**Course outline for Additive Manufacturing Process**

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**Course description**

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| **Course Title** | **A beginner’s guide to Additive Manufacturing Process** |
| **Course objective** | **This Additive manufacturing course seeks to provide students with information and abilities for designing, constructing, and analysing items using 3D printing and other additive manufacturing technologies. This entails comprehending diverse procedures, materials, design principles.** |
| **Course outcome** | **On completing this course, the learner will be able to**   * **have a comprehensive understanding of additive manufacturing** * **where it is used** * **how it used** * **what materials are used** * **the different types of additive manufacturing** * **Vat polymerization and its uses** * **Powder bed fusion and its uses** * **Binder jetting and its uses** * **They would also have an exercise to assess themselves on these topics.** |

**ADDITIVE MANUFACTURING PROCESS**

1. **What is it?**

**Imagine a beautiful house that is printed and not built. Does that sound unimaginable as well as interesting? Additive manufacturing is all about building homes and making objects with 3D printing technology, and it prints or to be precise, builds three-dimensional products.**

**Think about a machine that works like a construction worker who works hard on pasting the brick and cement together but multiple times faster and efficient. It would not only reduce the amount of danger while building but also the years taken to complete a project.**

**There are three processes in additive manufacturing,**

* **Liquid based**

**Liquid additive manufacturing (LAM) is a 3D printing process that creates items out of liquid materials such as photocurable resins or liquid silicone rubber. These liquids are applied to a building surface and subsequently cured or hardened by light, heat, or a mixture of both. This technique assembles the thing layer by layer, resulting in detailed shapes.**

* **Solid based**

**Solid-based additive manufacturing (AM) is a 3D printing method that uses solid materials to construct items layer by layer. Unlike liquid-based methods, solid-based additive manufacturing focuses on depositing or fusing solid materials such as plastics or metals to build a functional object. Solid-based additive manufacturing has a significant advantage over traditional subtractive manufacturing processes in terms of producing complicated geometries and reducing material waste.**

* **Powder based**

**Powder-based additive manufacturing (AM) is the method of layering a powdered material to create 3D objects. This is accomplished by either fusing the powder with heat (as in powder bed fusion) or adding a binding agent to the powder.**

1. **What are the materials used?**

**In the previous topic, we had learnt about the various process involved in additive manufacturing. Have you ever wondered what kinds of materials are used and their properties? It is important to know them as to understand how to use it.**

**Materials**

* ***Thermoplastic polymers***

**Thermoplastic polymers are melted and extruded layer by layer to produce objects. Some of the commonly used are Acrylonitrile Butadiene Styrene (ABS),**

**Poly-lactic acid (PLA), Polycarbonate (PC).**

* ***Metals***

**Metal additive manufacturing is utilized in a variety of industries, including aerospace, medical, and tooling, to produce engine components, medical implants, and tooling. Precious metals like gold or silver, strategic metals like Titanium or stainless steel are used.**

* ***Ceramics***

**Creating ceramic objects using additive manufacturing is better than the traditional way of making it as it helps in minimizing material waste, lowering tooling costs, and reducing lead times.**

**The materials that are used are zirconia, alumina and tri-calcium phosphate.**

* ***Biochemical materials***

**The use of hardened materials of silicone, calcium phosphate and zinc.**

**HOW IS IT PROCESSED?**

**Additive manufacturing involves a structured process. Let’s learn them from the initial process to the physical product being made.**

1. **CAD**

**First and foremost, CAD, or Computer-Aided Design, is the planning step of additive manufacturing, particularly 3D printing, since it enables designers to produce 3D models that are subsequently utilized as instructions for producing tangible products. The procedure entails producing a computer model, translating it to a machine-readable format (such as STL), and then layering the object using a 3D printer. Just like any other project or work needs planning before starting physically working, additive manufacturing also demands virtual planning. Through this process, one can visualize the end result or make changes s to how it needs to be virtually and by this they can save ample amount of time thinking and wondering if it would come out perfect.**

* **CAD software is utilized to generate three-dimensional models of the intended object.**
* **This can include techniques such as drawing, sculpting, and parametric modelling.**
* **Examples of CAD software include SolidWorks, AutoCAD, and PTC Creo.**

1. **STL conversion**

**A critical step in additive manufacturing procedures like 3D printing is converting a 3D model to STL (Stereolithography) format. This conversion entails creating a triangular mesh from the geometric data in the 3D model. The STL file format is compatible with all AA machines. This file serves as the foundation for the slices' calculation and describes the external closed surfaces of the original CAD model.**

1. **To AM machine and STL file manipulation**

**It is necessary to move the STL file that describes the part to the AM machine so that it can be generally altered to the proper size, position, and orientation.**

1. **Set the AM machine**

**For AM Machine to do its work, it has to be set up well. For example. We set the timer and the heat for a microwave to cook the food at the right temperature and for the right time. Any incorrect settings would end in malfunctioning of the oven. The same way, an AM machine needs a proper setting to do its work properly.**

**For an AM machine, the parameters are, material constraints, layer thickness, energy source and timings.**

1. **Build and supervise**

**Now, the machine is all set to build the product. Meanwhile, it is important to supervise if the process is being carried out in the right and a smooth way.**

**The main things to notice while supervising is if the machine runs out of material or power, and also if there are any software glitches.**

1. **Removal and post-processing**

**When the machine successfully had performed the task, the supervisor needs to remove it and clean it for further use.**

**Types of additive manufacturing**

1. **VAT POLYMERIZATION**

**• What is it?**

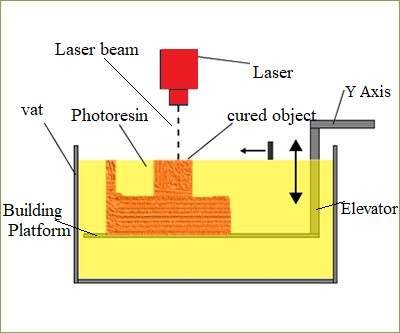
**This additive manufacturing method uses light-activated polymerization to selectively cure liquid photopolymer in a VAT.**

**• How is it used?**

**This approach involves keeping liquid photopolymer resin in a container. The resin is exposed to ultraviolet radiation in order to harden it where necessary. After every new layer is healed, the platform also descends.**

**• How does it work?**

**Let’s get a better understanding of how it works.** **Look at the labelled image carefully.**

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***Diagram of VAT polymerization process***

**First, in the diagram, the *liquid photopolymer resin*, the yellow liquid in the picture is added in the container. Next, the resin is cured layer by layer using a laser or UV light, the *laser beam* in the picture focuses on the yellow liquid. The brown part is the cured object that is created based in the design given. The platform keeps declining through the *elevator*, with new layers forming on top of the earlier ones. After the process the vat is drained of resin and is the product is removed.**

1. **POWDER BED FUSION**

**•** **What is it?**

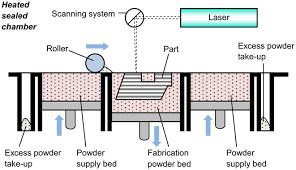
**An additive manufacturing process in which thermal energy selectively fuses certain parts of powder bed to create the desired product.**

**• How is it used?**

**In powder bed fusion, the metal powder is spread across the build platform, and the fuse material powder is melted together to create the desired three-dimensional shape by a laser or electron beam from the source.**

**• How does it work?**

**Look at the labelled image carefully.**

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**The build platform is covered with a powdered coating, in the illustration diagram the red particles are the powdered coating.**

**The provided model or shape's initial layer is fused using a laser or ultraviolet light that falls from the top from a blue machine called laser**

**Using a roller, another layer of powder is spread while the powder supply bed is elevated.**

**The same procedure is being carried out, adding and combining.**

**Until the complete model is being generated, it is repeated. The excess loose powder that hasn't been processed will be discarded and cleaned after the post-processing step.**

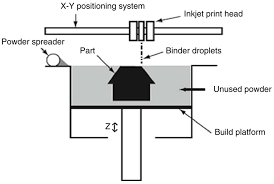
1. **BINDER JETTING**

**• What is it and how is it used?**

**It is an additive manufacturing process where prior to the raw material being deposited onto a powder bed, the binder material is jetted. The necessary component is created or printed by selectively spraying the binder on the raw material, which is deposited one layer at a time.**

**• How does it work?**

**Look at the given illustration carefully.**

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**With this technique, a *powder spreader* is used to spread powder material over the build platform, and the print head applies the *binder droplets*. The *build platform* is then lowered by the thickness of the model's layer, and new powder is applied, and so on, until the desired result is achieved.**

**TEST YOUR KNOWLEDGE**

**Fill in the blanks**

1. **\_\_\_\_\_\_\_\_\_\_ software includes techniques such as drawing, sculpting, and parametric modelling.**
2. **With \_\_\_\_\_\_\_\_\_\_ technique, a roller is used to spread powder material over the build platform, and the print head applies the binder adhesive**
3. **The thickness of the layer lowers the constructed platform from the top of the resin vat below. Next, the resin is cured layer by layer using a \_\_\_\_\_\_\_\_\_\_.**
4. **It is necessary to move the \_\_\_\_\_\_\_\_\_ that describes the part to the AM machine so that it can be generally altered to the proper size, position, and orientation.**
5. **There are three processes in additive manufacturing, \_\_\_\_\_\_\_\_\_,\_\_\_\_\_\_\_\_\_,\_\_\_\_\_\_\_\_\_.**