Additive Manufactured Aero-turbine Blade

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Abstract

Additive Manufacturing has proven to be a demanding technique in a wide range for the aero-vehicle industries. This investigation focused on the evolution of aero-turbine blades from conventional manufacturing technique to the additive manufacturing technique. Additive Manufacturing is known as rapid prototyping or 3-D printing technique involving layer-by-layer construction process that can develop a turbine blade with a wide range of parameters to design the turbine blade and reduce cost and weight compared to the conventional production processes. This presentation discusses various additive manufacturing techniques suitable for manufacturing high-temperature turbine blades, such as selective laser melting, selective laser sintering, electron beam melting, laser engineering network form, and electron beam fabrication free form. The associated parameter of AM such as particle size and shape, powder bed density, residual stresses, porosity, and roughness are discussed here.

Keywords: Additive Manufacturing, Turbine blade, Designing, Porosity, Density

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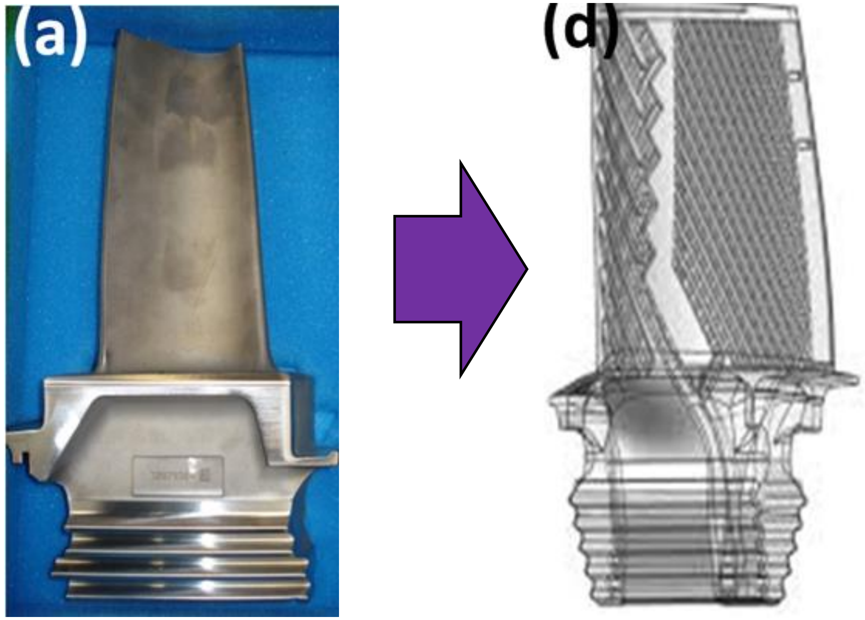
Outlines

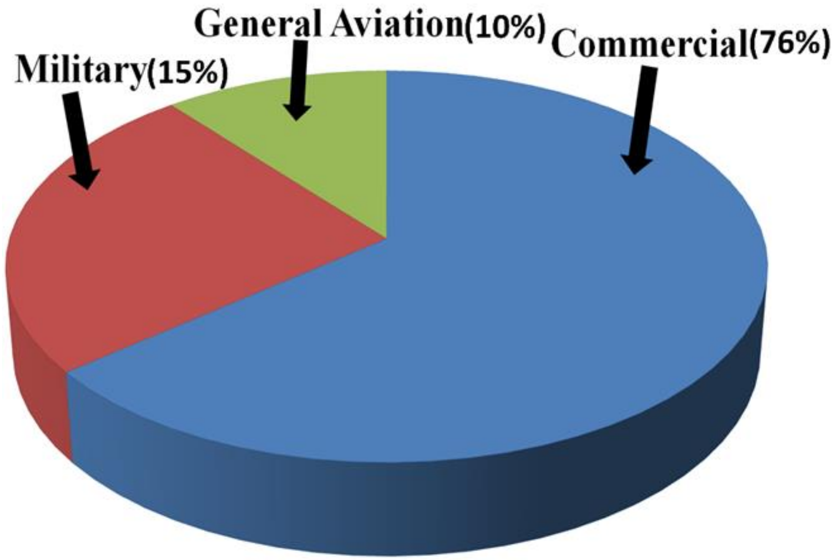
- Introduction
- Current scenario of Turbine blade
- Various AM techniques for turbine blade
- Processing Parameters
- Conclusion

Introduction



- ✓AM has become an integral part and an important contributor to industrial revolution 4.0.
- ✓A turbine blade is a discrete component of a gas or steam turbine engine.
- ✓The turbine engines operate at very high temperatures of about 850-1700 °C
- ✓Can develop a turbine blade with a wide range of parameters and reduce cost and weight compared to the conventional production processes.
- ✓Suitable for manufacturing high-temperature turbine blades, such as selective laser melting, selective laser sintering, electron beam melting, laser engineering network form, and electron beam fabrication free form.

Current scenario of Turbine blade



✓The turbine blade market being dominated by aerospace sectors is expected to grow at a decent pace over the next few years.

✓The AM field is estimated to grow from $ 16 billion to $ 40.83 billion by 2024 and in a decade it is expected to reach $ 80 billion with the aerospace industry contributing significantly to this growth.

✓The ability to produce complex components with these materials can incorporate complex designs. Furthermore, the current construction time of monocrystalline structures can vary from 60 to 90 weeks. Therefore, the reduction of production time can decrease the cost of production and increase productivity.

✓The Boeing 777X and Comac C919 are powered by General Electric's GE9X and developed engine has 3D printed low-pressure (LPT) turbine blades.

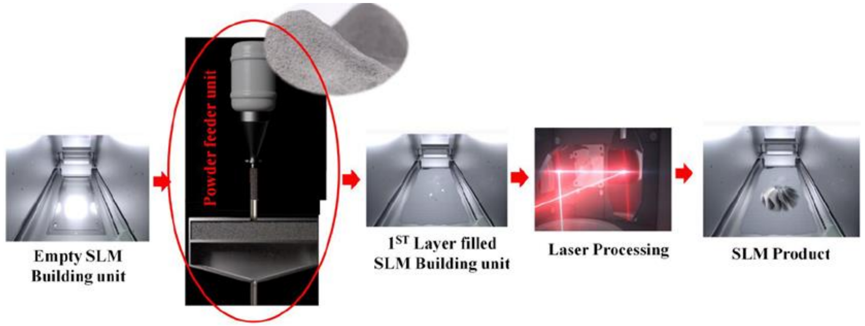
✓Leading companies in the aircraft blade market are General Electrical Company, MTU Aero Engines AG, Collins Aerospace, and Safran SA.

✓The advancement of lightweight blades and fan structures supports the growing market.

AM techniques for turbine blades

Turbine blade requires printing of the high-temperature materials that are superalloy constituents. Various AM techniques that are implemented to build the turbine blade are discussed below.

Selective Laser Melting



Selective Laser Sintering

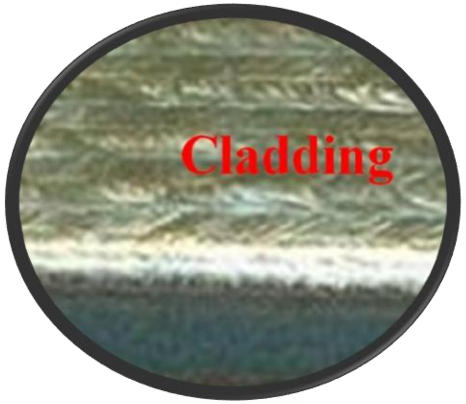
3D printed Ni alloy based turbine blade by Siemens

Electron Beam Melting

The 3D-printed TiAl blades for LPT of GE90X Engine

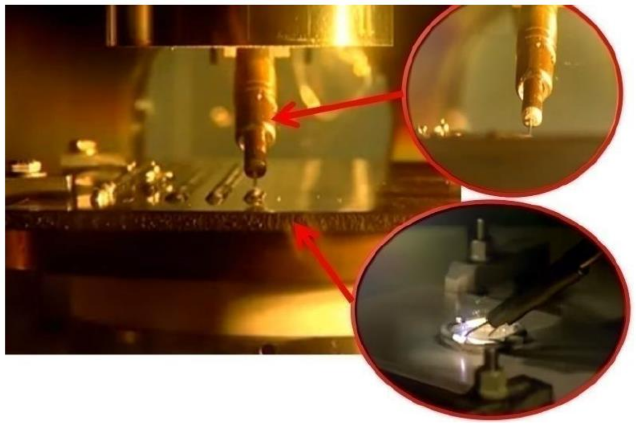
Laser Engineering Net Shape

Laser cladding



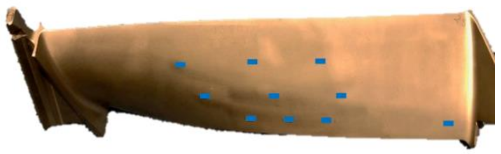
Side view of the morphology of laser cladding in grade 6 Stellite on carbon steel

Electron Beam Free-Form Fabrication



Electron beam freeform fabrication technique showing the first layer building in the layer-by-layer process

Aerosol Jet Process



3D printed sensors integrated turbine blade

Processing parameters

On the basis of various working principles, several parameters affect the processing of turbine blades. The effect of all those parameters is observed in the build quality of the turbine blade. Optimized process parameters of each process plays great role to print a good quality blade. Hence, a better understanding of the influencing parameters for a chosen technique is highly essential.

Particle size and shape of powder that to be printed

Powder bed density

Roughness

Residual Stresses

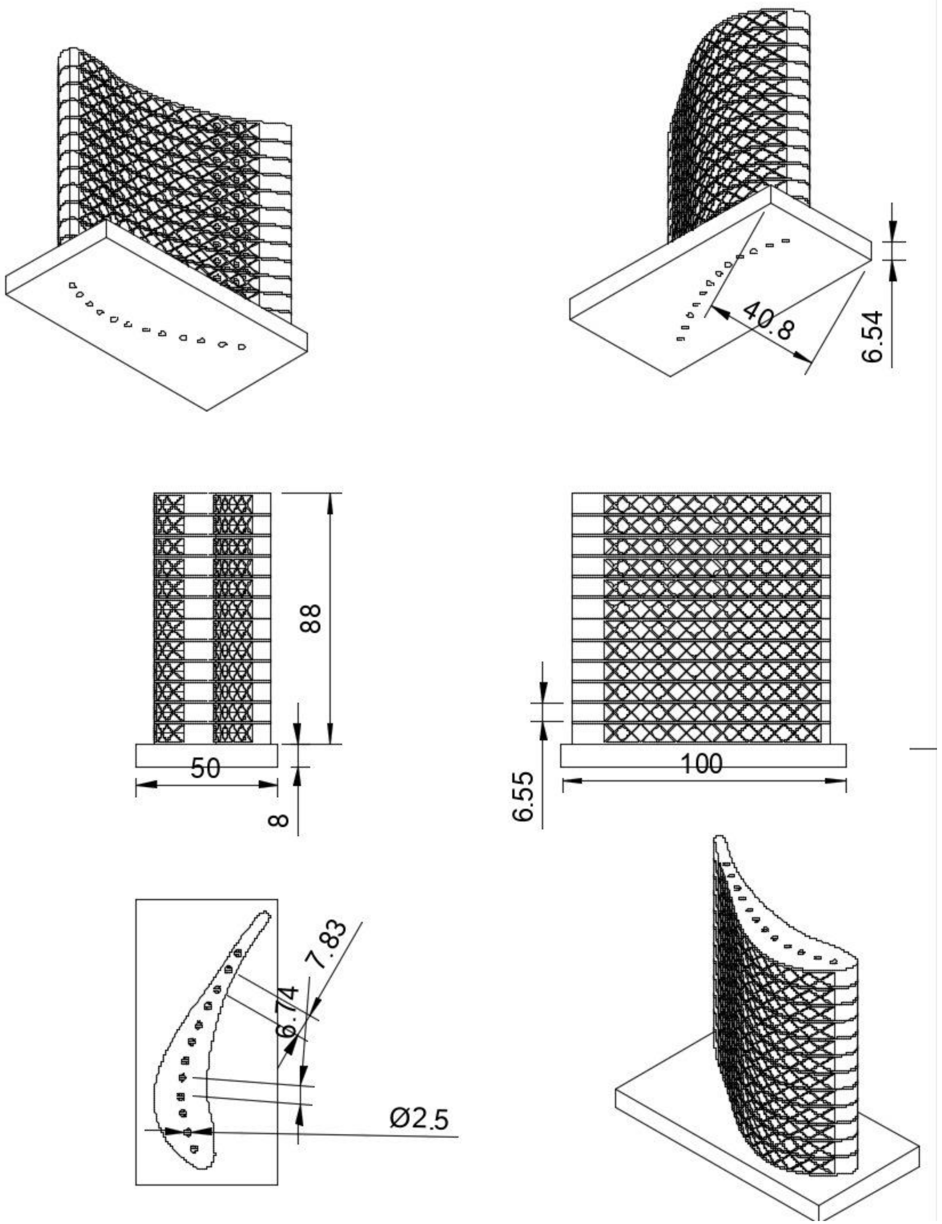
Core process resolution and precision

Porosity

Material feedstock-type, size, and quality

Print orientation

Support structure



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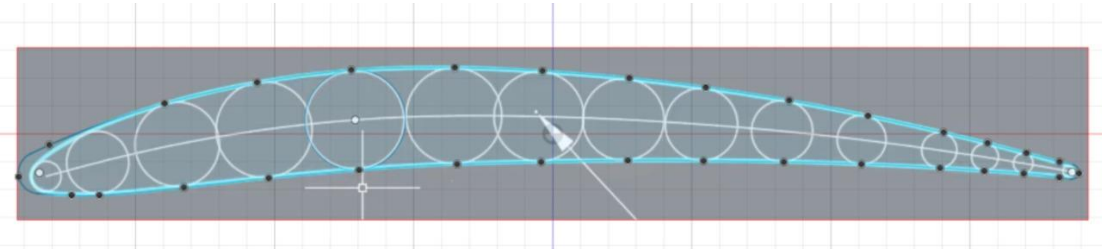

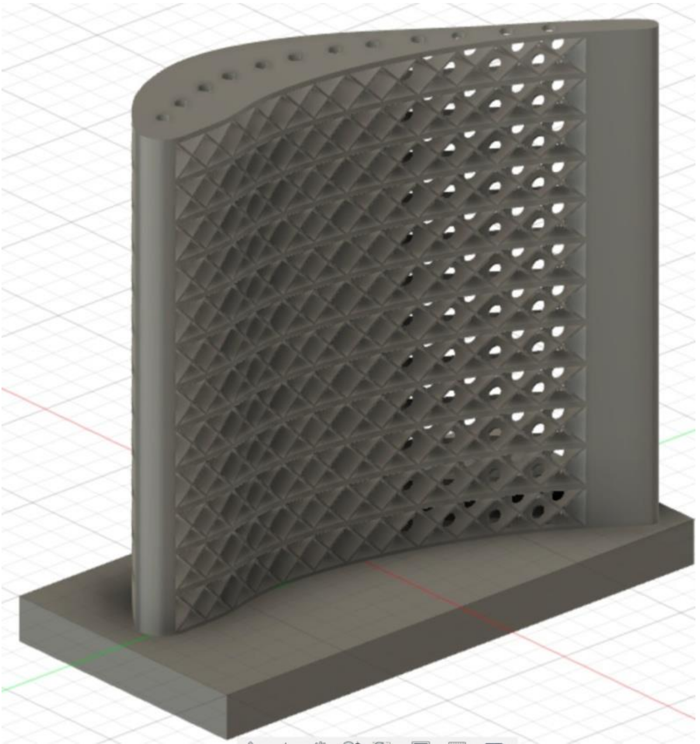

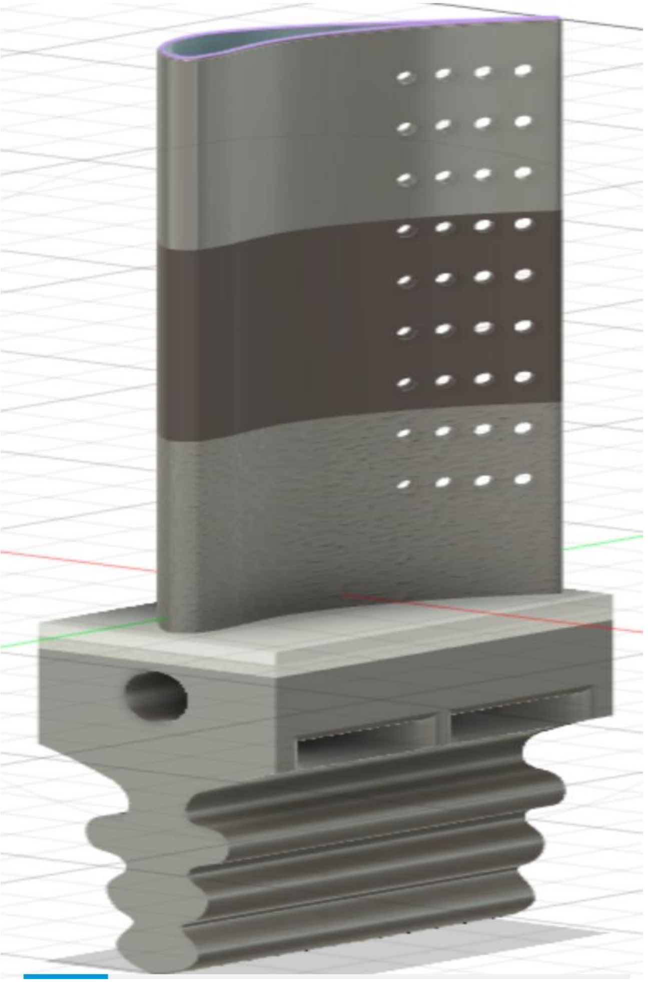

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Conclusion and Future aspect

✓Use of additive manufacturing techniques provides the opportunities to incorporate complex and flexible designs without changing production steps.

✓The flexibility of AM design further reduces the cost and weight of the components, as well as the development of the most complex internal geometry of turbine blades.

✓Yet there is huge scope for improvement in terms of design, newer materials, newer processing techniques, newer controlling and monitoring of process parameters, mechanical properties, and the overall quality of the turbine blade. This opens the way for more research and development necessary to annihilate several in-situ defects in products processed by AM.

Thank You!