Modelling and Manufacturing of Jet Engine Turbine Blade Using Additive Manufacturing

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Abstract:- Additive manufacturing (AM) technology has been researched and developed for more than 20 years. Rather than removing materials, AM processes make three-dimensional parts directly from CAD models by adding materials layer by layer, offering the beneficial ability to build parts with geometric and material complexities that could not be produced by subtractive manufacturing processes. Through intensive research over the past two decades, significant progress has been made in the development and commercialization of new and innovative AM processes, as well as numerous practical applications in aerospace, automotive, biomedical, energy and other fields. This paper reviews the main processes, materials and applications of the current AM technology and presents future research needs for this technology.

Keywords:- Additive Manufacturing (AM), AM Processes, AM Materials, Turbine Blade, 3D Printing

I. INTRODUCTION

The ASTM F42 Technical Committee defines additive manufacturing (AM) as the "process of joining materials to make objects from three-dimensional (3D) model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies" [1]. It is also known as additive fabrication, additive processes, direct digital manufacturing, rapid prototyping, rapid manufacturing, layer manufacturing and solid freeform fabrication. The term AM describes additive fabrication processes in the broadest way that includes AM of prototypes (for design verification, form and fit checking), tools, patterns, and concept parts, as well as functional parts with required properties for direct industrial applications and services. Since the late 1980s, AM processes have been investigated, and some have been developed commercially. They include, among others, Stereolithography (SLA) [2], Fused Deposition Modeling (FDM) [3], Selective Laser Sintering (SLS) [4], Laminated Objective Manufacturing (LOM) [5], Three Dimensional Printing (3DP) [6], and Laser Metal Deposition (LMD) [7]. The materials used in these processes include photo-curable resin, polyamide, wax, acrylonitrile-butadiene-styrene (ABS), polycarbonate, metal/ceramic/polymer powders, adhesive coated sheets, etc. Using AM technology, threedimensional parts are fabricated directly from CAD models and built in a layer-by-layer manner. AM technology allowsfreeform fabrication of geometrically complex parts without special fixtures as required in material removal processes. AM processes significantly shorten the lead time, are cost-effective for single parts and small batches, and can build parts not possible with subtractive manufacturing processes [8].

Over the past 20+ years, the research community has developed novel AM processes and applied them in the aerospace [9], automotive [10], biomedical [11,12] and other fields (e.g., digital art and architectural design). The driving force from industry also has changed AM techniques from prototype fabrication to rapid tooling and rapid manufacturing [13]. Popular applications of these techniques in the early phases included visual aids, form evaluation, fit assessment, etc. After intensive research and development in the areas of materials, processes, software and equipment, rapid tooling applications have been developed by directly or indirectly employing AM technology in the fabrication of tools, dies and molds. AM also has been used to produce prototype parts with desired material properties for evaluation and testing, as well as to manufacture small or medium quantities of end-use products. Currently, the direct fabrication of functional end-use products has become the main trend of AM technology.

Although AM techniques have progressed greatly, many challenges remain to be addressed. These challenges include the limited materials that can be used in AM processes, relatively poor part accuracy caused by the "stair-stepping" effect [14], poor repeatability and consistency of the produced parts, and lack of standards for AM processes. This paper reviews the existing AM processes, their underlying techniques, commercial systems, materials used in AM fabrication, and applications in the aerospace, automotive, biomedical, and energy fields. Future research needs of AM technology also are presented.

II. ADDITIVE MANUFACTURING PROCESSES

Various AM processes have been introduced to the commercial market by industrial companies [15], including the Electro Optical Systems(EOS) in Germany, Arcam in Sweden, MCP Tooling Technologies in the UK, and Stratasys, 3D Systems, Optomec , and Z Corporation in the United States, among others. There are several systems to classify the AM processes, e.g., the one proposed by the ASTM F42 Committee [1] classifies the AM processes into seven areas. In this paper, according to the state of starting material used, AM processes are divided into the following four broad categories [16,17]: (1) liquid,(2) filament/paste, (3) powder and (4) solid sheet. The working principles of AM processes with the different states of material are summarized in Table 1

A. Liquid

Stereo lithography (SLA) [2], the first commercially available AM technology, is characterized by the conversion of a liquid photosensitive resin to a solid state by selective exposure of a resin vat to ultraviolet (UV) light. In this process, a CAD model is sliced into layers, each of which then is scanned by the UV light to cure the resin selectively for each cross-section. After a layer is built, the platform descends by one layer thickness. Then, a resin- filled blade sweeps across the part's cross-section, recoating it with one layer thickness of fresh resin. The subsequent layer then is scanned, adhering to the previous layer. Commercial SLA machine vendors include 3D Systems (USA), EOS (Germany), and CMET (Japan). In addition to the typical polymeric parts, variants of the SLA process have been developed to fabricate ceramic and metal parts by using suspensions of ceramic or metal particles in a photo-curable monomer vat [18–20]. Researchers have also developed alternative processes using digital mask generators, e.g., the digital micro mirror device (DMD), to build structures using photo-curable polymers [21,22]. Compared to the UV-laser based SLA

Stateofstarg in material	**Process**	**Materialpreparat**	**Layer creationtechnique**	**Phasechange**	**Typicalmaterial**	**Applications**
Liquid	SLA	Liquidresininavat	Laser scanning/ lightprojection	Photopoly- merization	UVcurableresin, ceramicsuspensio	Prototypes,castin g
	MJM	Liquidpolymerinjet	Ink-jetprinting	Cooling&photopo ly-	UVcurableacryl ic	Prototypes,cast ing
	RFP	Liquiddropletinnozz le	On-demanddroplet deposition	Solidificati on	Water	Prototypes,cast ing
Filament/ Paste	FDM	Filamentmelted innozzle	Continuousextrusion anddeposition	Solidification bycooling	Thermoplastics, waxes	Prototypes,castin pattern
	Robocasti	Paste innozzle	Continuousextrusion	–	Ceramicpaste	Functionalparts
	FEF	Paste innozzle	Continuousextrusion	Solidificati on	Ceramicpaste	Functionalparts
Powder	SLS	Powderinbed	Laser scanning	Partialmelting	Thermoplastic s, waxes,metal powder,ceram	Prototypes,casting patterns,metaland ceramicpreforms(to be
	SLM	Powderinbed	Laser scanning	Fullmelting	Metal	Tooling,
	EBM	Powderinbed	Electronbeam scanning	Fullmelting	Metal	Tooling,
	LMD	Powderinjectio n throughnozzle	On-demandpowder injectionandmeltedbyl aser	Fullmelting	Metal	Tooling, metalpart repair,functionalp
	3DP	Powderinbed	Drop-on-demand binderprinting	–	Polymer,Metal,cera mic, other	Prototypes,cast ing
Solidsheet	LOM	Laser cutting	Feedingandbindingof sheetswithadhesives	–	Paper,plastic,metal	Prototypes,cast ing models

Table1: Working Principles of AM Processes

III. METHODOLOGY

FDM starts with a product procedure which forms a STL record (stereo lithography document organize), numerically cutting and arranging the model for the fabricate procedure. On the off chance that required, bolster structures might be created. The machine may administer numerous materials to accomplish distinctive objectives: For instance, one may utilize one material to develop the model and utilize another as a solvent help structure, or one could utilize various shades of a similar kind of thermoplastic on a similar model.

The model or part is created by expelling little leveled strings of liquid material to frame layers as the material solidifies instantly after expulsion from the nozzle A plastic fiber or metal wire is loosened up from a loop and supplies material to an expulsion nozzle which can kill the stream on and. There is normally a worm-drive that pushes the fiber into the nozzle at a controlled rate The nozzle is warmed to dissolve the material. The thermoplastics are warmed past their glass progress temperature and are then saved by an expulsion head.

The nozzle can be moved in both even and vertical headings by a numerically controlled instrument. The nozzle takes after an instrument way controlled by a PC supported assembling (CAM) programming bundle, and the part is developed from the last, one layer at a time. Stepper engines or servo engines are regularly utilized to move the expulsion head. The component utilized is regularly a X-Y-Z rectilinear outline, albeit other mechanical plans, for example, deltabot have been utilized.

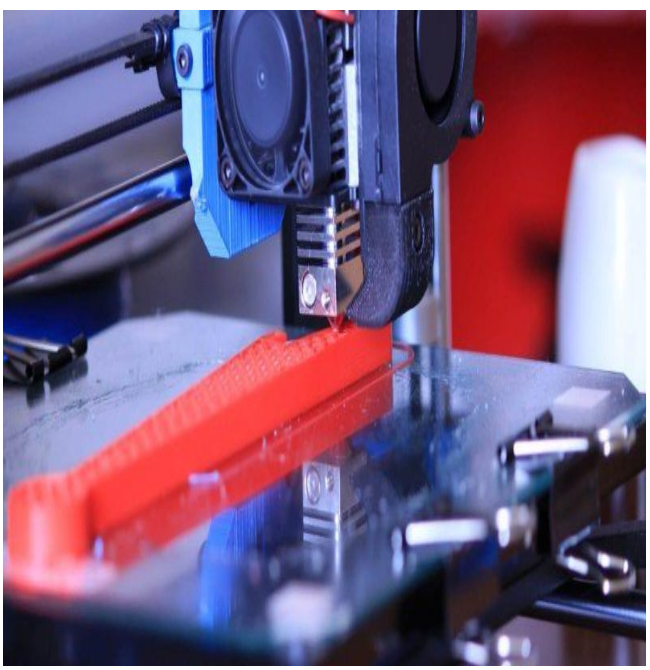

Figure :1 FDM Setup

A. Design Specifications

	Leading edge radius	20 mm
	Trailing edge radius	3.167 mm
	Blade height (h)	90 mm
	Axial Chord (ca)	228.53 mm
	Pitch (s)	99.77 mm
	Max. Thickness (tmax)	59.63 mm

B. Structural Analysis

Auxiliary investigation directed on turbine sharp edge with ABS material and steel material Limit conditions are indicated beneath.

C. ABS Material Properties

Property	Value
Density	1.04 g cm ^3
Young modulus	2588 MPa
Poisson ratio	0.35

D. Steel Properties

Property	Value
Density	7.85 g cm ^3
Young modulus	2e+05 MPa
Poisson ratio	0.3

IV. RESULTS AND DISCUSSION

From the all outcomes I inferred that ABS material is less weight contrasted with steel material. Furthermore, quality of the ABS turbine cutting edge is more contrasted with steel turbine edge.

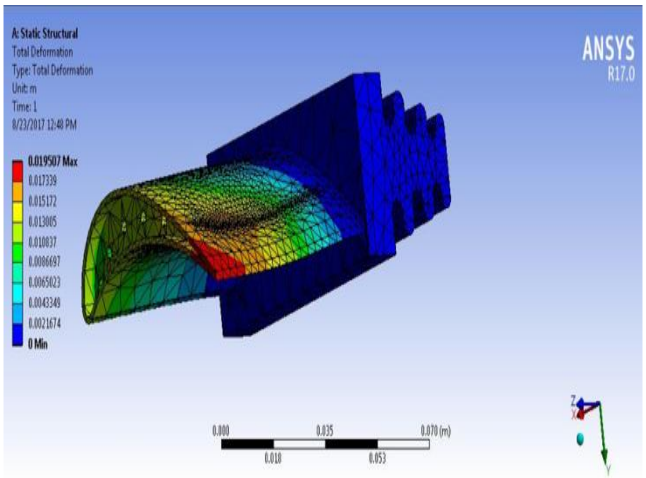

Figure 2: Total Deformation for ABS Turbine Blade

Mass of the Steel turbine blade is = 0.59529 kg
Mass of the ABS turbine blade is = 7.8867e-002 kg

We have taken the fly motor parameters for the outline of turbine sharp edge with a specific end goal to ascertain the geometric parameters that impact the turbine cutting edge profile they are driving edge span of 20mm, trailing edge sweep of 3.167mm, pivotal harmony 228.53mm, greatest thickness 59.63mm. Some streamlined parameters are
Absolute flow angle α = 37.40, Absolute velocity V1=462.21 m/s,

Whirl velocity Vw1= 367.18 m/s,
Flow Velocity Vf1= 353.386 m/s, Blade angle atS
inlet, θ = 47.300, Blade outlet angle=50.510, Gas inlet angle= 37.400, Gas outlet angle= 35.500.

V. CONCLUSION

In this task we are outlining plane motor turbine sharp edge by utilizing CATIA V5 R2 following required outline particulars and cutting edge edges. We looked at both steel and ABS plastic material Turbine cutting edges in ANSYS work Bench. We computed sharp edge proficiency is delicate to the thickness of the edge trailing edges, and different examinations of this impact show that the proportion trailing edge thickness/edge pitch is the noteworthy parameter against which misfortune in productivity might be corresponded. Added substance fabricated parts are utilized as a part of the avionic business for utilitarian parts including motor turbine cutting edges, fuel frameworks and guide vanes. The topological advancement of parts can enhance usefulness and decrease weight. Lighter parts can add to lighter airplane and diminish fuel utilization. To locate the best possible relationship between the outlines parameters are the essential destinations of the present work and applying added substance assembling to make the turbine sharp edge by 3 D printing innovation to get practical and light weight parts.

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