

# An Investigation of Fused Deposition Modeling based 3D Printers for Industry 4.0 Applications

<sup>1</sup>MD MOIZ <sup>2</sup>G.MALLIKARJUNA

<sup>1</sup>M.Tech Scholar, <sup>2</sup>Assistant Professor,

<sup>1</sup>Department of Mechanical Engineering,

<sup>1</sup>Bheema Institute of Technology & Science, Adoni, Kurnool Dist, A.P, India.

**Abstract:** 3D printing is a unique manufacturing philosophy for industry 4.0 that enables the flexible preparation of highly complex and precise structures that are difficult to realize using traditional fabrication methods such as casting and machining. In this paper we describe the investigation over the various benefits offered and capabilities of 3D printer for industry 4.0 and also its challenge were presented. The paper proposes the design and analysis the 3D printer using FDM technology and SOLIDWORKS tool. In this paper, we also provide about the 3D Printing helps to fight COVID -19.

**IndexTerms** – AM, 3D printer, industry 4.0, FDM, CAD, COVID-19, IoT. Corona virus.

## I. INTRODUCTION

Industry 4.0 refers to the intelligent networking of machines and processes for industry with the help of information and communication technology (ICT). Industry 4.0 will involve the technical integration of Cyber Physical Systems (CPS) into manufacturing and logistics and the use of the Internet of Things (IoT) and Services in industrial processes. The essential components of industry 4.0 includes Big data, model simulation, cloud technology, augmented reality, three-dimensional (3D) printers/additive manufacturing, industrial, internet of things, artificial intelligence, autonomous robots and cyber security. 3D printers are a vital part of Industry 4.0 and it hit the market way back in the 80s, commercially viable 3D printing has been possible only in the last decade [1]. 3D printing technology today is at a stage where companies are starting to realize significant, tangible new value for themselves and their customers using them. Leading corporates and consultants across the world are making significant investments in 3D printing knowledge and capabilities so that they can advise and join their clients in the Industry 4.0 wave and revolutionize supply chains, product portfolios, and business models in the process[2]. This augurs well for the 3D printing industry and leading manufacturers. 3D printing is a series of advanced manufacturing technologies used to fabricate physical parts in a discrete point-by-point, line-by-line or layer-by-layer additive manner from 3D CAD models that are digitally sliced into 2D cross sections. The optimization of process parameters is a major challenge for dimensional accuracy, surface roughness, parts strength, and builds time parts improvement. For this reason, existing additive manufacturing machines are currently modified in order to improve their accuracy and capabilities for industry 4.0 applications. An investigation of current application of 3DP in the industry 4.0 and the associated challenges are carried out. Also, the design and analysis of 3D printer using CAD tool is carried out to know the capabilities of 3D printer for Industry4.0 applications [3].

The remaining paper is organized as follows section II gives the details of literature review of 3D printer, FDM and industry 4.0 section III describes about 3D printer in Industry 4.0 applications, section IV describes about proposed 3D printer for industry 4.0, the section V presents about the design result and discussion. Finally the section VI presents about the conclusion, future work and references.

## II. LITERATURE REVIEW

Asif A, et al (2019) has suggested the low cost of 3D printer design with CD drives. They also used CD drives as a replacement for of the Stepper motor and this will reduce costs [4].

N.Shahrubudina et al (2019) have investigation of application 3D printing in industry. They presented the overview of the types of 3D printing technologies and materials used [5].

B. P.Santos, et al (2018) has presented the debate and provides an overview of Industry 4.0 in order to illustrate how the convergence of emerging technology and the internet will create new opportunities to address existing industrial challenge [6].

T.D. Ngoa, et al (2018) has carried out systematic study on key 3D printing (AM) methods, materials and their production in biomedical, aerospace, buildings and protective structures. They also carried out a survey on the principles, advantages and disadvantages of 3D printing as a benchmark for future or potential research and development [7].

Ashish P, et al (2017) suggested the design of an FDM technique-based portable 3D printer. The built printer is cost-effective and can be operated by a computer, and we can also submit G-codes from the SD card directly [8].

The study on the design and manufacturing of 3D printers using FDM technology was proposed by Ngoc-H.T et al (2017). Geometric precision of the printed product is obtained by the test results of the 3D printing process with ABS, PLA materials [9].

Dr. Rajashekar P, et al (2017) proposed the design and manufacture of an FDM process-based portable 3D printer. Through the use of the aluminium portion, the frame design is durable and lightweight [10].

The study on the challenges and opportunities of Industry 4.0 in production systems was conducted by A.Khan et al (2016). They performed a report on emerging production-level approaches and innovations and new prospects, scenarios, and applications for industry 4.0[11].

Vinod G. Surange, et al (2016) suggested the design of the 3D printer in solid works of 3D Modeling Software and properly evaluated each portion and selected readily available material to create a cost-effective printer[12].

### III. 3D PRINTERS IN INDUSTRY 4.0 APPLICATIONS

#### i. *Role of 3D printer in Industry 4.0*

We are on the verge of another revolution in manufacturing called Industry 4.0. 3D printers are expected to play an important role in this digital transformation of the industry as the speed, reliability, safety and efficiency of 3D printers increase, and the cost decreases. As performance improves rapidly and the cost decreases, new possibilities will appear that will bring 3D printing ever closer to mass production [13]. The variety of products that can be produced is also expected to expand as 3D printing grows. Adoption of 3D printers in Industry 4.0 will increase the pace of production of advanced printing materials, incorporation of digital security to secure IP and certification of 3D products by regulatory agencies, but of course it is the ability of creative manufacturers who want to adopt the concepts of Industry 4.0 and rapidly digitalize their companies that will profit most. The 3D printer plays a key role in industry4.0 and these are as follows:

- 3D printing is data-driven manufacturing developed for Industry 4.0.
- With the use of 3D printers the productivity in the industry 4.0 can be significantly increased
- 3D printers will allow us to materialize products in the Industry 4.0 space and form the production end of Cyber Physical Systems. Robots will also increase industrial 3D printing and AI will create everything on demand over the internet network.
- The 3D printer lets manufacturers provide industrial automation solutions.
- In Industry 4.0, the use of 3D printing technologies would greatly reduce the cost of producing parts used in the assembly of vision systems.
- 3D printers are perfect for mass customization due to improved printing speed.
- 3D printers have excellent quality in Industry 4.0 for the printing of complex designs.
- Big Data of industry 4.0 can be processed by 3D printers

#### ii. *3D Printing Helps to Fight COVID -19*

The COVID–19 pandemic has destroyed destruction across nations. As several nations are forced to lock down their population, the virus has affected all around nations and the world economy is reeling. This has resulted in a decrease in demand and a lack of clinical supplies that are genuinely required under the current conditions. Developing nations such as India, as well as industrialized countries such as the United States, the United Kingdom, and other European countries, are facing a significant shortage of clinical hardware that is needed to combat the Corona infection. Producers around the world are making a good attempt to adjust to the interest, and the 3D printing network is helping to mitigate the problem as much as possible.

The protective instruments that clinics and hospitals need today are face masks, swabs, ventilators, face shields, gowns, etc., returning to the disruption in the supply of medical equipment caused by the Corona virus. The medical profession is looking at these and other such life-sustaining devices and equipment in the absence of any vaccine to identify and support the affected [14]. And this concerns not only the patients, but the physicians and the medical personnel themselves, and there is a supply shortage. The 3D printing industry is uniquely equipped to deliver medical manufacturing solutions that resolve the urgent gaps produced by the current crisis with minimal wastage and maximum production. The capabilities of 3D printing make it a capability to help resolve shortages of parts related to shields, masks and ventilators, among other things, be anywhere, print practically anything, adjust on the fly. The U.S. Food and Drug Administration tells COVID-19 on using 3D printing content to combat it. During the COVID-19 pandemic, due to the high demand and overall interruptions in the global supply chain, the need for some medical devices, including personal protective equipment (PPE), could exceed the supply available to health care organizations.

We acknowledge that during the COVID-19 pandemic, the public could attempt to use 3D printing to assist in meeting demand for such items. Although the long-term economic and socio-psychological consequences are not yet known, the urgent need for an hour is to provide people with sufficient medical assistance. By experimenting with established and creative ways to manufacture medical devices currently needed, the 3D printing group contributes its mite and lends a helping hand. The roles of 3D printer in helping to fight covid-19 are as follows

- 3D printing to help develop protective devices(face masks, face marks and gowns) and ventilators to tackle corona virus
- 3D printing enthusiasts (fans) work from home to help fight the Corona virus in hospitals.
- A 3D printed door opener might bring down the danger of the virus spreading, as you would utilize your lower arm to open the door, eliminating physical contact with the handle.
- In Italy, one of the countries that have been hit hardest by the virus, 3D printing is used. The design of valves for resuscitation devices was carried out in a town near Brescia. After responding to the call about the shortage in nearby hospitals, the founder of the ICF ( Isinnova Crisitian Fracassi) left no time to waste and built the valves.
- It is possible to use the 3D printing process to manufacture reusable FFP3 respirators.

### IV. PROPOSED 3D PRINTER FOR INDUSTRY 4.0

We have proposed the fused deposition modeling (FDM) based 3D printers for industry 4.0 applications [15]. The process adopted is FDM technology and mechanism used as a part of development of FDM 3D Printers is Cartesian framework as seen in figure 1. This proposed printer is designed using CAD tool. The performance is analyzed using FEA software.

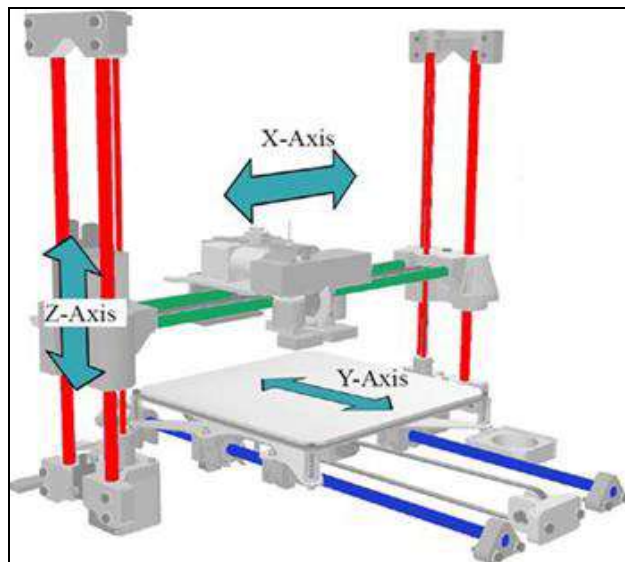


Figure 1 Schematic diagram of 3D printer

3D printing machine have 4 axis in which 3 axis are x, y, z and the fourth one is extruder. In figure 3.4, the schematic diagram of the working principle of the 3D printer for industry 4.0 is shown. The X, Y and Z axes in Figure 1 form the Cartesian coordinate system. The nozzle and the heating device are moved along the X and Y axes on the Z axis.

In Sketch up, a 3D model of the printer was designed with all mechanical and electrical components included. The software utilized to design the 3D printer for industry 4.0 is CAD design and slicer tool[16]. 3D object designing tool is open source software and the CAD file is not machine readable and thus needs intermediate software known as slicer. The slicer deals with extruder hearing, layer thickness and calculates in three axes for the motor ultimately creates a STL file, which is machine readable. The 3D printed parts were built in our work using solid works to create an assembly of a full design 3D printer with solid works that can be printed directly on a 3D printer. The generated by solid work is STL file. Metals, polymers, ceramics, composites and smart materials (shape memory alloys and shape memory polymers), PLA(Polylactic Acid), ABS (Acrylonitrile Butadiene styrene), polyamide, PET(polyethylene terephthalate), (TPE) Thermoplastic Elastomer filament, TPU (Thermoplastic polyurethane), Laybrick , LayWoo-D3 and Gel- Layare the materials used for FDM based 3D printing technologies in Industry 4.0 manufacturing[17].

## V. DESIGN RESULT & DISCUSSIONS

The result of investigation of capabilities of 3D printer for industry 4.0 applications and analysis results have shown that 3D printers are set to play an important role in digital transformation of industry 4.0. The figure 2 shows the 3D model design of 3D printer validation for Industry 4.0 application.

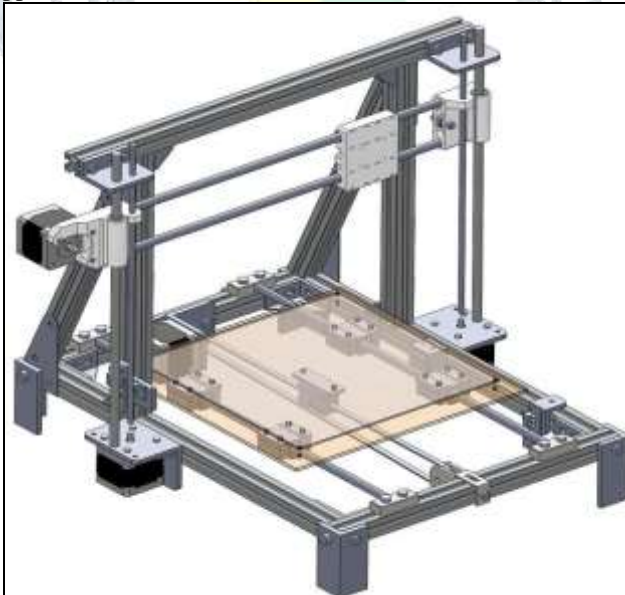


Figure 2 CAD model of 3D printer structure for industry 4.0

Also we have carried out design and analysis of 3D printer using CAD tools to verify the capabilities of 3D printers to industry 4.0 applications. The figure 6.6 below shows the CAD design model of 3D printer structure and from this design we see that the 3D printer is the key actor for realizing industry 4.0.

## VI. CONCLUSION AND FUTURE WORK

We have been investigated the current application of 3DP technology in the industry 4.0 and the associated challenges. Also we have investigated the protection of innovative 3D printed content in order to help improve the penetration of the technology within industry and we have successfully designed and analyzed a 3D printer for industry 4.0 using CAD tool kit. The results of design are shown that 3D printer is one of the key pillars of Industry 4.0,



In the future, the benefits offered by 3D printer designed using internet of Things (IoT) and big data for industry 4.0 and smart manufacturing can be investigated.

## REFERENCES

- [1] Leuven Belgium, "3D Printing-A Maturing Technology", the International Federation of Automatic Control", pp-468-472, 2013.
- [2] Barry Bermon, "3D Printing-The New Industrial Revolution", Elsevier Journal of Business Horizons 55, pp-155-162, 2012.
- [3] Rayna & Striukova, "From Rapid Prototyping to Home Fabrication– 3D Printing Is Changing Business Model Innovation", Elsevier Journal of Technological Forecasting & Social Change 102, pp-214-224, 2015.
- [4] Asif A, Avinash B, Pushkar A, Pawan N, "Design and development of low cost 3D printer," International Research Journal of Engineering and Technology, vol:06, issue: 05, ISSN: 2395-0072 pp. 7294- 7297, may 2019
- [5] [N. Shahrubudina](#) and [T.C.Lee](#) [R.Ramlana](#) "An Overview on 3D Printing Technology: Technological, Materials, and Applications," [The 2nd International Conference on Sustainable Materials Processing and Manufacturing, , South africa , Vol: 35](#), Pp: 1286-1296, 2019.
- [6] B. Paiva Santos, F. Charrua-Santos, T.M. Lima "Industry 4.0: An Overview," Proceedings of the World Congress on Engineering 2018 Vol II WCE 2018, July 4-6, 2018, London, U.K.
- [7] T.D. Ngoa, A.Kashania, G. Imbalzano, K. T.Q. Nguyena, and D Huib "Additive manufacturing (3D printing): A review of materials, methods, and challenges," Elsevier Composites Part B 143,172–196, 2018.
- [8] Ashish Patil, Bhushan Patil, Rahul Potwade, Akshay Shinde, Prof. Rakesh Shinde, " Design and Development of FDM Based Portable 3D Printer," International Journal of Scientific & Engineering Research, ISSN 2229-5518, pp. 116-120, Vol:8, Issue 3, Mar. 2017
- [9] Ngoc-H.T, Van-C.N, Van-N.N," Study on Design and Manufacture of 3D Printer based on FDM Technique," IJEAT, ISSN: 2249 – 8958, Vol: 6 Issue-6, pp.83-88, Aug.2017.
- [10] Dr. Rajashekar P, Ishtiaq A, Mohammed S S, Syed I. Z, Prashanth S and Harsha N, Pradeep K,K ,"design and fabrication of portable 3D printer," International Journal of Mechanical Engineering and Technology, ISSN 0976-6340, Vol: 8, Issue 11, pp. 129–135, Nov.2017.
- [11] Ateeq Khan and Klaus Turowski, A Perspective on Industry 4.0: From Challenges to Opportunities in Production Systems," In Proceedings of the International Conference on Internet of Things and Big Data (IoTBD 2016), ISBN: 978-989-758-183-0, pp: 441-448, 2016.
- [12] Vinod G. Surange, and Punit V. Gharat, "3D Printing Process using FDM, "International Research Journal of Engineering and Technology, Vol: 03 Issue: 03, pp.1403-1406, Mar.2016
- [13] M. D. Ugur, B. Gharehpapagh, U. Yaman, & M. Dolen, "The role of additive manufacturing in the era of Industry 4.0," Procedia Manufacturing, Vol. 11, pp. 545-554, 2017
- [14] L. Y. Yee, S.E.T. Yong, K.J.T. Heang, K.P. Zheng, Y. L. Xue, Y. Y. Wai, C. H. T. Siang, & L. Augustinus, "3D Printed Bio-models for Medical Applications," Rapid Prototyping Journal, Vol. 23, No. 2, pp. 227-235, 2017.
- [15] Galantucci & Lavecchia, "Analysis of dimensional performance for 3D printer based on FDM technique", Elsevier Journal of Procedia. CIRP 28, pp: 82-87, 2014.
- [16] Junk & Kuen, "Review of Open Source and Freeware CAD Systems for Use with 3D-Printing", Elsevier Journal of Procedia CIRP50, pp-430-435, 2016.
- [17] Weng & Wang & Senthil & wu, "Mechanical and Thermal Properties Of ABS /Montmorillonite Nanocomposites For Fused Deposition Modelling 3D Printing", Elsevier Journal of Material Design, pp-519-526, 2016.