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3D printing – A review of processes, materials and applications in industry 4.0

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ABSTRACT

3D printing, unlike other manufacturing processes, being an additive process has emerged as a viable technology for the production of engineering components. The aspects associated with 3D printing such as less material wastage, ease of manufacturing, less human involvement, very less post processing and energy efficiency makes the process sustainable for industrial use. The paper discusses numerous 3D printing processes, their advantages and disadvantages. A comprehensive description of different materials compatible for each type of 3D printing process is presented. The paper also presents the various application areas of each type of process. A dedicated section on industry 4.0 has also been included. The literature studied revealed that although the field of 3D printing has evolved to a great extent, there are still issues that need to be addressed such as material incompatibility and the cost of the materials. Future research could be undertaken to develop and modify the processes to suit a broad range of materials. To broaden the range of applications for 3D printed parts, more focus needs to be laid on developing cost effective printer technologies and materials compatible for these printers.

1. Introduction

The very basic question that comes to our mind regarding the field of manufacturing is that how do we make stuff or how do we proceed from materials into something that we want to use, buy or consume in any way. The first way to make something is subtractive manufacturing- where we begin from raw material and proceed towards the desired product. Then the next type of manufacturing is called forming- in which a block of material undergoes changes into its dimensions when force is applied. The third type of technology of making things is casting- where the material in solid form is melted into liquid form, the liquid metal is then poured into a specific mold to obtain the object. The fourth way of manufacturing is Additive manufacturing (AM) wherein the parts are developed additively layer by layer [54,56]. AM and 3D printing are umbrella words that cover a wide range of processes for creating three-dimensional prototypes and structures from digital files. The solid modelling component of Computer-Aided Design is the basis for additive technologies. This solid modelling data is used by additive models to create layers of extremely thin cross-sectional areas, which entitle manufacturing of intricate and complex shapes and surfaces that are very difficult to achieve by using conventional methods [1].

One will conclude a machine as a 3D printer if it comprises the three properties that are, three-dimensional, additive, and layer-based. An additive process is adding different substances to make the desired substance. Let's say if we want to bake cupcakes, we take an empty bowl and add ingredients, one by one until we get the finished batter, this is an additive way to make it. Another way to make a cupcake is, we can buy a big cake and cut away everything to give it the shape of a cupcake. This is a subtractive process, wherever we tend to begin from a bigger part and take away everything that's not needed. Examples of subtractive manufacturing would be manual wood carving, CNC machining or laser cutting, etc.

In 3D printing, which is basically an additive manufacturing process, we start with the fundamental design of the part we want to model [55]. The said design is created on a computer software that is attachable to 3D printers. This software then generates a special type of file to be sent to the printer. The 3D printer reads that file and creates the product by adjoining one layer over the other [22]. Almost every process in 3D printing uses layers to form a part. 3D printers read the parts as a single two-dimensional layer at a time rather than a whole single part. The working of 3D printers as shown in Fig. 1 is based on the fact that they are designed to read Standard Tessellation Language (STL) file type.

The sustainable aspects of 3D Printing such as less material wastage, less post processing and very less cost even for manufacturing complex parts makes 3D Printing a technology of the future. The other sustainable aspects include the potential of 3D printing to reuse plastics, recycle and reduce emissions. The technology is also capable of producing designs with complex and optimized geometries, which help in developing

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