

5D PRINTING AND ITS APPLICATIONS IN DENTISTRY

Kumari Sindhu Pravin¹, Bibhuti Prasanna², Ujjal chatterjee³, Neeta Sinha⁴, Nagbhusan mandal⁵

1. Final year MDS Dept. of Prosthodontics, Buddha institute of dental sciences & hospital Patna Bihar.

2. Dental Doctor, PHC Kuchaikot, Govt. of Bihar.

3. Prof. & Head, Dept. of Prosthodontics, Buddha institute of dental sciences & hospital Patna Bihar.

4. Professor, Dept. of Prosthodontics, Buddha institute of dental sciences & hospital Patna Bihar.

5. Reader, Dept. of Prosthodontics, Buddha institute of dental sciences & hospital Patna Bihar.

ABSTRACT

The concept of 5D printing originated from American University by Mitsubishi Electric Research Labs (MERL) by William Yerazunis in 2016. 5D printing is a latest branch of additive manufacturing with extensive potential in solving problems of dental, medical and other associated fields. The concept behind 5 dimensional additive manufacturing is rotation of extruder head and rotation of print bed in order to print in 5 different axes. 5D printing is 3 to 4 times stronger than 3D and 4D printing. In 5D printing technology, the curved complex surfaces can be produced and its applications are mainly used in different fields like dentistry, medical and other industrials area. With the help of 5D printing, some of the dental appliances, surgery equipment like dentures, dental implants, and other devices which are complicated in shapes are manufactured. This technology can efficiently fulfil the complex challenge and create endless possibilities in dentistry. In this review paper, we focus on the future aspects and current applications of 5D printing in dentistry.

KEYWORDS:- 5D Printing, 3D Printing, Advancement in dentistry, 4D Printing.

INTRODUCTION:

William Yerazunis from Mitsubishi Electric Research Lab invented the 5D Printing process with raw materials PLA, ABS, Polycarbonate, Nylon, Carbon, Metal, On-metal in 2016. The name 5D Printing comes from the five axis using for creating objects. In this printing, the printing head can move in x, y & z-direction(axis) and, the printing bed is capable of move in 2 directions (axis). The print head & printing bed can move simultaneously while printing¹. The product is made by the horizontal layer by layer. So, concave & convex parts can become easy to make with high accuracy & concerning design constraints².

5-axis printing has many advantages over traditional 3D printing for complex model.

1. It can create a curved layer object with great strength.
2. 5D Printed parts are five times stronger as compared to 3D & 4D Printed objects.
3. It's use for creating a complex prototype in the dental and medical fields.
4. 5D printing object having a higher life span.
5. 5D printing produce much smoother, higher-quality prints with less need for post-processing.

6. It's Possible to make a Complex object with 25% less material².

There are some disadvantages of 5D printing over 3D printing.

1. There are pretty expensive, required for the 2 more-axis required for the printing bed.
2. Require highly skilled resources to develop ping & maintain 5D Printer.
3. There's also very limited support available for these printers compared with something like standard 3D printing.
4. Creating and slicing models for 5D printing can be hard work.

Out of these disadvantages we can hope that, it's may become less and less relevant as research continues and 5D printing machines gain popularity.

DISCUSSION:

5D Printing is an additive manufacturing process, printing head and bed both are movable to create objects. We are not much familiar with the term, "5D printing" would be more accurately called "5-axis printing", as we are actually printing using five axes rather than adding more dimensions to the print. Standard 3D printers use three linear axes: X, Y, and Z. But 5-axis printers additionally allow for rotation in the X- and Y-axes so that curved layers can be printed. This technology is a new version of 3D printing which allows curved layers³.

This means complex models can be printed more easily, using fewer supports. It can also mean less material used, stronger

models, higher-quality surfaces, and less post-processing. William Yerazunis & his colleague experimentally proves that the 5D printed object having higher strength than a 3D printed object. Also, they prove that it requires 25% less material as compared to the 3D Printing process².

Application of 5D printing in dentistry

In dentistry surgery, there is an essential requirement of complex and strong implants dentures and other devices are not flat, all of these having curved surfaces. With the help of 5D printing, some of the dental appliances, surgery equipment like dentures, dental implants, and other devices which are complicated in shapes are manufactured easily³.

Also, a tooth that has curved shapes & curved parts are made accurately with the required surface finish & reliability. The strength needed for the equipment is higher and it can be possible with this technology only. For manufacturing of human body parts require exact accuracy & good strength⁴. Because these parts are needed to use inside your body. So, it is necessary to have proper shape & size.

This new technology will become an innovative manufacturing technique for manufacturing dental implants, orthodontic braces, clear orthodontic appliances, crowns, aligners, bridges and tools with excellent strength using the input of computer-aided design (CAD) data. Five-dimensional printing process follows almost the same steps as 3D printing technology³. Here, a 3D image is created by using suitable dental 3D scanner/designing software, and the same is converted into standard triangulate language (STL) format or a printable format. This file is easily

printed through the 5D printing and then tested and used for clinical applications in dentistry⁴.

The dental implants, dentures and other devices are not flat and have a curved shape. This technology could manufacture a complex curved shape with higher strength. These can improve patient outcomes and reliability of implant after surgery⁴. Missing tooth of a patient is easily manufactured with its required reliability and surface finish. Therefore, it provides dental surgical guides with a high degree of precision. Creating orthodontics models and aligners as per required strength is helpful⁵. This technology will be applicable for complex shape manufacturing, planning, education and making reliable operation³. This technology is useful for manufacturing artificial bones with excellent strength. Because curved parts are manufactured with good accuracy & required surface finish².

REFERENCES:

1. Zeijderveld J.V. 5D printing: a new branch of additive manufacturing. Sculpteo report. 2018. <https://www.sculpteo.com/blog/2018/05/07/5d-printing-a-new-branch-of-additive-manufacturing/>
2. Reddy P.R., Devi P.A. Review on the advancements of additive manufacturing-4D and 5D printing. Int J Mech Prod Eng Res Dev. 2018;8(4):397–402
3. Benedict Mitsubishi's '5D Printed' Parts 3-5x Stronger than 3D Printed Counterparts. 3D Printer and 3D Printing News; 2016. <https://www.3ders.org/articles/20160623-mitsubishis-5d-printed-parts-3-5x-stronger-than-3d-printedcounterparts.html>.
4. Haleem A., Javaid M., Vaishya R. 4D printing and its applications in Orthopaedics. Journal of Clinical Orthopaedics and Trauma. 2018
5. Scott C. 3D Printing Is So Last Week...Say Hello to "5D Printing" at Mitsubishi Electric Research Labs!. 3D print.Com, the Voice of 3D Printing/Additive Manufacturing; 2016. <https://3dprint.com/139742/mitsubishi-electric-5d-printing/>.

CONCLUSION:

5D printing fulfils the drawback of 3D & 4D printing. It's having high strength & able to make curved & complex parts. Researchers are researching this technology to increase its capacity to withstand pressure up to 3.4 Mpa.

So that it is useful in high-pressure applications in the dental, medical & manufacturing industries. It reduces 20 to 30% of wastage. In the future, this technology widely used in all the subsectors of the dental and medical due to its various advantages. This technology helps to create digital dentistry by enhancing it to the level of mass customisation using digital data of the patient. To reduce the cost of implants, and this technology has scope for successful use in dentistry and will be helpful for complicated cases.