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DEPARTMENT OF AEROSPACE ENGINEERING

19ASZ401-3D Printing for Space Components

UNIT-I INTRODUCTION

TOPIC: Application of 3D in Space components

NAME: Mr.N.Venkatesh., M.Tech.,(Ph.D)
Assistant Professor
Aerospace Engineering
SNS College of Technology

3D Printing

- 3D printing or additive manufacturing is a process of making three dimensional solid objects from a digital file .
- The creation of a 3D printed object is achieved using additive processes

3D Printing in Aerospace

The Aerospace and industry is a great example of utilization Additive Manufacturing (AM) with a clear value proposition and the ability to create parts that are stronger and lighter than parts made using traditional manufacturing.

Aerospace depends on 3D printing to alleviate -

- supply chain constraints,
- limit warehouse space,
- reduce wasted materials
- Cost & time from traditional manufacturing processes. -

Integrating 3D Printing in the Design Workflow

3D printing is implemented at all stages of the design workflow for applications in the aerospace industry.

- ➔ Design Communication
- ➔ Validation Stage
- ➔ Pre-Production
- ➔ Production
- ➔ Customization

Integrating 3D Printing in the Design Workflow

Design Communication

Designs in the aerospace industry often begin as concept models showcasing a component of an aircraft. SLA and Material Jetting are used to produce high detail, smooth, scale models of aerospace designs.

Validation Stage

Prototyping using 3D printing is now commonplace in the aerospace industry. From a full-size landing gear enclosure printed rapidly with low-cost FDM, to a high-detail, full-color control board concept model, there is a 3D printing process suited to every prototyping need .

Pre-Production

One of the areas 3D printing has been most disruptive and valuable is the production of low-cost rapid tooling for injection molding, thermoforming and jigs and fixtures. This validation mitigates the risk when investing in high-cost tooling at the production stage

Production

Because of the production Volume industry , the speed they are able to print at and the materials that are available mean that 3D printing is now a viable option for many medium-sized production runs, particularly for high-end interior build-outs.

Customization

3D printing also provides part consolidation and topology optimization of many custom aerospace components.

Common 3D printing use-cases in aerospace

- Jigs & Fixtures - > For each individual aircraft, companies have hundreds of fixtures, guides, templates, and gauges 3D printed, generally with 60 to 90 percent reductions in cost and lead time compared to other manufacturing processes .

- Surrogates -> Surrogates are placeholder parts used throughout production that represent components that are later installed in final assemblies.

- **Mounting brackets ->** 3D printing is commonly used to manufacture structural, low-volume metal brackets (with DMSL/SLM) that mount complex life saving systems to the interior wall of a plane.

- High detail visual prototypes -

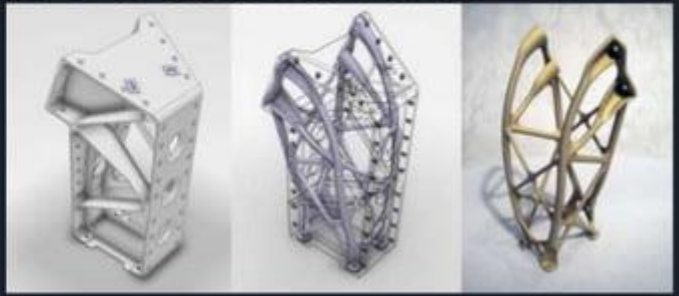
  3D printing with Material Jetting is able to produce multicolor designs with a surface finish comparable to injection molding.

  These visually appealing models allow designers to get a greater understanding of the form and fit of a part before production decisions.

Manufacturing Considerations

- ❑ **Geometric design freedom**
- ❑ **Consolidating assemblies into a single part**
- ❑ **Surface finish**
- ❑ **Part orientation**
- ❑ **Supports structures**

Case study - Production of Satellite Parts



Currently satellites include geometrically specific brackets that link the body of the satellite with reflectors and feeder facilities mounted at each end .

Problem - Engineers faced two key challenges regarding the construction of the brackets -

1. The brackets must affix the component securely to the satellite's body .
2. Brackets is to mitigate the vast temperature fluctuations experienced outside of earth's atmosphere.

Solution:- The end result ended up covering the entire spectrum of the advantages of 3D printing as an alternative to traditional manufacturing:

- Utilized premium material with little waste = cost savings
- Part consolidation = fewer man hours required for assembly
- Optimised geometry = higher performance designs not subject to traditional constraints
- Lightweight components = fuel savings over the life of the project

SuperDraco

(Hypergolic engine)

- Draco was the first Hypergolic liquid rocket Engine built by spacex , used in Dragon Spacecraft .
- SpaceX has been evaluating the benefits of 3D printing and perfecting the techniques necessary to develop flight hardware .

SpaceX Uses DMLS to 3D Print Inconel SuperDraco Engine Chamber

Compared with a traditionally cast part, a printed valve body has superior strength, ductility, and fracture resistance, with a lower variability in materials properties.

- It is approximately 200 times as powerful as the Draco thruster engine.
- Further It is used in Dragon 2 (successor of Dragon) .
- It has multiple restart capability and uses the same shared hypergolic propellants.Thus Used in Dragon 2 , make it as Reusable spacecraft .

The engine chamber of the SuperDraco was 3D printed out of Inconel; a superalloy used in High Temp. , Multiple Starts & Extending firing durations .

Falcon 9

-> **Falcon 9** is a two-stage-to-orbit medium lift launch vehicle designed and manufactured by SpaceX .

-> It is powered by Merlin Engines .

Main Oxidiser Valve

-> It is the valve which controls the flow of liquid Oxygen as it enters into main combustion chamber , A faulty part could be catastrophic for any launch .

->The 3D printed valve performed exceptionally well, under extreme temperatures and vibrations. It takes 2 days only while traditional method will take 2 months .

->After various tests and qualifications this part was allowed to replace cast parts on all Falcon 9 flights.


Thank You!