UNIT-5- ADDITIVE MANUFACTURING APPLICATIONS

Additive Manufacturing in Medical Applications

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Additive manufacturing - production processes, benefits and materials

To get an overview of additive manufacturing applications within the medical sector, it is necessary to understand how the 3D printing process works. Additive manufacturing differs from other manufacturing methods. The material is not cast, as it would be in the manufacture of injection molded parts, or cut from a larger block, as is the case with CNC machining.

As the term "additive" suggests, the material is *added* layer-by-layer. Even if the individual additive methods differ in the precise process and materials, the process of layered production is still the same. This enables more freedom for part design and possible geometries compared to other processes.

Since its early days, 3D printing has seen a great deal of differentiation, with a number of manufacturing processes that vary greatly. The most important manufacturing processes used in the production of medical products today are direct metal laser sintering and stereo lithography

Direct metal laser sintering (DMLS)

In principle, the procedure for printing DMLS parts differs only slightly from other methods of additive manufacturing. Support structures dissipate the heat generated during the process and ensure stability of the components. Without support structures there would be a risk of wiping away new material during the printing process.

DMLS uses a computer-controlled, high-power laser beam to melt and fuse layers of metallic powder together. This melting and fusing process is done layer-by-layer, to finally produce a solid, finished component.

Once completed, the component is released from its support structures and the excess metal powder is post-processed depending on its application. A large number of metals are suitable for production using DMLS including titanium alloys, which are important for medicine, for example in the production of bone implants.

1.2 Stereo lithography

Stereo lithography is comparable to other additive manufacturing methods. It prints polymers and plastics with complex geometries or very small structures that require a particular rigidity, impact resistance or durability.

As with DMLS, it uses a laser to do the actual printing. Unlike DMLS, however, the raw material is not in powder form, but rather a resin consisting of photopolymers and additives. An ultraviolet laser hardens this resin into a thermosetting plastic. The build platform is lowered at each stage, ensuring that a new layer of resin covers the component, which is then hardened into the required shape by the laser.

After the part is produced, the remaining resin is cleaned off in post-processing and the support structures are removed. Finally, the parts undergo a UV-curing cycle to fully solidify the outer surface of the part.

. **3D Printed Implants**

Currently implants are the most extensively produced 3D printed parts in the medical industry. They offer a whole range of advantages, particularly when it comes to the replacement of bone material. These parts are printed using CAD files, often generated using medical imaging techniques.

Applications of 3D printed Implants

Since implants are usually custom-made products for a well-defined purpose, additive manufacturing is ideal, due to its ability to produce unique items quickly and cost effectively. Until recently these types of implants would usually have been mass-produced and then adapted for the patient, often by the surgeon.

It can make simple parts such as femur implants or hip bones tailored to the individual patient, figure joints, bones and jawbones, as well as complex implants such as orbital implants, cranial bones and thoracic implants. And implanting/attachment of artificial teeth is now a standard application for 3D printing.

Due to 3D printing's comparatively fast manufacturing times and the possibility of on-demand production (i.e. implants as and when they are needed), the medical sector is increasingly recognizing the benefits of this technology and is using it for both standard implants, such as individual vertebrae in the spine as well as more customized options.

Advantages of 3D Printed implants

The benefits of 3D printing in medicine are similar to those of more industrial sectors. First, there's the wide range of possibilities that 3D printing opens up when designing individual implants. Other manufacturing processes simply cannot create the geometries and shapes that are possible with 3D printing and are therefore less suitable for use. The flexibility additive manufacturing allows in the manufacturing process, also enables the integration of lattice and sponge structures that can drastically improve biocompatibility of implants, helping improve their ability to integrate with endogenous material.

For hospitals and health insurers, there is the advantage that individual specialised implants are more cost-effective than those produced using conventional methods. Other manufacturing processes require significant investment in special tools and equipment geared in each case to the individual implant. In 3D printing, these additional costs are eliminated due to the more flexible manufacturing process. Special implants produced using additive manufacturing do not have to be expensively reworked.

Materials and Legal Requirements for 3D-Printed Implants

By manufacturing parts using DMLS, implants can be printed directly from a material that is suitable for medicine. For implants such as hip bones or orbital implants, in most cases Ti6Al4V is used - an alloy that's main component is titanium. This alloy is characterised by its high-biocompatibility and enormous strength and stability, whilst being comparatively light. Another material used in medical 3D printing is stainless steel 316L.

In contrast, when producing standard implants by milling or casting, the materials used have poorer biocompatibility ratings, which mean that in addition to production they need the addition of a titanium coating.

Implant production must observe legal regulations, especially in regard to the selection of materials. For Ti6Al4V, legal requirements include ISO 5832-3, ASTM F1472 and ASTM B348, which classify the material and chemical components as suitable for use in medicine. Special implants require no CE certification. Ultimately, the responsibility and decision as to whether and how an implant is suitable for use on a patient, rests with the relevant doctor. Another advantage of 3D printing in this area is that many of the materials are familiar to the medical industry. The strict standards and regulations that these materials must meet are not affected by 3D printing. Thus, there is nothing to prevent them from the medical industry using them after the additive manufacturing process.