International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 8 | August 2022 www.irjet.net p-ISSN: 2395-0072

An Overview of Additive Manufacturing Technology, its Materials, Applications and Implementation of IoT & Embedded System

Bhushan S. Kumbhar[1], Rushikesh S. Kokane[2], Samruddhi S. Patil[3], Shreya S. Chaugule[4], Shubham R. Kulkarni[5], Saurabh S. Kadam[6]

[1, 2]Mechanical Engineering student at Sharad Institute of Technology College of Engineering, Yadrav, Maharashtra, India
[3]Electronics and Telecommunication Engineering Student Sanjay Ghodawat University Kolhapur, Maharashtra, India
[4]Electronics and Telecommunication Engineering Student at Walchand College of Engineering, Sangli, Maharashtra, India
[5, 6]Instrumentation Engineering Student at Padm. Vasantraodada Patil Institute of Technology, Sangli (Budhgaon), Maharashtra, India

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Abstract - *In this modern era, the additive manufacturing technique 3D printing is expanding day by day and playing a significant role in the manufacturing industry. The utilization of additive manufacturing 3D printing is very broad as they are being used in the Aerospace industry, Automotive industry, Food industry, Healthcare and medical industry, Architecture, building, and construction industry, Fabric and Fashion Industry, Electric and Electronic Industry. This paper demonstrates how 3D printing is being used with different types of materials in various fields of manufacturing such as ABS, PLA, PVA and PC. As the various types of material used in 3D printing for different applications, it is required that the 3D printed product should be superior and better than other products that are manufactured form other production technique. So it is mentioned what type of composite materials are utilized in 3D printing and how they are useful to add more value than other materials. Composite materials are created and utilized in a broad range of applications in additive manufacturing 3d printing to increase material strength and other features such as stiffness, impact strength, durability, temperature resistivity, chemical resistivity, insulating property, elasticity, and so on. To advance the process of additive manufacturing 3D printing it is enabled with the Internet of Thing that it makes the process more efficient and make it ease to operate. The IoT thing made possible to print the prototype wireless on the network. The advanced system also used to scan the product make it as actual by 3D printing. In 3D scanning, an object is scanned, transformed to a cad file, and then 3D printed by converting it to a STL file. The main purpose of this article is to demonstrate how 3D printing technology may be used in conjunction with other advanced technologies such as composite materials, the Internet of Things (IoT), and 3D scanning that may bring manufacturing industry at next level in the future.*

Key Words: 3D Printing, Materials, Composite material, 3D scanning, 3D printing applications, IoT, etc.

1. INTRODUCTION

The principle of 3D printing was first sketched forth by David E. H. Jones in 1974. Chuck Hall of the 3D Growth In the organization filed his own invention in 1984. Objects are created by printing layers of a specific layer on top of one another till the whole object is formed [1]. In latest years, additive manufacturing (AM) has emerged as a viable manufacturing option. 3D printing is also known as additive manufacturing, provides for more manufacturing options because it can manufacture complicated geometric shapes using software applications [2]. An object is built in an additive manufacturing process by laying down the material until the component is complete. Some of these layers can be regarded as a horizontally cross-section of the finished product, thinly sliced. Stereo lithography (SLA), laser sintering (SLS), and fused deposition manufacturing are the technology used in ALM (FDM). The filament is a string of composite mass used in the FDM printing process. This filament is routed from a spool attached to the 3D printer to a heated nozzle that melts the material within the 3D printer. Once the material has melted, it can be extruded along a precise and predefined path created by computer programs [3]. IoT and embedded electronics are now becoming highly popular as a result of their numerous applications in residential, industrial, and industrial sites. Since of developments in portable devices, integrated and ubiquitous communication devices, cloud computing services, and data analysis techniques, the term IoT (Internet of Things) has recently become more relevant to the actual world. The Internet of Things (IoT) is a term that refers to the ability to communicate about everything in our environment. Machine-to-machine communication, wireless sensor networks, sensor networks, 2G/3G/4G, GSM, GPRS, RFID, WIFI, GPS, microcontrollers, and microprocessors are all examples.[4] In a virtual world with precise dimensions, 3D scanning digitally recreates information about physical elements. When something comes to measuring goods in 3D, there are a few methods. Laser scanners, light scanners,

coordinate measurement machines (CMMs), and commercial computed tomography (CT) scanners are all part of this category. 3D scanning technology gather raw data in the form of point clouds and transform it into user-friendly formats such as CAD models [3]. In traditional manufacturing, a strategy for dealing with enormous amounts of difficult and high-dimensional data was established. The Gray-Level Co-occurrence Matrix (GLCM) and selected Haralick features were used to offer a method for real-time observation of the status of the 3D printing process. The method was demonstrated using images produced by scanning the 3D printed plates [2].

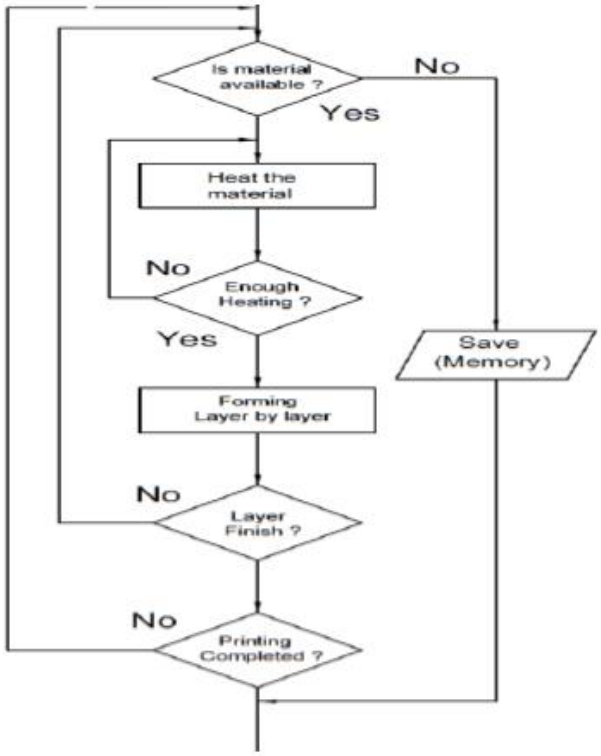

Fig -1: Flow chart of 3d printer operation [1]

2. APPLICATION WISE 3D PRINTING MATERIALS

In the early 1980s, the first publicized observations of 3D printing were made in Japan. Hideo Kodama set out to create a rapid prototyping system in 1981. He invented a layer-by-layer manufacturing method based on a photographic film epoxy that was modified by UV light [5]. The most widely used FDM 3D printing materials are ABS, PLA, PVA, PC and various contaminants. 3d printing technology build objects or products out of powdered materials. Within the printer, the powders are melted and spread in layers until the preferred depth and structure are reached. In printers, a variety of powders are used, and the most popular are Polyamide (Nylon), Alumide. Typically, 1.75mm or 3mm diameter filament is used for 3D printing. This material comes in the form of wire, which is fed into the extruder by a motor. [1]. Ceramic, metallic, polymers, and their combinations in the form of hybrid, composites, or essentially classified materials can all be printed as fully operational parts using 3D printing technology (FGMs).highly developed FDM printers can print specialized materials with better heat resistance, impact resistance, chemical resistance, and rigidity.[6] 3D scanning is used in production for a long period. To reach quality standards for all parts, industries required dimensional measurements [7]. There are indeed a variety of industries in which we can implement this technology, including Aerospace industry, Automotive industry, Food industry, Healthcare and medical industry, Architecture, building, and construction industry, Fabric and Fashion Industry, Electric and Electronic Industry [6]. Elevated seamless plaster molds of aerospace design are developed using SLA and material jetting. Our automotive manufacturers are rapidly developing, and new innovations are emerging from the industry. 3D technology can also be used in medical science for printing skin bones, drug organ, medical equipment, and tissues [1]. Today's world, a 3D printer can establish any complicated jewellery design while also removing a few steps from conventional method. Food products could be printed utilizing semisolid, powder, and viscous liquid food products using a 3D printer. Food manufacturing with even to cartridges has a long lifespan and a controlled amount of nutrients, making it a great choice for providing astronauts with fresh food [5]. 3D printing technology is an ecofriendly derivative that provides infinite geometric sophistication moment of realization possibilities. 3D printing technology could be used to print entire houses or create construction elements in the construction sector. Building Information Modeling (BIM) will help 3D printing technology be using it efficiently. Different 3D printing technologies are now commonly used for structural electronic equipment such as active electronic materials, electrodes, and devices with customized products and flexible design by embedding conductors into 3D printed equipment [6].

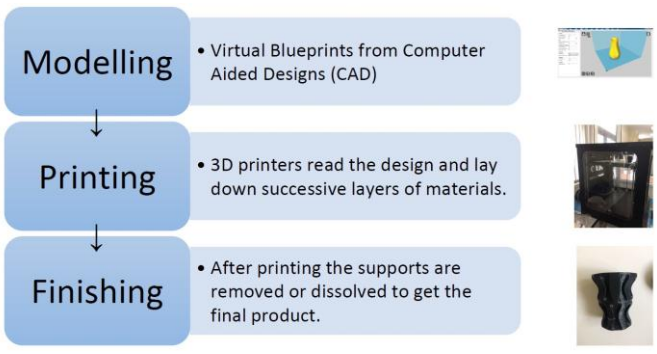

Fig -2: Three major steps involved in 3D printing [16]

3. COMPOSITE MATERIALS AND ITS APPLICATIONS

Composite materials are created and utilized in a broad range of applications in additive manufacturing 3d printing to increase material strength and other features such as stiffness, impact strength, durability, temperature resistivity,

chemical resistivity, insulating property, elasticity, and so on. Composite materials are mostly employed in areas that require significant strength and stiffness while also being lightweight. The lack of advanced polymer materials and Nano composites to meet all of the criteria is the significant issue in AM. As a result, many organizations have concentrated their research efforts on inventing new high-performance materials, increasing the efficiency and speed of the process, and expanding the range of qualities and applications [8]. There are several methods of AM such as fused deposition modelling (FDM), directed energy deposition (DED), selective laser sintering (SLS) are using thermoplastic composite materials. Because FDM has been utilized to make polymer-based fibre composites, adding fibre to the thermoplastic matrix increases modulus, tensile strength, and bending strength when compared to the pure thermoplastic material [9]. Carbon fibre composites are lightweight, high-strength manufactured materials that may be up to ten times stronger than steel and eight times stronger than aluminium while only a fraction of the weight [10].

The use of composite materials is not restricted to industrial applications; they are also being utilized sensibly in medical applications to produce tailored equipment for a specific patient or to develop a new organ or any part of the body with tissues to give the patient new life and appearance. Basically, the desired human object is scanned using 3D scanning technology, then it is converted into a 3D cad file, modified as per requirements, and manufactured using additive manufacturing 3D printing technology. 3-D scanning is used for data gathering and analysis of an object's present 3-D shape, and it may be utilized for things like 3-D vision and modelling, cloud- to-cad comparisons, prototyping, architectural data demands, and digital archival. The polymers that are presently utilized in 3D printing are polycarbonate (PC), nylon, thermoplastic Polyurethane (TPU), chlorinated polyethylene (CPE), acrylonitrile butadiene styrene (ABS), and polylactic acid (PLA). Except for PLA, all of the polymers described are expensive and difficult to breakdown from fossil base materials [11]. The use of 3D printing technology is becoming more prevalent in a variety of sectors. 3d printing has been utilized in the pharmaceutical industry to create tailored medications, oral dosage forms, medicinal devices, and tissue engineering [12]. Polycaprolactone (PCL) is a biocompatible polyester that has been utilized in wound dressings, tissue engineering, and drug delivery, resulting in the FDA approval of many PCL drug delivery devices [12]. Another technology in additive manufacturing 3D printing is now immerging and being used with great efficiency that is 3D printing with nanoclay. Nanoclay can increase the dimensional flexibility of polypropylene filaments and minimize the deformation of 3D models [11].

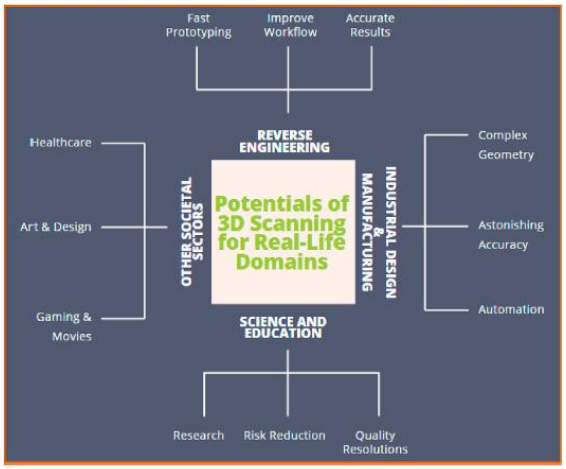

Fig -3: Capabilities of 3D scanning for Various Industrial Spheres [7].

4. IMPLEMENTATION OF IOT & EMBEDDED SYSTEM IN 3D PRINTER

IoT and Embedded system electronics is getting more and more popular due to its versatile applications. However the electronics or electrical system that were built earlier requires some enclosure to protect it from environment and some other concerns. Authors have done the demonstration of the project and documentation related to rapid prototype for making it customized IoT sensor step by step .This will help to summarize the strengths and weaknesses faced in this technology. Now a days existing technologies are getting replaced by new technology. Also the traditional technologies are effective and efficient while additive technology is added that can be adapted without major changes in the structure. People now consider this additive technology as their small businesses but as for IoT sensored project we need to protect the electronic product in case of hardware and also need to add the asthetics to the prototype. Hence through modelling the FDM technology like 3D printing we can print the case according to the selected assembly and the placements of the components. As this technology is ideal for rapid prototyping of custom packages it is elaborated that as compared to low cost capitals foe 3D printers this technology is most beneficial for mass production [13]. Additive manufacturing technology like 3 printer often has potential to accelerate innovation, compress supply chain, minimize material and energy usage and reduce waste. This was originally developed at Massachusetts Institute of Technology in 1993. 3D printing technology forms the basis of Z Corporation's prototyping process. 3D Printing technology is a technology is a technology that makes use of liquid blinder to create 3D physical prototype of solidified layer of deposited powder. 3D printer printing process has shown a versatility and rapidness in adapting the geometry due to varying complexity in hundreds of different applications, and supporting many types of materials. Z Corp.

Has helped to develop the commercial use of 3D Printer technology and evolved 3D printers to lead the manufacturers use to produce early concept models and product prototypes. Use of 3D Printer technology and Z Corp. has developed 3D printers that operate at unknown speeds, extremely low costs, and within a broad range of applications [14]. 3D printers can be built up by using raspberry pi to print the things remotely. Turn your printer off and on then check the status of the prints, and watch your prints with a live video feed and more. 3D printing technology is a processes of joining and then solidifying the material under the control of computer to create 3 dimensional object. Object designs may have complex shapes or geometrical errors and are produced from a digital 3D model or a CAD file. Then it is necessary to convert a CAD model into an STL file. Then there comes the slicer program that takes the STL file and convert it into G-code. G-code is nothing but the numerical control (NC) programming language. The IoT based octoprint system provides a web interface for controlling 3D printers and allows the users to start printing job by sending G-code to 3D printer connected via USB. Raspberry pi is used to monitor all the aspects of 3D printer and perform remotely on octoprint. As the system is IoT based octoprint provides a web interface for controlling 3D printers. Wireless 3D printer has number of advantage over the traditional wired setup. There is no longer need to use an SD card to copy files from the computer to the 3D printer. It has made possible to print the prototype wireless on the network [15].

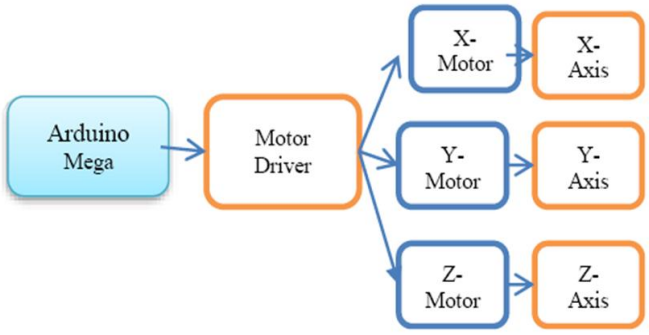

Fig -4: General Block diagram of 3D printer implemented with Aurdino mega [14]

5. CONCLUSION

In this article the various possible technologies and techniques used for implementing 3D printing technology are stated. It can be built using ALM (FDM) method where it includes (SLA) Stereo lithography, (SLS) laser sintering, and fused deposition manufacturing technologies. The Internet of Thing technique of building 3D printing has evolved the earlier concepts of the model and the prototype of product which uses raspberry pi, wireless communication, GPS, GPRS etc. Thus these techniques of building additive manufacturing 3D printing has helped the mankind in various fields like aerospace and automotive industry, food industry, medical industry, architecture, fabric and fashion industry, electric and electronic industry.

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