Chapter 12
Applications of Fused Deposition Modeling in Dentistry

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ABSTRACT

Fused deposition modelling (FDM) is a popular additive manufacturing (AM) technique for modelling, prototyping, and production. FDM is a technology that creates three-dimensional things directly from three-dimensional CAD data. Layer by layer, thermoplastic material is extruded by a temperature-controlled head. FDM, also known as fused filament fabrication (FFF), is a simple and low-cost method of additive manufacturing that was first introduced in 1989. A thermoplastic filament is fed to a heated

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nozzle in the FFF process. The material is melted here, and the material is deposited as the nozzle travels layer by layer in the x and y axes along the geometry. FDM has proved beneficial in the medical field to produce more naturalistic models for educational, training, and research reasons, as well as treatment and surgical planning.

INTRODUCTION

In recent years, the introduction of digital technologies in dentistry has represented a significant breakthrough. In the last years, digital technologies were imbibed in therapeutic and diagnostic applications, thus bringing a revolution in medicine and dentistry (Cousley, 2020). An integrated combination of computer-aided design and computer-aided manufacturing (CAD/CAM) is AM, where the available digital data replaces the existing materials (Scribante et al., 2022). AM follows three steps, first a scanner is used to convert the part into a digital data, second the acquired data has to be edited utilizing a software and finally the transformation of the available data into a final product (Brown et al., 2018). AM is such a technology that fabricates 3D objects by depositing the fused material in form of films or layers, one over the other in a successive manner, hence the name additive, whether the material is metal, concrete, exclusive materials such as ceramics, carbon fiber, thermoplastic or even human tissues or parts in dentistry (Kenett et al., 2019) (Rayappa Shrinivas Mahale, V. Shamanth, K. Hemanth et al., 2022).

One of the hottest topics in current trend is 3D printing technique nowadays it is known as FDM/FFF technology (Chia & Wu, 2015). Thermoplastic materials are used in technology to create solid items. Thermoplastic materials are heated till melting temperature is reached, at which point the printer deposits the melted material in a predetermined pattern using extrusion heads to build an object layer by layer. Layers of the substance are put one after the other such that they fuse together and later it solidifies. The main benefit of FDM is that it allows for printing with a minimum layer thickness of 127 μm and post-processing of fabricated parts is not necessary (Liu et al., 2006).

One of the major drawbacks of FDM is the shrinking of material as it solidifies and hardens, thus the material utilized for fabrication must have thermal qualities and viscoplastic. Its appeal as opposed to other 3D printing techniques can be attributed to its instant usability (Isobe et al., 2018) and lack of additional equipment (such as moulds, kiln, or tools), which results in minimal costs for equipment and procedures (Sood et al., 2010) (Sodeifian et al., 2019) (Krajangsawasdi et al., 2021).

FUSED DEPOSITION MODELLING

FDM, is the process of creating solid things out of a thermoplastic substance (Bartkowiak & Walkowiak-Śliziuk, 2018). In this process the material is deposited in a defined thickness layer, from the point of melting the material followed by passing it through a extrusion head in a predetermined manner (Chia & Wu, 2015). This causes the material to be discharged layer by layer, and as the structure hardens, these strata are bonded together. There are typically no further processes needed on the substance itself to enhance mechanical qualities apart from support removal (Liu et al., 2006). Among the most often used processes for printing three-dimensional (3D) objects) is fused deposition modelling (FDM) (Zhu et al., 2017). This technology makes it possible to produce moulds, prototypes on demand, and parts with intricate shapes (Shofner et al., 2002). Due to its minimal production time, negligible waste and