U20AE614 -ADDITIVE MANUFACTURING

UNIT I-INTRODUCTION

PART-A

1.Development Of Additive Manufacturing ?

Developing additive manufacturing systems involves conceptualizing requirements, designing hardware and software, selecting appropriate materials, prototyping, manufacturing, testing, optimizing, and deploying the system with ongoing support. Collaboration and staying updated on technological advances are crucial throughout the process.

2. Define the term layer based manufacturing**.**

Layer-based manufacturing, also known as rapid prototyping, is a set of techniques for rapidly fabricating a scale model of a physical part or assembly from three-dimensional CAD data by adding raw material in layers.

3.What is soft tooling ?

Soft tooling is a low-cost tooling process that enables manufacturers to produce medium to low numbers of parts at high speeds

4.What is the difference between model and prototype ?

S.No	**Model**	**Prototype**
1.	It is used for display and demonstration of product.	It is used for performance evaluation and further improvement of product.
2.	It contains only the exterior of the product.	It contains only the exterior of the product.
3.	It is cheap to manufacture.	It is cheap to manufacture.

5.Differentiate Between Direct And Indirect SLS System.

S.No	**Direct SLS System**	**Indirect SLS System**
1.	Direct SLS Processes Use Metal Powders Directly Without Any Binder.	Indirect SLS Involves The Use Of A Polymer Binder To Produce A Green Part.
2.	Direct SLS Eliminates The Need For Post-Processing.	Post-Processing Is Needed In Indirect SLS To Produce A High-Density Metal Part.

6. What Is Photopolymerization ?

Photopolymerization Is A Method Of Forming A Linear Or Cross-Linked Polymer Structure By Initiating A Polymerization Reaction With Light (Visible Or Ultraviolet).

7.Explain The Term Powder Bed Fusion Processes.

Direct Metal Laser Sintering (DMLS), Electron Beam Melting (EBM), Selective Heat Sintering (SHS), Selective Laser Melting (SLM), And Selective Laser Sintering (SLS) Are The Four Energy Sources Used In Powder Bed Fusion (PBF) (SLS).

8.Write A Short Note On STL File.

The STL File Is Derived From The Word Stereolithography. STL Files Are Generated From 3D-CAD Data Within The CAD System.

9. Write A Brief Note On STL File Resolution.

The STL File Is A Data Format File That Uses Connected Triangles To Construct A Solid Model's Surface Geometry. The Higher The Resolution, The Smaller The Triangles, Which Means That More Triangles Will Be Used To Construct The Surface Of The 3D Model, Which Will Show More Detail. A Low Resolution Will Result In Larger Triangles And Less Information On The Model's Surface. As A Result, Selecting The Right STL File Resolution Is Critical In Producing A Decent 3D Printed Object.

10. Define 3D Printer Technology Used In Additive Manufacturing.

In 3D Printing Technology, A Design Of An Object Is Created Using Software, And The Object Is Created By The 3D Printer By Adding Layer Upon Layer Of Material Until The Shape Of The Object Is Completed.

Part-B

1. Write A Descriptive Note Or Distinction Between Cnc And Am.

2. Why Is Additive Manufacturing Important? Also Classify Additive Manufacturing Systems.

3. What Are The Materials Used In Rapid Prototyping?

4. Discuss In Detail About The Problems Associated With STL Files Used In Additive Manufacturing.

5. With An Example, Discuss The Type Of Materials Available For Additive Manufacturing And Their Suitability In Product Development.

6. Describe The Steps Involved In Production Of Inserts Using The 3d Keltool Process With Neat Sketches.

7. Define Additive Manufacturing. Explain The Basic Methodology Involved In It. Also Explain Time Compression Engineering With The Help Of Block Diagram

8. Define Additive Manufacturing. Explain The Basic Methodology Involved In It. Also Explain Time Compression Engineering With The Help Of Block Diagram

9. Explain The Working Principle Of Directed Energy Deposition (Ded) Processes With Neat Sketch. What Are The Process Parameters Of DED ?

10.What is the Difference Between Model And Prototype

UNIT 2- REVERSE ENGINEERING AND CAD MODELING

PART-A

1. What Is Reverse Engineering?

   Reverse Engineering Is The Process Of Dissecting And Analyzing A Product, System, Or Technology To Understand Its Structure, Functionality, And Operation. This Is Typically Done By Taking The End Product And Working Backward Through The Steps Of Its Development To Uncover How It Was Created. Reverse Engineering Can Involve Techniques Such As Disassembly, Decompilation, And Analysis Of Code, Physical Examination Of Hardware Components, Or Even Examining A Finished Product To Understand Its Design And Manufacturing Processes. It's Often Used In Various Fields Such As Software Development, Engineering, Manufacturing, And Cybersecurity, Among Others, To Gain Insights Into Existing Products Or Systems For Purposes Like Emulation, Improvement, Or Security Assessment.

2.What Is Geometric Modeling?

Geometric Modeling Is The Creation And Manipulation Of Digital Representations Of Shapes And Objects. It's Used In Fields Like CAD, Computer Graphics, And Simulation To Design, Visualize, And Analyze Complex Structures.

3. What Is Model Reconstruction?

Model Reconstruction Involves The Process Of Creating Digital Representations Or Models Of Physical Objects Or Environments Using Techniques Such As 3D Scanning, Photogrammetry, Or Reverse Engineering. It's Used In Fields Like Archaeology, Architecture, Engineering, And Cultural Heritage Preservation To Capture And Recreate Real-World Objects Or Scenes In A Digital Format For Analysis, Visualization, Or Restoration Purposes.

4. What Is Additive Manufacturing?

Additive Manufacturing, Often Referred To As 3D Printing, Is A Manufacturing Process That Builds Objects Layer By Layer From Digital 3D Models. It Enables The Creation Of Complex Geometries And Customized Designs With Various Materials, Including Plastics, Metals, Ceramics, And Composites. Additive Manufacturing Is Used In Prototyping, Production Of End-Use Parts, And Rapid Manufacturing Across Industries Such As Aerospace, Automotive, Healthcare, And Consumer Goods.

5. What Is Data Processing?

Data Processing Is The Transformation Of Raw Data Into Useful Information Through Operations Like Collection, Manipulation, Analysis, And Interpretation.

6. Classify the Digitization Techniques

Data Digitization Techniques Include Scanning, OCR, Photography, Audio And Video Conversion, And Manual Data Entry, Enabling The Conversion Of Analog Information Into Digital Formats For Storage And Processing.

7.What Is Wire Frame Modeling?

Wireframe Modeling Is A Technique Used In Computer Graphics To Represent 3D Objects Using Only Their Skeletal Structure, Typically Composed Of Lines And Vertices. It Provides A Simple Visual Representation Of The Object's Geometric Form Without Surface Details Or Textures. Wireframe Models Are Often Used In The Initial Stages Of 3D Design And Visualization To Define The Basic Shape And Structure Of Objects Before Adding More Complex Surface Information.

8. Mention Few Data Formats

Common Data Formats Include CSV, JSON, XML, SQL, Parquet, And AVRO, Each Serving Specific Purposes Like Tabular Data, Structured Interchange, Database Management, And Big Data Processing.

9.What Is Data Interfacing?

Data Interfacing Is The Process Of Connecting And Exchanging Data Between Different Systems Or Components Through Apis, Middleware, Data Integration Platforms, Message Brokers, And Database Interfaces, Facilitating Seamless Communication And Interoperability.

10.Brief About Part Orientation?

Part Orientation Involves Positioning Components Optimally Within Manufacturing Processes To Ensure Efficient Production, High Quality, And Minimal Resource Usage. It Considers Factors Like Manufacturability, Mechanical Properties, Surface Finish, Support Structures, Assembly Requirements, And Material Usage.

PART-B

1. Explain about data formats and data interfacing.

2. What is part orientation? Explain with illustrations.

3. Explain the need of support generation with flow charts.

4. What are the steps involved in model slicing?

5. Discuss various aspects of tool path generation

6. Write a note on

a) Virtual prototyping

7. Explain the concept of reverse engineering?

8. Explain in detail data processing for RP.

9. Explain the geometric modeling techniques?

10. What are the techniques used in Tool path generation?

UNIT 3- LIQUID BASED AND SOLID BASED ADDITIVE MANUFACTURING SYSTEMS

PART-A

1. Why pre-build process is required in SLA?

   The pre-build process in Service Level Agreements (SLAs) is necessary to clarify requirements, align expectations, customize services, assess and mitigate risks, ensure quality assurance, and establish transparency and accountability. This process sets the foundation for a successful service relationship by ensuring both parties understand what will be delivered and how success will be measured within the agreement.

2. What is SLA?

   SLA is an abbreviation for Service Level Agreement, a contract between a service provider and a customer defining the level of service expected.

3. What are part-building steps in SLA?

   SLA part-building steps involve preparing the CAD file, resin vat, exposing layers with a UV laser, solidifying each layer, lowering the platform, and repeating until the part is complete. Post-processing follows printing.

4. What are the steps in post-build processes?

Post-build processes in SLA involve cleaning, support removal, curing, surface finishing, inspection, and final finishing to ensure the part meets specifications and quality standards.

5. What is photo polymerization in SLA?

Photopolymerization in SLA is the process where liquid resin solidifies into a solid object layer by layer using UV light exposure, initiating a chemical reaction in the resin.

6. What is the role of process planning in SLA"

Process planning in SLA involves optimizing print parameters, generating support structures, orienting the part for optimal printing, minimizing material waste, ensuring quality, and estimating costs.

7. What is SGC?

SGC could refer to Standard Generalized Markup Language (SGML), Stratified Gaussian Classifier (SGC) in machine learning, or Sociedade Ginástica de Porto Alegre (SGC), a club in Brazil.

8. What are the strengths of SGC? 9. What are the weaknesses of SGC?

Strengths of SGC:

- Effective for multiclass classification.

- Robust to noise.

- Interpretable results.

Weaknesses of SGC:

- Assumes Gaussian distribution.

- Sensitive to outliers.

- Computationally expensive.

- Requires feature independence, which may not always hold true.

10. What are the applications of SGC?

SGC (Stratified Gaussian Classifier) is applied in pattern recognition, image classification, medical diagnosis, natural language processing, financial forecasting, bioinformatics, and fault detection.

11. What is FDM

FDM stands for Fused Deposition Modeling. It's a popular 3D printing technology where a thermoplastic filament is heated and extruded through a nozzle layer by layer to create a three-dimensional object.

12. Brief the FDM process.

The FDM process involves loading thermoplastic filament into a 3D printer, heating it to melting point, extruding it through a nozzle layer by layer onto a build platform, and rapidly cooling and solidifying each layer to create the final object.

13. What are process variables in FDM?

Process variables in FDM include extrusion temperature, print speed, layer height, bed temperature, extrusion rate, cooling fan speed, and material properties. Adjusting these variables optimizes the printing process for desired results.

14. Mention the products of FDM? 15. What are the limitations of FDM?

Products made with FDM include prototypes, customized parts, functional components, architectural models, and medical models. Limitations include layer resolution, material constraints, support structure requirements, warping, and surface quality iss

15. What is LOM?

LOM stands for Laminated Object Manufacturing. It's an additive manufacturing technique where layers of material, typically paper or plastic film, are bonded together and cut to shape using a computer-controlled laser or knife. This process is repeated layer by layer until the final object is created.

PART-B

1. Explain the working principle of SLA

2. What are the part building and post building process involved in SL.A?

3. Explain the recoating issues in SLA?

4.Explain the working principle of SGC,

5. Brief about strength, Weakness and applications of SGC?

6. Explain the working principle of FDM.

7. Explain the process variables of FDM,

8. Explain the working principle of LOM. 9.

9.What are the steps in pre build and post-build process for LOM?

10. Compare the liquid based and solid based AM systems.

UNIT 4- POWDER BASED ADDITIVE MANUFACTURIN SYSTEMS

PART-A

1. What is LENS?

A lens is a transparent material that refracts light to focus it and create images. Lenses are essential in cameras, microscopes, telescopes, and eyeglasses, bending light to achieve specific functions like magnification and focusing.

2. What are the materials used in LENS?

The materials commonly used in lenses include optical glass, crystals, and plastics like CR-39 plastic, polycarbonate, high-index plastics (e.g., 1.67 high-index plastic), Trivex, and high-index glass. These materials offer various benefits such as impact resistance, lightweight design, thinness, optical quality, and UV protection, catering to different needs like safety glasses,

3. What is SLS?

SLS stands for Symbiosis Law School, which is a renowned institution in India known for providing quality legal education. SLS has campuses in various locations like Pune and Nagpur, offering programs like B.A./B.B.A. L.L.B. (Hons.) and hosting events like the Annual Meeting of the International Association of Law Schools. SLS is recognized for its commitment to academic excellence, professional ethics, and preparing students for successful legal careers.

4. What are the advantages and limitations of LENS?

Advantages of Lenses:

- Efficient light bending and focusing for sharp, clear images
- Lightweight and durable materials like silicon
- Temperature stability for consistent performance

Limitations of Lenses:

- Higher manufacturing costs for some materials like silicon
- Lower infrared transparency for certain lens types
- Complexity in designing complex lens shapes
- Susceptibility to scratches for plastic lenses
- Potential for chromatic aberration in high-index plastic lenses

5. What are the advantages and limitations of SLS?

Advantages of SLS:

- No need for support structures
- High productivity and fast printing
- Excellent mechanical properties
- Suitable for dyeing and coloring
- Reduces product development time

Limitations of SLS:

- Limited choice of materials
- Rough surface and porosity
- High shrink rate during cooling, affecting dimensional accuracy

6. What are the materials used in SLS?

1. Nylon/Polyamides (PA):

- Nylon 12 and Nylon 11 are the most common single-component nylon powders used in SLS.
- Nylon powders can also be reinforced with materials like glass fiber or carbon fiber

7. Brief the post processing types of SLS

Post-processing methods for parts produced using Selective Laser Sintering (SLS) include depowdering, sandblasting/bead blasting, dyeing, metallization, and other options like vibratory grinding, tub coloring, bonding, powder coating, and flocking. These methods are used to remove excess powder, improve surface finish, add color, enhance mechanical properties, and achieve specific aesthetic or functional requirements for SLS parts.

8. Why surface deviation occurs in SLS? 9. Why is accuracy important in SLS

The surface roughness in Selective Laser Sintering (SLS) is influenced by various process parameters like build orientation, laser power, layer thickness, beam speed, and hatch spacing. These parameters play a significant role in determining the surface quality of SLS parts. Studies have shown that laser power, layer thickness, and orientation are crucial factors affecting surface roughness in SLS, and empirical models have been developed to estimate and predict the surface roughness of parts produced through this additive manufacturing process.

10. What are the applications of SLS?

Selective Laser Sintering (SLS) finds applications in industries such as automotive, aerospace, medical, motorsports, consumer goods, rapid prototyping, manufacturing, tooling, and patterns. It is used for producing precision parts, prototypes, tools, and components with high accuracy and complexity, making it a versatile technology across various sectors.

11. Brief the post processing types of LENS.

The post-processing types of Laser Engineered Net Shaping (LENS) include annealing, heat treatment, and other forms of post-processing to enhance the properties of fabricated parts. These post-processing steps are crucial for improving the quality, durability, and functionality of LENS parts in various industries such as medical and aerospace

12. Why surface deviation occurs in LENS? 13. Why is accuracy important in LENS?

Surface deviation occurs due to imperfections in the shape of the lens surface compared to the intended shape. This can lead to aberrations and impact the lens' ability to focus light accurately.

14. What are the applications of LENS?

1. Corrective lenses: Lenses are used in eyeglasses and contact lenses to correct vision problems like nearsightedness, farsightedness, and astigmatism.3
2. Imaging systems: Lenses are used in cameras, telescopes, microscopes, and other imaging devices to focus light and produce clear, magnified images.23
3. Magnification: Lenses, such as in magnifying glasses, are used to magnify small objects so they can be seen in more detail.2
4. Solar energy concentration: Large lenses can be used to concentrate solar energy onto photovoltaic cells to harvest more energ

15. Why case studies are analyzed for sintering?

1. The first source discusses the role of the electronic configuration model of the condensed state in explaining the sintering behavior of various alloys, including copper base alloys, ferrous alloys, tungsten-based heavy alloys, and more1.
2. The second source presents a case study on briquetting and sintering, where various milling, mixing, and agglomeration options were investigated to identify the best technology and approach for processing feedstocks effectively2.
3. The third source focuses on the sintering of cermets, specifically sintering Ni-Co ferrite with dispersed alloy particles to enhance the mechanical properties of ceramics3.

PART-B

1. What is LENS? Explain the same.
2. What are the processing techniques used in LENS?
3. What is SLS? Explain the same.
4. What are the advantages and limitations of LENS? Explain with examples
5. Explain the applications of SLS and its processing techniques.
6. Brief the post processing types of LENS. Explain each with suitable example.
7. Explain the effect 1 of surface deviation in LENS?
8. What is indirect SLS and direct SLS. Explain the same.
9. Mention the post processing techniques of direct SLS.
10. Mention the post processing techniques of direct SLS.

UNIT5-OTHER ADDITIVE MANUFACTURING SYSTEMS

PART-A

1. Brief the material system of 3DP.

Answer

The material system of 3D printing (3DP) involves using various materials to create objects through additive manufacturing processes. Here is a brief overview of the material systems based on the provided sources:

- **Mortar**: 3D mortar printing (3DMP) is a real-scale additive manufacturing process that uses mortar as the material for 3D printing1.
- **Plastics**: Plastics are commonly used in 3D printing for prototyping, manufacturing, anatomical models, and more. Different plastic materials can be selected based on the specific application and 3D printing technology used2.
- **Metal Alloys**: Metal X 3D printers, like the Metal X system, can cost-effectively print parts using tool steel, stainless steel, inconel, and other metal alloys4.
- **Multi-Material Printing**: Multi-material 3D printing involves using more than one type of material within a single print. This technique allows for the creation of complex objects with different material properties in a single print

2. Brief solid, liquid and powder based system of 3DP.

Solid-Based 3DP Systems:

- Fused Deposition Modeling (FDM): This technique uses solid thermoplastic filaments that are melted and extruded to build up the 3D object layer-by-layer.12
- Laminated Object Manufacturing (LOM): This process involves cutting sheets of material (paper, plastic, or metal) to shape and laminating them together to form the 3D object.1

Liquid-Based 3DP Systems:

- Stereolithography (SLA): SLA uses a UV laser to selectively cure and solidify a

3. What is SDM"

SDM stands for Sub Divisional Magistrate. It is an administrative post responsible for overseeing legal and administrative duties at the sub-divisional level. An SDM may be a senior officer of State Civil Services with relevant work experience or a junior member of the Indian Administrative Service.

4. What is 3DP?

- 3DP Chip is a program that automatically detects and displays information about a computer's CPU, motherboard, video card, sound card, etc.124
- 3DP is a Facebook website that provides news, community, and downloads for 3DP Chip, 3DP Net, and 3DP Cleaner software.2
- All3DP is a leading magazine for 3D printing, additive manufacturing, 3D scanning, CAD, laser cutting, and related topics.

5. What is the principle of 3DP?

The principle of 3DP (3D printing) involves using powdered metal or plastic and other adhesive materials to construct objects layer by layer based on digital model files. This technology, also known as additive manufacturing, is a type of rapid prototyping technology that allows for the creation of objects without the need for traditional machining or molds. 3D printing works by spraying solid powder or molten liquid material to solidify into special flat layers, then stacking these layers to form 3D objects.

6. What are the strength and weakness of 3DP?

Strengths of 3D Printing (3DP)

- Enables complex shapes and structures not possible with traditional methods
- Allows for rapid prototyping, reducing time and cost
- Less wasteful compared to subtractive manufacturing
- Potential to significantly reduce manufacturing costs

Weaknesses of 3D Printing (3DP)

- Rough surface texture of printed parts
- Low heat deflection and strength of 3D printing materials
- High material prices limiting market growth
- Lower part density and durability compared to other manufacturing processes
- Challenging design process and complex software toolchain

7.What are the applications of 3DP?

Medical Applications

- Surgical planning and education
- Patient-specific anatomical models
- Implants and prosthetics
- Bioprinting for research and drug testing

Pharmaceutical Applications

- Customized drug formulations
- Unique dosage forms
- Controlled drug delivery systems

Other Applications

- Rapid prototyping and product design
- Manufacturing complex parts
- Electronic skin development

8. What is BPM? 9. What is EBM?

BPM (Beats Per Minute): Measure of tempo in music, indicating beats per minute.**EBM (Electronic Body Music):** Genre of electronic music blending industrial, synth-punk, and dance elements. Emerged in the 1980s with repetitive basslines and programmed rhythms.

10. What is SLM!

Based on the provided search results, SLM stands for Selective Laser Melting, which is a metal additive manufacturing technology:

- Selective laser melting (SLM) is a metal 3D printing process that uses a high-power laser to melt and fuse metallic powders together layer-by-layer to create complex 3D objects.12
- SLM is one of the proprietary names for this powder bed fusion additive manufacturing technology, which is also known as direct metal laser sintering (DMLS).1
- The SLM process fully melts the metal powder into a solid, dense part, unlike selective laser sintering (SLS) which is a true sintering process.

11. Brief the physics of 3DP.

Physics of 3D Printing (3DP)

- **Layered Fabrication**: Objects built layer by layer.
- **Material Deposition**: Material deposited and solidified/fused.
- **Computer-Aided Design (CAD)**: Digital models sliced and printed.
- **Multiscale Physics**: Understanding material behavior at different scales.
- **Emerging Techniques**: 4D printing, intelligent materials introduce new complexities.

12. What are the types of 3DP?

Types of 3D Printing (3DP)

1. Stereolithography (SLA)
2. Liquid Crystal Display (LCD)
3. Digital Light Processing (DLP)
4. Selective Laser Sintering (SLS)
5. Selective Laser Melting (SLM)
6. Electron Beam Melting (EBM)
7. Material Jetting (MJ)
8. Drop-On-Demand (DOD)
9. Binder Jetting (BJ)
10. Multi Jet Fusion (MJF)

13. Brief the process capabilities of 3DP.

Key Process Capabilities of 3D Printing (3DP)

1. Dimensional Accuracy: Varies across different 3DP technologies.
2. Material Flexibility: Wide range of solid, liquid, and powder-based materials.
3. Design Freedom: Enables complex geometries and internal features.
4. Rapid Prototyping: Faster product development and testing.
5. On-Demand Manufacturing: Reduced need for supply chains and inventory.

6. Sustainability: Potential for reduced material waste and localized production.
7. Customization: Easy digital customization of parts and products.

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14. What are the applications of EDMY

The applications of Electrical Discharge Machining (EDM) include:

1. **Small Hole Drilling**: EDM is particularly useful for drilling small holes in materials, regardless of their hardness, and can create holes on inclined faces and other challenging positions.
2. **Mold and Die Making**: EDM is widely used in the production of molds and dies, especially those with complex shapes and internal features, due to its ability to achieve high precision and fine surface finish.
3. **Components Disintegration**: EDM can be used to disintegrate components into smaller parts, which is useful in various industries such as aerospace and

15. What are the applications of SDM?

Software-Defined Wide Area Networks (SD-WANs) offer better control at lower cost and ultimately give network managers the ability to configure and deploy branch offices quickly and easily. SD-WANs allow you to manage your entire WAN centrally in the cloud even if your enterprise is spread across many different locations around the world.

PART-B

1. Explain the working principle of 3DP
2. Compare solid, liquid and powder based system of 3DP.
3. Explain the working principle of SDM
4. Explain Ballistic Particle Manufacturing (BPM)
5. Discuss few case studies of 3DP.
6. Explain Electron Beam Melting.
7. Differentiate between SDM and EBM.
8. Brief the post processing in SDM.
9. Brief the post processing in EBM.
10. (a) Explain the advantages of SLM and EBM.

(b)Brief the pre and post processing in BPM