Optimizing Aerospace Components with 3D Printer

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Abstract*— The aerospace industry constantly seeks innovative methods to enhance component performance, reduce weight, and streamline production processes. Additive manufacturing (AM), particularly 3D printing, has emerged as a transformative technology offering significant potential in achieving these objectives. This paper explores the application of 3D printing in aerospace component optimization, focusing on design flexibility, material advancements, and manufacturing efficiency. By harnessing the capabilities of AM, aerospace engineers can create complex geometries, lightweight structures, and integrated functionalities, leading to improved performance and reduced operational costs. Moreover, advancements in materials tailored for 3D printing enable the production.*Keywords—Additive Manufacturing, 3D Printing,**

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I. Introduction

In today's world, manufacturing a product with traditional methods is getting replaced with the new technologies [2]. It helps in reducing human effort and maximizing the production of goods. The production that involves additive or subtractive manufacturing is stepped with the process like 3D modelling which comes under the rapid prototyping process [3]. Before manufacturing any product, a CAD (Computer Aided Design) model is designed with the help of different 3D modelling software like Solid Works, CREO Parametric, Blender, etc., with proper dimensions [1]. Such a model is transferred into an STL file where each part is converted into the triangulated and slice form, so the machine understands the way of manufacturing. CNC Cutters, CNC Lathe, and 3D printers are some advanced manufacturing machines. In this report, additive manufacturing machine, 3D printer is detailed with its design along with manufacturing for the laboratory use [4]. 3D printer gets STL file of any CAD model designed by the user, that is further sliced into a machine defined form and then prototype product is manufactured.

3D Printing also known as additive manufacturing, is a method of creating a three- dimensional object layer-by-layer using a computer created design [4]. It is an additive process whereby layers of material are built up to create a 3D part. This is the opposite of subtractive manufacturing processes, where a final design is cut from a larger block of material [10]. As a result, 3D printing creates less material wastage. 3D printing is also perfectly suited to the creation of complex, bespoke items, making it ideal for rapid prototyping [5]. Superior properties of both materials without compromising on the weakness of either [9].

3D Printing Technologies

There are three broad types of 3D printing technology; sintering, melting, and stereolithography.

Sintering is a technology where the material is heated, but not to the point of melting, to create high resolution items. Metal powder is used for direct metal laser sintering while thermoplastic powders are used for selective laser sintering [7]

Melting methods of 3D printing include powder bed fusion, electron beam melting and direct energy deposition, these use lasers, electric arcs or electron beams to print objects by melting the materials together at high temperatures [15].

Stereo lithography utilizes photo polymerization to create parts. This technology uses the correct light source to interact with the material in a selective manner to cure and solidify a cross section of the object in thin layers [.

III. Materials and Methods

Delta 3D printers are a type of FDM printer that also use Cartesian coordinates [6]. Yet, they're mechanically unique from rectilinear printers in a few different ways. Delta 3D printers work with three (or sometimes even more) arms attached to vertical rails.

The print head is connected to the end of each arm with hinges, and the arms work together to adjust the print head's position [10]. The coordinated movement of a delta printer's arms controls the print head's height (Z-axis) and location (X- and Y-axes) relative to the print bed.

The Arduino Mega is a microcontroller board based on the ATmega2560 [13]. It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button [12]. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC- to-DC adapter or battery to get started. Figure below shows the Arduino mega 2560 [12].

End stop is a kind of switch also known as mechanical end stops which are contact based manual switches that determine when an object is at the end of the axis path. It works using simple touch sensor that functions as a switch where the switch is touched by an object. It signals to the motherboard that the main object is at the end of the path.

FDM 3D printing is a technology that works both horizontally and vertically, where an extrusion nozzle moves over a build platform. The process involves the use of thermoplastic material that reaches melting point and is then forced out, to create a 3D object layer by layer. Many different industries choose to use FDM 3D printing. Industries including automotive and a wide range of consumer goods manufacturers [8]. They use FDM because it helps to aid their product development, their prototyping and their manufacturing process. Manufacturers of certain products use FDM 3D printing because of the thermoplastic that is used during development is perfect for anything ranging from Children's toys or even sports equipment. Combining different raw materials isn't always possible with mass production methods because of the high costs involved, as well as their chemical and physical properties, which make them difficult to combine using traditional methods. Many of these limitations have been removed by 3D printing, not only because of the initial reliance on plastic, but also as a result of constant innovation by enthusiasts who believe that 3D printing's potential has yet to be realized [11].

FIGURE 1 3D PRINTER

Process of 3D Printing

3D printing process can be described and followed by the following steps CAD

CAD model is designed by the user as per the requirement. Model can be of different types and shapes that are designed with the help of 3D modeling software like Creo Parametric, SolidWorks, etc.

Conversion of STL

Any 3D model that are designed need to be converted into .stl format which is tessellation language which almost all the manufacturing machine understand the product that need to be produced [14].

Slicing of Model

Computerized model is sliced into closely spaced parallel horizontal layers. Depending on the size and number of layers, quality of product can be manufactured. More the number of layers good the quality of the product. Below figure shows the conversion of a solid model of an object into layers.

Software and file codes

Here is some software, which are compatible for the model to operate. Those softwares will help to prepare prints with a few clicks, integrate with CAD software for an easier workflow, or dive into custom settings for in-depth control. Some of them are listed below [15].

- Cura
- Simplify 3D
- Repetirt Host

PRODUCT IDEOLOGY

Ideology

The product ideology of an engine assembly nozzle dispenser using a 3D printer involves leveraging advanced manufacturing techniques to create a precise and efficient tool. Here are some key points:

1. Innovative Design: The nozzle dispenser is designed with a focus on functionality and durability, integrating intricate features that optimize the assembly process.

2. Material Selection: Utilizing suitable materials compatible with 3D printing technology ensures the dispenser meets the necessary strength, heat resistance, and precision requirements for engine assembly tasks.

3. Customization and Prototyping: 3D printing allows for rapid prototyping and customization, enabling iterative improvements and tailored designs based on specific engine assembly needs.

4. Precision and Accuracy: The product ideology emphasizes the use of 3D printing's high precision capabilities to produce nozzles with exact specifications, critical for precise fluid application in engine assembly.

5. Efficiency and Cost-Effectiveness: By employing 3D printing, the manufacturing process can be streamlined, reducing production time and costs associated with traditional machining methods.

6.Integration and Compatibility: The design considers integration into existing assembly processes, ensuring compatibility with standard equipment and enhancing overall workflow efficiency [16].

In summary, the product ideology behind an engine assembly nozzle dispenser using 3D printing revolves around leveraging technology to create a highly functional, customizable, and cost-effective tool tailored for the demands of engine manufacturing and assembly processes [16].

RESULTS AND DISCUSSIONS

With the help of 3-D-printed components, aircraft and parts are 70% lighter while remaining as strong as conventional parts, indicating cost savings, carbon reduction, and reduced particle emissions. It uses fewer raw materials and produces parts that are lighter, more complicated, and stronger As per the requirement, design and assembly of the 3D printer was successfully done. Overall process went smoothly but some problems were faced during the assembly process. Calibration part was quite difficult and equally interesting as printer has to calibrate in an infinitesimal distance between nozzle and bed. G-CODE is found most effective mode of code for printing. Rapid prototyping advancements have provided materials required for final manufacturing, resulting in the possibility of manufactured finished components and parts.

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