Gas Turbine Hot Gas Path Hardware Concept Design Using Additive Techniques

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Power – Gas Turbines

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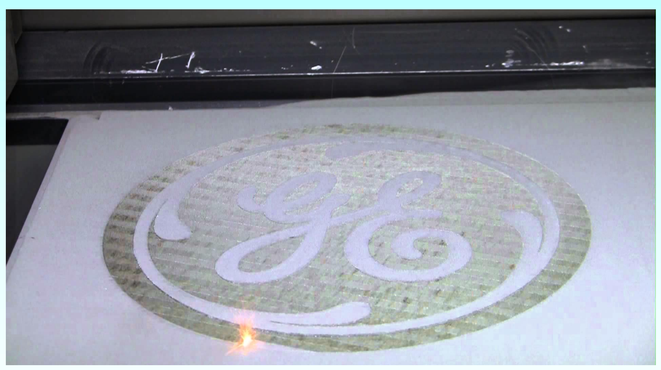
Introduction

- Additive Manufacturing at GE Power improves efficiency, lowers cost, and reduces production time.
- Direct Metal Laser Melting(DMLM) is the current technique being used by GE's 3D metal printers located in their Advanced Manufacturing Works building.
- DMLM is a relatively new technology that allows metal powder to be shaped into solid three-dimensional shapes.
- Additive techniques benefit the company by its applications on gas turbines and aviation, however there are still problems needed to be addressed.

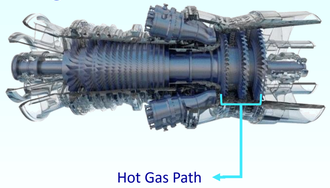
Process

- Metal Powder is layered onto the bed of the additive machine(on a metal substrate plate).
- Chamber is filled with a controlled atmosphere
- Lasers melt the powders at high temperatures creating rapid, localized heating and cooling.
- The bed is lowered and another layer is placed and scanned by the laser.
- A solid three-dimensional shape is eventually formed.
- Object is heat treated and separated from substrate plate by wire electrical discharge machining (EDM).
- Object is machined to specifications.



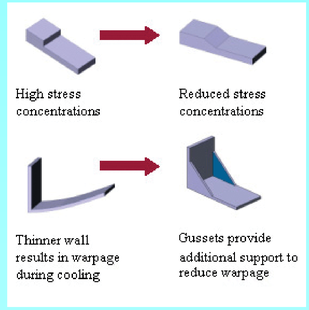
Application of Additive Manufacturing to Turbine Hot Gas Path

- Advancements in Heat Transfer
- Improved fluid flow
- Virtually no Geometry Restrictions While Designing.
  - Complexity of geometry comes for free.
- Increased options for internal part cooling while maintaining or improving structural design
- Rapid Prototyping (Design and Test)
  - Prototypes are being used during product development to test certain designs and properties before series production begins.
  - Due to the reduction of final machining time, testing may take a few months instead of a few years.
- Rapid Repair
  - Damaged areas of a part may be removed and replaced by new, better designs
- Rapid Product Introduction
  - New products with better designs are rapidly introduced to help the efficiency of the turbine.
- Simplified and integrated assemblies make for easier part installation.



Challenges with Additive Manufacturing

- Required assurance that material properties are adequate for operating
- Some available materials do not match industry needs
- Programs like GOM Inspect may be used to compare CAD model to 3D printed model.
  - Additive part is scanned in 3 dimensions by a blue light scanner x-ray.
  - Analyze parts for improvement
- Warping
  - Factors such as barometric pressure, humidity, part angle, and temperature differences in the part play a role in it.
  - Ribs, rafts, and gussets may be introduced to prevent this problem.
- Matching two parts that are required to fit into each other.
- Printing at steep angles without supports
- Size limitations
- Surface finish



Conclusions

- Additive manufacturing can help in turbine applications that can improve part life, introduce products faster, improve designs, and increase gas turbine efficiency.
- Although Additive Manufacturing seems promising, there are still problems that must be addressed such as warping, maintaining material properties, and having powders of different materials.
- Steps are being taken by engineers at GE to address these problems and additive techniques are beginning to be applied to developments of gas turbines.

My Experience

- This was an awesome summer where I got to network with professionals and be introduced to new technologies
- My technical skills were improved using CAD and FEA.
- I now know what impact additive engineering can have to better society and would like to put my efforts into contributing.
- All of the employees and fellow interns that I met over the summer will have a lasting effect on me for the rest of my life.
- This fellowship has powered me to pursue a career in the gas turbines industry.