbine components for future AM fabrication.**
- **Design features into the components that may improve turbine performance and durability.**
- **Lower costs by reducing manufacturing time and eliminating scrap material.**
- **Future applications:**
  - Develop material properties design curves for other high temperature alloys.
  - Establish the baseline methodology for evaluating and qualifying future alloys.