A novel approach for Dental equipment design

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Abstract

Additive Manufacturing (AM) transforms, using computer-aided design (CAD), digital 3D design of physical model of dental equipment. By layer architecture of CAD models, 3D scanning, or tomography data, AM creates equipment layer by layer without the any special and conventional machining processes. AM facilitates the distributed creation of custom objects on demand by storing and retrieving digital information and accessing the same through the Internet. The *transition from* rapid prototyping to rapid manufacturing has created new mechanical engineering and materials problems for scientists. Since polymers are the most commonly used class of product for AM, this report focuses on manufacturing, polymer production and advanced polymer systems for AM in particular. The covered AM techniques are vat-photopolymerization (stereolithography), selective laser sintering (SLS), binder jetting and material (inkjet and 3D aerosol printing), laminated object processing (LOM), extrusive production (FDM, 3D dispensing, 3D fiber deposition and 3D plotting) and 3D bioprinting.The polymers used in AM include thermoplastics, thermosets, elastomers, hydrogels, functional polymers, polymer mixtures, composites and biological systems, polymer design aspects, additives and processing parameters as well as improving the speed and accuracy of the construction, functionality, surface finishing, stability, mechanical properties and porosity. The listed applications show that AM is used in lightweight technology, construction, food processing, energy technology, dentistry, medication distribution and customized medication. Unparalleled by metals and ceramics, polymer-based AM plays a key role in the production of AM in advanced multifunctional and multi-material systems, including living biological systems and living synthetic systems.

Keywords: Dental Equipment, Handpiece, 3D design, AM of fiber, 3D Printing, Rapid Prototyping, SLM

I. Introduction

The first additive manufacturing (AM) is mirror part 3 D printing developed in the 1980s to meet the highly specialized needs of model making and rapid prototyping (RP) has grown into a resourceful technical area for computer-aided design (CAD) and fast development. AM provide better platform to production of custom parts from different metals, material, ceramics and *polymers without the* need for traditional machining and subtractive production. 3D printers are available on the market today for less than dollar 500, enabling the production of 3 D products even at home. Just, as in conjunction with desktop publishing, the development of electronic 2 D printing has revolutionized interaction and data. Together with the 'Internet of Things' the development of AM technologies has the potential to revolutionize the computer-controlled production of complex objects and multifunctional material systems. Although traditional manufacturing is controlled by industrial mass production-related processing constraints, AM is fundamentally agile, allowing faster turnaround in the design and manufacture of custom artefacts designed to meet individual specifications and particular applications. The terms additive manufacturing, fast prototyping, coated manufacturing, solid freeform manufacturing, 3 D manufacturing and 3 D printing are used more or less synonymously throughout the literature. Although the same manufacturing process is represented by both additive manufacturing (AM) and 3 D printing. AM enables the creation in 3D structures of highly complex geometry and shapes. While a coffee mug is not very complex, a convenient sample of AM concepts is provided (Figure 1). In the first step, CAD software is used to create a virtual object which is then digitally sliced. Objects with overhanging portions (i.e. the coffee mug handle) are designed with temporary support structures to avoid the collapse of these overhanging portions during the construction process. The virtual image and the positions of the digital slices are then used to guide the motors, which control the orifice location of the 3D-dispenser. This type of computer-aided production (CAM) is usually carried out for practical purposes layer by layer with typical layer thicknesses ranging from 15 to 500 µm. If the layer thickness is less than 50 µm, the naked eye would not recognize the steps associated with a layered production process.

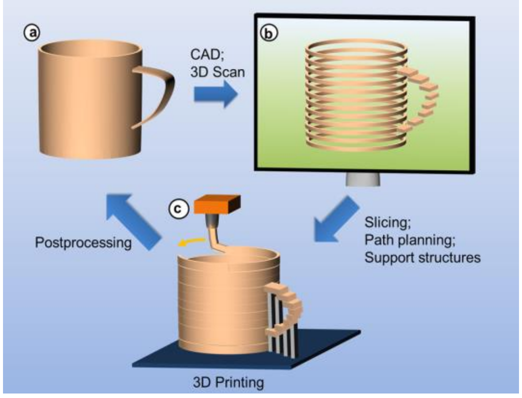


Figure 1. Basic principles of additive manufacturing.

(a) Development of product idea that is transformed into digital data by means of CAD, or analysis of geometric data by means of 3D scanning; (b) preprocessing of model data: slicing of virtual model into layered data, adjustment of support structures to stabilize craning structures, path planning, and successive transfer of layered data to 3D printer; (c) and additive manufacturing of model or product, for example, by melt extrusion, postprocessing to remove typical artifacts including support structures and surface roughness due to staircase effects.

Temporary support structures to prevent collapse during the build process. The coordinates of the virtual object and digital slices are then used to steer the motors, which control the position of the building device or the 3D-dispenser orifice respectively. For practical purposes, this type of computer-aided manufacturing (CAM) is normally performed layer by layer with typical layer thicknesses ranging from 15 to 500 μm. When the layer thickness is below 50 μm, the naked eye will in most cases not be able to recognize the stair-steps associated with a layered manufacturing approach. For thicker layers or in demanding applications, postprocessing may be used to remove support structures or to improve surface properties. As compared to conventional polymer processing (see Figure 2) by formative techniques like injection molding and subtractive techniques like CNC machining, AM is slower but enables CAD-guided fabrication of multifunctional material systems with complex shapes and functionalities, including bio systems. With the development of easy-to-use systems exhibiting sufficiently fast build-speeds and decreased system prices, AM has moved from the arena of niche-manufacturing processes into the spotlight of a much larger audience. Despite the significant progress that has been achieved in recent years, there are still a number of challenges that need to be tackled to establish AM as a manufacturing tool on a large scale. Many of these challenges are related to the insufficient material properties (thermo mechanical properties, anisotropy, porosity, long-term stability, cost, corrosion properties, creep, etc.) of the currently used build materials. With a focus on polymeric materials, this Review describes the different AM processes that use polymers along with the technical requirements of the utilized materials.

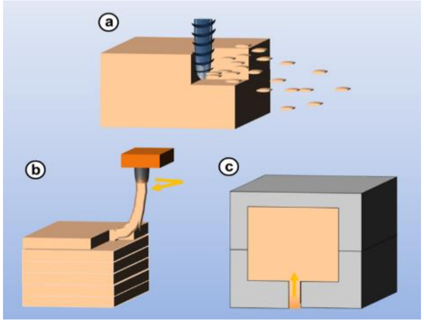


Figure 2. Comparison of (a) subtractive, (b) additive, and (c)formative manufacturing techniques.

Critical points, which currently limit the further use of AM in manufacturing, will be pointed out, and possible strategies for overcoming these issues will be discussed.

II. MECHANICAL PROPERTIES

Recently As application of AM progresses from (visual) prototyping to manufacturing of end-user parts, the functionality of these parts is expected to match or surpass the performance of products fabricated using subtractive and formative technologies. Despite numerous research activities, products produced by AM are inferior with respect to mechanical properties in many cases. Depending on the specific process employed, this weakness may be due to a limited choice of materials suited for a process (e.g., photocurable vinyl- or epoxy-functional oligomers for photopolymerization in the case of SLA) or to an unavoidable porosity of parts derived from powder bed fusion or material extrusion. Moreover, due to the layered production process, mechanical properties of parts tend to be anisotropic, with the boundary between adjacent layers representing weak regions with maximum residual stresses in applications where mechanical integrity is a major concern.33 Kotlinski conducted an in-depth analysis of the mechanical properties of commercial AM materials and techniques and found anisotropy to be the worst for LOM and least critical with SLS. Mechanical properties and anisotropy for

FDM were found to be highly dependent on material and process parameters. Anisotropy is also a problem with lithographic AM, where post curing has been found to provide improvements. Improving the mechanical properties of AM formed objects is an active area of research, where the development and application of composite materials can provide unique solutions.

III. METHOD AND DESIGN

The cellular lattice structures were fabricated using in-house developed titanium-tantalum powder blend. The powder blend is obtained from mixing gas atomized commercially pure titanium and tantalum powders. The commercially pure titanium powder (Grade 2 ASTM B348, LPW Technology Ltd, United Kingdom) particles are spherical with average particle size of 43.5 μm. The tantalum powder (Singapore De- mand Planner Ltd, Singapore) particles are irregular with average size of 44 μm. The two elemental powders were mixed in weight ratio of 1:1 and then spun at a rate of 60 rpm for 12 h using a tumbler mixer (Inversina 2 L, Bioengineering AG). The powder preparation and characterization have been described in further details in previous work. The fabrication of the samples was carried out on a SLM 250 HL machine (SLM Solutions Group AG), equipped with a fiber laser with a Gaussian bean profile and focus diameter of 80 μm. The maximum laser power is 400 W. All processes were carried out in an argon environment with less than 0.05% oxygen to prevent oxidation and interstitial element contaminations such as hydrogen and nitrogen pick up during the SLM process.

A. METROLOGICAL CHARECTERIZATION

The dimensions of the as-fabricated lattice structures were measured using digital Vernier calipers with 0.01 mm accuracy (ABS Digimatic Calipers, Mitutoyo Corporation). The sample dimensions were derived from the average of three points (n = 3) on each of the three replicates (N = 3) of the as-fabricated samples. Dry weighing occurred under nor- mal atmosphere conditions using a XS Analytical Balance with sensitivity of 0.001 g and repeatability of 0.0001 g (XS 204, Mettler Toledo). The density of the samples ρabs was calculated by dividing the actual weight, obtained from dry weighing, by the volume of the parts, obtained from dimension measurements. The part porosity is obtained using the formula as follows:

$$Porosity\ (\%) = (1 - \rho abs\ /\rho theoretical) \times 100 \qquad (2)$$

where $\rho_{theoretical}$ is taken to be 7.10 g/cm 3. The struts of the as-fabricated samples underwent morphological characterization using optical microscope (OM, SZX 7, Olympus). The same equipment was also used for measurement of the strut dimensions using the OM images. The strut dimensions were measured based on the fully formed strut, without taking into consideration of powder adhesion to the struts. For every OM image, 15 values of the strut dimensions were measured (n = 15) and the average value was taken.

B. MECHANICAL CHARECTERIZATION

The fabricated cubic samples have designed dimensions of 10 mm by 10 mm by 10 mm, which are used as test coupons for compression tests based on ISO 13,314:2011 (Mechanical testing of metals –Ductility testing – Compression test for porous and cellular metals). Uniaxial compression tests at room temperature (25 °C), were carried out to assess the compressive properties of the lattice structures, each with three replicates (n = 3), by using Instron Static Tester Series 5569 equipped with a 50 kN load cell. The loading speed was set at a constant of 0.6 mm/min, so as to maintain a constant strain rate for all tests as recommended by the standard. The compression tests were carried out until axial deformation of the samples was equal to 100% or when the maximum loading of 50 kN was reached, whichever came first. The stress-strain curve, yield strength and elastic constant in compression of the as-fabricated samples were then obtained through the compression tests.

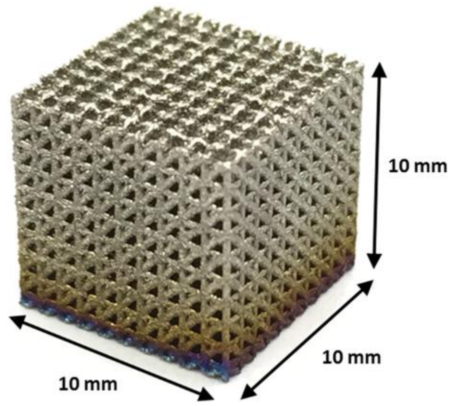


Fig.3 SLM fabricated lattice structure.

IV. RESULT

A. Disc Pad PDformation without Thermal Effects

1. Head Technology

The smaller the head the better the access to and view of the treatment site. The purchaser should consider not only the diameter and the height of the head but also the working height (head + bur). The smallest turbines have a working height of about 17 mm (with a bur length of 16 mm). The heads of these miniature turbines have a diameter of less than 9 mm and a height of approx. 10 mm.

Figure 4 Microturbine head

Despite their very small size, they still offer high power. The products had to be designed with special applications in mind to allow such small head dimensions. This means that microturbines can be used for minimally invasive applications and for patients with a small mouth opening (children and older patients). Some manufacturers have even integrated two impellers into the turbine to meet these requirements. The turbine rotor tends to suck air from its immediate vicinity when slowing down. Consequently, there is a danger of sucking contaminated air into the interior of the turbine. Modern turbines now have what is referred to as a hygienic head. This innovative system prevents external air from being sucked into bypass channel.

Figure 5 Hygienic head system

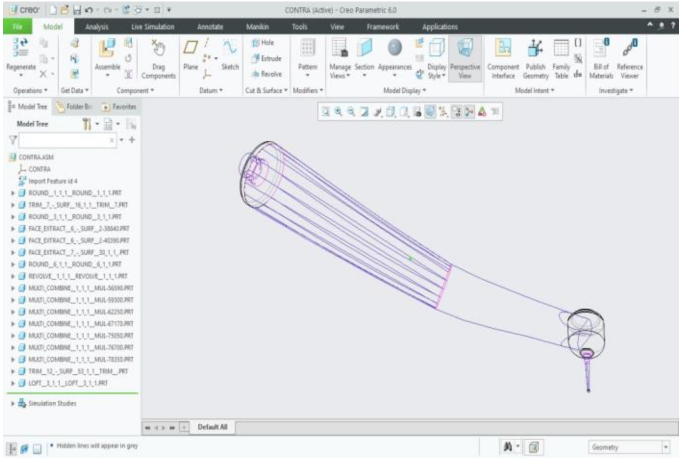
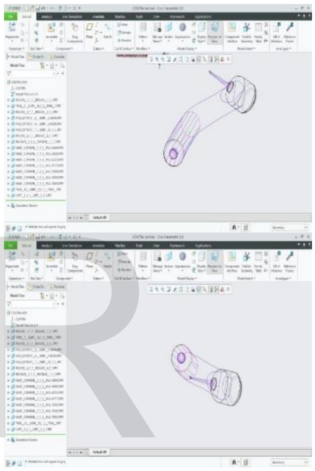


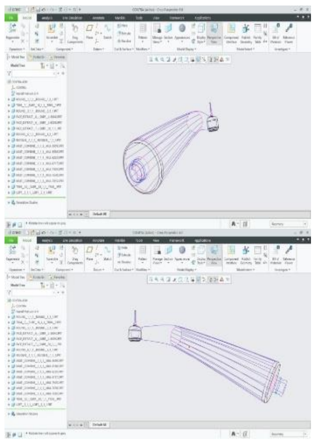
Figure 6 Handpieces Back wire Diagram

In figure 6 is back wire structure of handpieces. It is initial part of dental equipment. which is provide handiness of instrument and flexibility.



(a)

(b)



(c) (d)

Figure 7 a, b, c, d is shows Handpieces Back wire Diagram Here

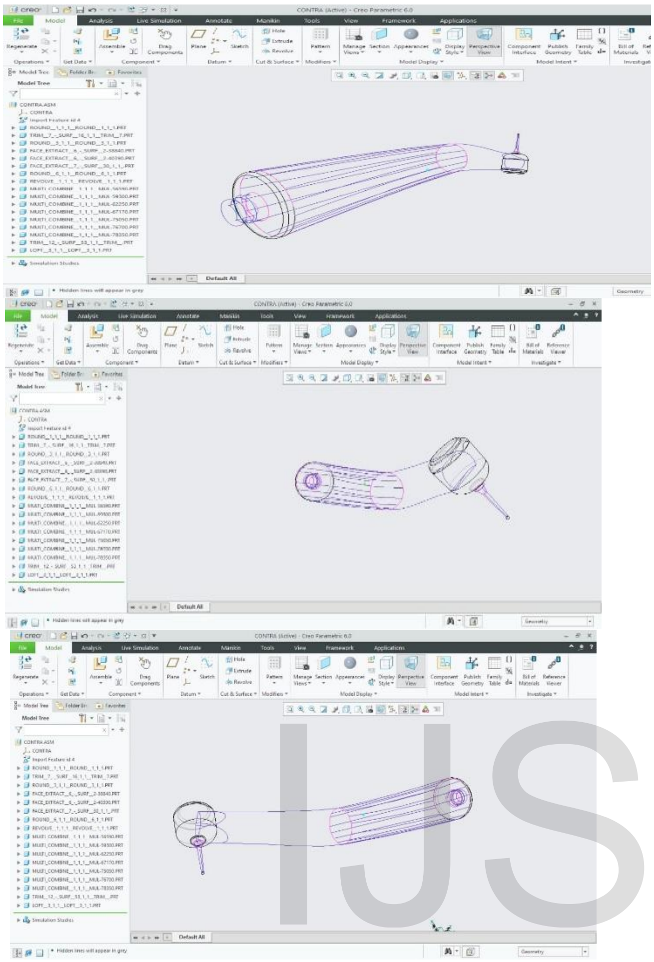


Figure 8 Handpieces structure wire Diagram

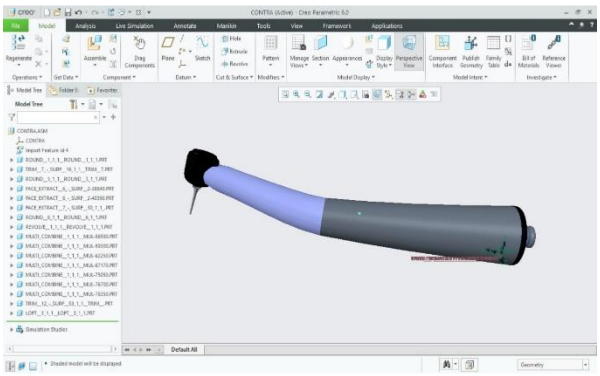


Figure9 Handpieces Diagram

Table.1 Handpieces Parameter analysis

Fiber	Density (g/cm^3)	Tensile strength GPa	Young's modulus (GPa)	Elongation (%)	Coefficient of thermal expansion (10^{-7}/°C)	Poison's ratio	Refractive index	Ref.
E-glass	2.58	3.445	72.3	4.8	54	0.2	1.558	17
C-glass	2.52	3.310	68.9	4.8	63	–	1.533	
S_2-glass	2.46	4.890	86.9	5.7	16	0.22	1.521	
A-glass	2.44	3.310	68.9	4.8	73	–	1.538	
D-glass	2.11–2.14	2.415	51.7	4.6	25	–	1.465	
R-glass	2.54	4.135	85.5	4.8	33	–	1.546	
EGR-glass	2.72	3.445	80.3	4.8	59	–	1.579	
AR glass	2.70	3.241	73.1	4.4	65	–	1.562	

V. CONCLUSION

This proposed work provides a better understanding of the SLM process parameters that have significant effects on the fabrication of lattice structures. SLM process parameters have been found to have a significant effect on the dimensional accuracy, porosity, yield strength and elastic modulus of the fabricated lattice structures. we used Selective laser melting (SLM) is one of the additive manufacturing (AM) techniques to design based dental equipment. Based on the statistical modeling, the key findings can be summarized as follows:

(1) The regression analysis method can be used to analyze the effect of SLM process parameters on the strut dimensions and mechanical properties of the lattice structures fabricated quantitatively.

(2) By careful manipulation of the process parameters, dimensional ac- curacy of the lattice structures can be improved. It can also lead to better control of the resulting mechanical properties.

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