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3D Food Printing Technologies

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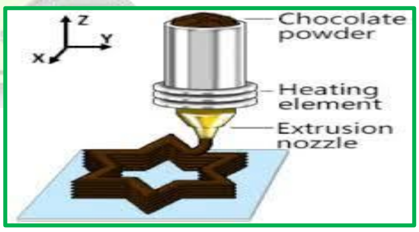
The Fourth Industrial Revolution era is coming considerably faster in the post-corona age, also known as the new normal era. 3D printing technologies are getting more attention as one of the customizable production process technologies needed in this era.

Three-dimensional printing technology is a technology created by stacking plastic in three dimensions (Kim et al. 2017) and is known as additive manufacturing or rapid prototyping, whereby products are built on a layerby-layer basis through a series of cross-sectional slices (Gu. Z., et al. 2020). Three-dimensional printing technology was invented in 1986 by Chuck Hull in the USA. It is a method that was developed to create intricate structures out of high polymer materials. It generates three-dimensional items utilising stacked layers and a computer modelling tool. Due to the benefits of high-speed production, it previously primarily produced expensive equipment like cars, aeroplanes, and medical supplies, but recently it has broadened the range of applications for technology. (Kim, S.H. 2015).

Process: A actual food item is contained in a food-grade syringe or cartridge that is part of a 3D food printer. Collaboration between hardware and software is necessary for 3D printing. Advanced 3D food printers have user-friendly interfaces and pre-loaded recipes with designs that are simple to access on a computer, mobile device, or Internet of Things (IoT) device.

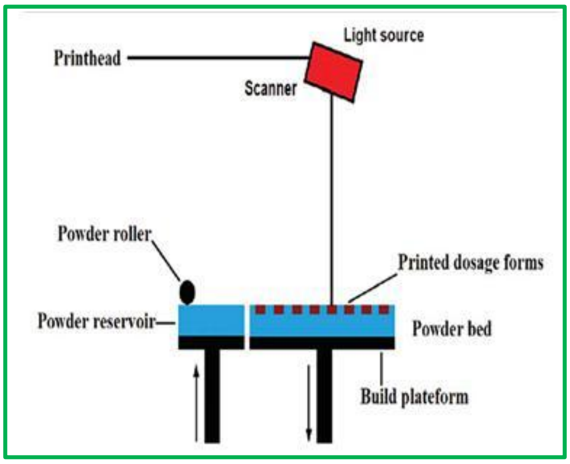
Category of 3D Food Printing Technique The 3D food printing technique has been classified into three categories that are an extrusion-based printing, binder jetting and inkjet printing.

Extrusion Based Printing: In this technique, molten material or a paste-like slurry is continually extruded from a moving nozzle, and when it cools, it joins to the earlier layers. This kind of 3D food printing is used to create edible chocolate and soft foods like dough, mashed potatoes, cheese, and meat paste. After printing is finished, further structural elements that supported the product geometry are removed.

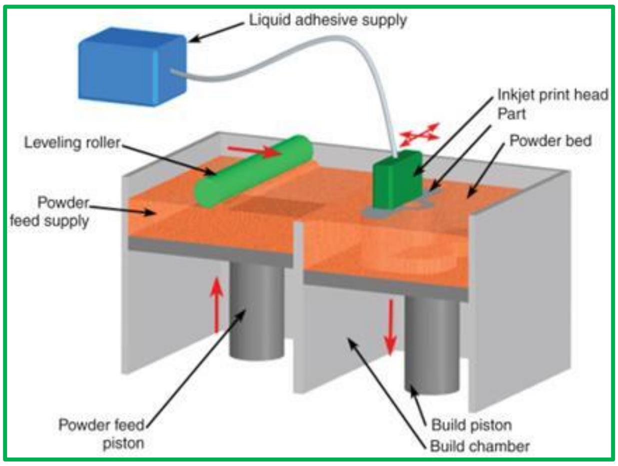


Selective layer Sintering: This technique uses a powerful laser to layer by layer fuse powder particles into a three-dimensional structure. In this approach, each cross section is checked separately to see if any powder constituents are fused together. The powder bed is lowered and a fresh layer of powder is placed on top after scanning each cross section. Up till the desired structure is attained, this process is repeated. If any unfused powder remains after the procedure, it can be recovered and used for the subsequent printing. It enables the creation of more sophisticated, free-standing, three-dimensional structures. This method is specially used for powdered materials such as such as sugar, fat, or starch granule (low melting point). Properties like particle size, flow ability, bulk density, and laser type and laser spot diameter are critical to the printing precision and accuracy of fabricated parts.

Binder Jetting: The binder jetting process uses two materials: a powder-based material and a binder. Between the layers of powder, the binder serves as an adhesive. The construction ingredient is often in powder form, whereas the binder is typically in liquid form. Alternating layers of the construction material and the binding material are deposited by a print head as it advances horizontally along the machine's x and y axes. The printed product is slid onto its build platform after each layer. By adjusting the binder composition, this technique has the ability to build intricate and delicate 3D structures as well as colourful 3D edible things. However, this technique is only applicable to powdered components.



Selective layer Sintering



Binder Jetting

Continuous Jet Printer: In this method, ink is ejected continuously through a piezoelectric crystal vibrating at a constant frequency. The ink is charged by the addition of some conductive chemicals to achieve the desired flowability. Under the pressure that the valve exerts, ink is ejected from the heads. Drop-on-demand printing systems typically print at a lesser rate than continuous jet printing systems. The images that are created are of higher resolution and precision. Inkjet printing often works with low viscosity materials that lack the mechanical stability to support 3D structures. Food hydrocolloids are essential for the creation of food ink. Any colloid system in which the colloid particles are spread in water is referred to as a hydrocolloid. A hydrocolloid has a colloid particle spread throughout water and depending on the quantity of water available that can take place in different states e.g., Gel or sol (liquid). Food Hydrocolloid can form and hold 3 D structure easily.

Post processing: In the post-processing phase, printed food may require additional steps before consumption. Processing operations like baking, cooking, cleaning, etc. are included in this. As the food must be safe for consumption, this step may be one of the most important ones for 3D-printed food. The deformation of the printed food brought on by these extra procedures is another issue that needs to be addressed during post-processing. The current approach relies on trial and error. Specifically, using food additives in conjunction with the materials and ingredients to strengthen complicated structures and guarantee that the printed structure keeps its shape. Additives such as transglutaminase and hydrocolloids (Cohen, D. L. et al. 2009) have been added to ingredients in order to help retain the printed shape while printing and after cooking.

Applications

Personal nutrition: 3D printed food can provide the control necessary to put a custom amount of protein, sugar, vitamins, and minerals into the foods we consume.

Space exploration: Currently NASA is exploring ways of integrating 3D printing food into space in order to sustain the crew's dietary requirements. The vision is to 3D print powdered food layers that have a shelf life of 30 years instead of using traditional freeze dried food that have a shelf life of 5 years. (Gannon and Megan, 2013).

Creative food design: Food customization and creative designs have required hand-made skills, which results in low production rate and high cost. 3D food printing can overcome this problem by providing the necessary tools for creative food design even for home users.

Reduced food waste: 3D food printing is a very promising way of reducing food waste during the phase of consumption, by utilizing food products like meat off-cuts, distorted fruits and vegetables, sea food by-products and perishables. These products can be processed in a suitable form for printing.

Challenges

Multi-material printing: The current available 3D food printers are limited to using a few different materials due to the challenge of developing multiple extruder capabilities. This limits the variety of food products that can be 3D printed, leaving out complex dishes that require a lot of different materials

Safety: Microbial stability is a crucial parameter of the quality of the printed food, thus it needs to be addressed both during the design of the printer and during the printing process.

Design: When designing a 3D model for a food product, the physical and geometrical limitations of the printing materials should be taken into account. This makes the designing process a very complex task and so far there is no available software that accounts for that. Building such software is also a complex task due to the vast variety of food materials.

Conclusion

3D printing is a ground-breaking technology that can improve the nutritional value of meals and even address hunger issues in countries where fresh and affordable ingredients are inaccessible. Therefore, global food industry should adopt 3D printing technology to make food production more efficient and sustainable.

References

1. Cohen, D. L., Lipton, J. I., Cutler, M., Coulter, D., Vesco, A., & Lipson, H. (2009, August). Hydrocolloid printing: a novel platform for customized food production. In Solid Freeform Fabrication Symposium (pp. 807-818). Austin, TX.
2. Gannon 2013-05-24T21:32:51Z, Megan (24 May 2013). "How 3D Printers Could Reinvent NASA Space Food" (https://www.space.com/21308-3d-printing-nasa-space-food.html). Space.com. Retrieved 2020-01-10.
3. Gu, Z.; Fu, J.; Lin, H.; He, Y. (2020). Development of 3D bioprinting: From printing methods to biomedical applications. Asian J. Pharm. Sci. 15, 529–557.
4. Kim, C.T.; Meang, J.S.; Shin, W.S.; Shim, I.C.; Oh, S.I.; Jo, Y.H.; Kim, J.H.; Kim, C.J. (2017). Food 3D-printing technology and its application in the food industry. Food Eng. Prog. 21, 12–21.
5. Kim, S.H.(2015). Technology opportunities in 3D printing. Korean Ind. Chem. News. 18, 11–26.