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RESEARCH ARTICLE

A NEW BIO-INSPIRED WING DESIGN WITH 3D ADDITIVE MANUFACTURING SCANNING AND PRINTING METHOD: MJF TECHNOLOGY

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ABSTRACT

In this study, unlike many wing profiles currently available, a new wing design has been carried out with bio-inspiration, which has attracted the attention of many scientists. There are many traditional methods in 3d additive manufacturing technologies. There are several types of 3D printing method. The four most preferred 3d printing methods are as follows. Fused Deposition Modeling (FDM), Stereolithography (SLA), Selective Laser Sintering (SLS), Multi Jet Fusion (MJF). MJF technology, one-to-one prototype production of wings with very small dimensions and aerodynamic structure has been achieved. In contrast to FDM and other additive printing technologies, it is possible to eliminate highly sensitive and high surface quality products.

Keywords: Bio-inspired wings, 3D additive manufacturing technologies, Multi Jet Fusion (MJF) technology

1. INTRODUCTION

Until the industrial revolution, different working styles were not adopted, except for handmade production and design. With the industrial revolution, the increase of mechanization and the introduction of new technologies into our lives has paved the way for achieving low material prices and fast delivery times. Despite all this forward-looking movement, the basic design and manufacturing process has not changed fundamentally over the past 100 years. Celebi et al. produced a damaged skull with a three-dimensional printer made of PLA material and performed prosthesis production with Ti-6Al-4V, a biocompatible material on the damaged area, and concluded that using three-dimensional printers used in the medical field will safely reduce the time of operation to be applied to the patient [1]. Karaman et al. conducted a study on the furniture sector; 8 mm diameter brackets were manufactured using ABS and PLA materials and used in furniture corner joints. As a result, it was noted that PLA material gives better results and three-dimensional production technology will also be used as an alternative in the furniture sector [2]. Ozgül et al. in 2021, 3D printer design and production was carried out using FDM technology. Tensile and bending tests of 5 different geometrical hourglass were performed and their mechanical properties were examined. They emphasized that FDM technology is the most popular, most preferred production method and the cheapest method on the market[3].

With MJF (Multi Jet Fusion) technology, a different perspective has come to production and design. Today, many leading companies are taking advantage of MJF technology by using 3D printing method. In this way, it can produce products for final use or prototyping. The flexibility offered to the designer, the fact that the raw material is reusable for the next production, high surface quality, low cost per part and the ability to produce 10 times faster than competitors have allowed HP MJF technology to lead the industry.

1.1.Raw Materials used in 3D Printers

A lot of work is being done on new materials that eliminate some of the traditional obstacles to the non-choice of 3D printing, such as cost, quality and variety. When we look at the areas where MJF

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technology is used and the raw materials that can be used with this technology, we can examine the raw materials that can be used with the systems in two main categories respectively; Polyamides and Polyurethanes. The raw materials belonging to the Polyamide family that can be used in the HP MJF 4200 and HP MJF 5200 systems are PA12, PA12 Glass Beads and PA11. With the HP PA12, it is possible to produce powerful, functional and finely detailed parts. Due to its ability to ensure dimensional accuracy, provide fine details in complex designs, and be waterproof, it is used in the industry for the production of functional final parts/prototypes. PA12 is a thermoplastic that has excellent chemical resistance to oils, greases, aliphatic hydrocarbons and alkalis. In addition, thanks to the US FDA biocompatibility certificate, it is also possible to use it in the medical / medical field.

Since the HP PA12 Glass Beads are 40% glass bead filled thermoplastic material, it is possible to produce hard, functional and cost-effective parts with the product. For example, it is suitable to be used in the production of fixtures, models, body and housing parts. It is a material that has both favorable mechanical properties and high reusability.

It is possible to produce powerful, soft and functional parts with the HP PA11. PA11 is a thermoplastic with a low environmental impact, since it is a renewable raw material derived from vegetable castor oil. It has high impact resistance and flexibility, so it is suitable for use in areas such as prostheses, insoles, sports equipment, snap-in parts, movable hinges.

1.2. Polyurethane Raw Material

The raw materials belonging to the Polyurethane family that can be used in the HP MJF 4200 and HP MJF 5200 systems are ESTANE 3D TPU M95A1 and BASF Ultrasint TPU01. ESTANE 3D TPU M95A1 is a thermosplastic polyurethane (TPU) material developed by Lubrizol specifically for use in HP's Multi Jet Fusion 4200 3D printing solution. Its use is recommended for a wide range of applications that require high elasticity, good wear resistance and high impact absorption. BASF Ultrasint TPU01 is a multi-purpose thermoplastic polyurethane (TPU) material developed by BASF specifically for use in HP's Multi Jet Fusion 5200 Series 3D printing solution. TPU01 is an easy-to-print material with good UV and hydrolysis resistance and can only be used on HP Multi Jet Fusion 3D printing machines. This material can be used in the production of parts that are flexible, have high shock absorption, and whose thin structures require printing with high detail.

Today, due to the reasons mentioned above, this technology appears in many areas due to the point we have come to. With MJF technology, products with high strength and surface solubility, the ability to produce very detailed models without support, products with sealing and high strength can be obtained.

2.MATERIALS AND METHODS

Aerodynamics is the study of phenomena around objects moving in air, or a constant an event that occurs due to the movement of air around an object or one of these two in the form of a combination. In order to design and produce maple seed in the form of turbine blades in the form of first of all, there are about a hundred different lengths and sizes of various parks and gardens in Bursa. Dried maple seeds were collected on the expanses. Maple seeds were collected from different places and scanned as shown in Figure 1 so that they could be processed in 3D printers.

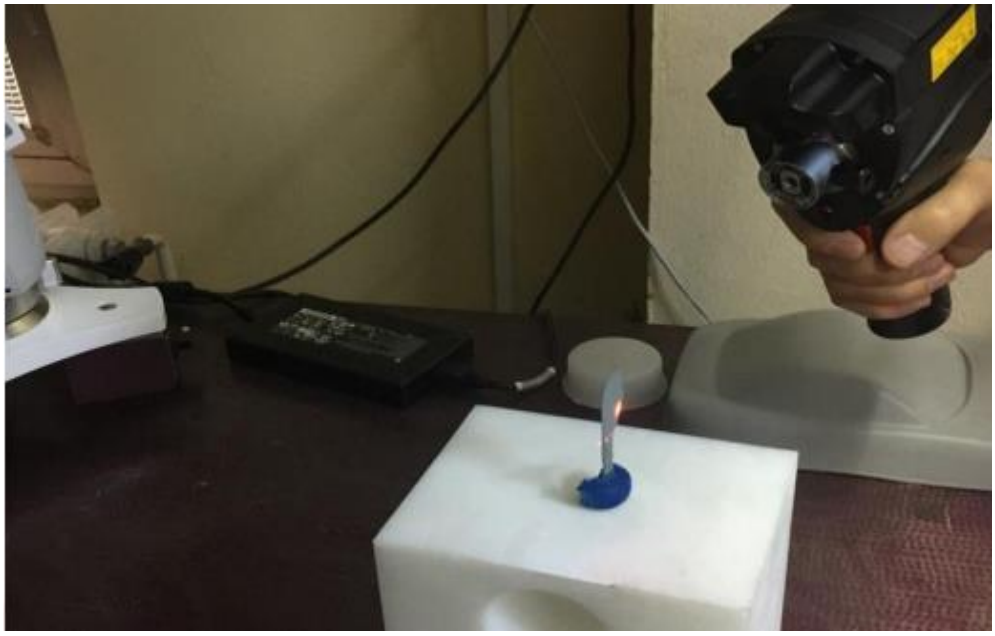

Figure 1. 3D laser scanning of maple seed

Maple seeds collected from parks and gardens from various places are processed by optical scanning and laser scanning the measurement. They will be scanned with scanners and transferred to a computer and will be 12-14-16 cm the model created in the figure has 3 prototype models of different lengths for experimental study. CAD files have been created.

3.RESEARCH FINDINGS AND DISCUSSION

3.1.Fused Deposition Modeling (FDM)

FDM (Fused Deposition Modeling) or FFF (Fused Filament Fabrication) is a technology used in three-dimensional printing technologies to create strong, durable and dimensionally stable parts with its dimensional accuracy and repeatability. It is an additive manufacturing technology that works with thermoplastics. It is based on the principle of melting thermoplastic parts made into filaments and applying them to the production table layer by layer. Fused Deposition Modeling, also known as FFF (Fused Filament Fabrication), can create any geometry you have in mind. For this reason, you can use the parts produced with this technology as end-use components in the aircraft industry, to meet all your prototype needs, such as production vehicles in the military industry or automotive factory. Tagliaferri in 2019 compared 4 different 3D production technologies in terms of production techniques and cost. They have suggested that FDM technology is the most preferred production technique in the Italian manufacturing and industrial sector for economic and mass production [4].

3.2.Stereolithography (SLA)

SLA (Stereolithography) technology is a 3D printer technology that works by curing the resin with light. Light solidifies a liquid resin through a process called photopolymerization, layering on the part to be produced. Currently, Stereolithography Technology is one of the most stable forms of dimensionality of 3D printing. There are two main types of SLA technologies: laser-based (typically abbreviated as SLA) or projection-based (DLP abbreviated for Digital Light Projection). Stereolithography was the world's first 3D printing technology, invented in the 1980s, and is still one of the most popular

technologies for professionals. Material manufacturers have created innovative SLA photopolymer resin formulations with a wide range of optical, mechanical, and thermal properties to match those of standard, engineering, and industrial thermoplastics.

3.3.Selective Laser Sintering (SLS)

Selective laser sintering is the most common additive manufacturing technology for industrial applications, trusted by engineers and manufacturers across different industries for its ability to produce strong, functional parts. Rosso et. al have experimented with the mechanical properties of materials produced by MJF and SLS 3d printers. They have observed that there is less porosity and ductility for MJF technology [5].

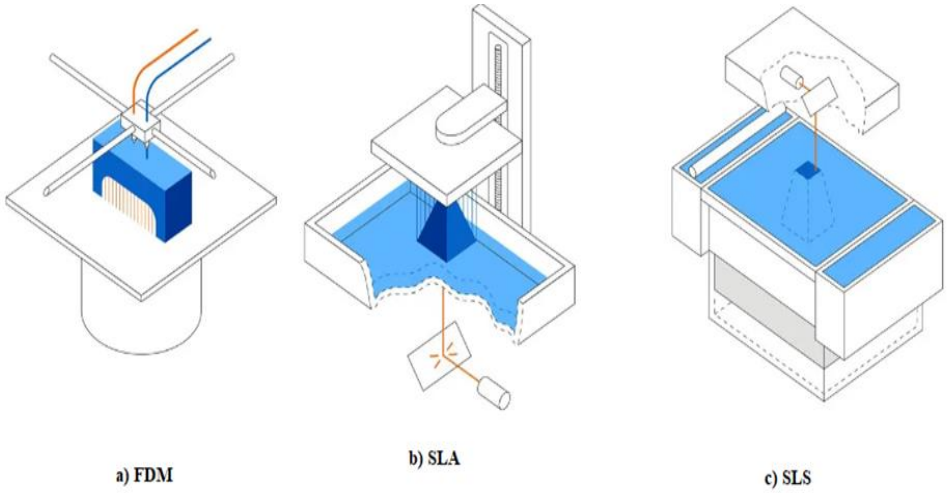

Figure 2. 3D Printer Technologies in used traditional methods. respectively; a)FDM, b) SLA, c)SLS

3.4.Multi Jet Fusion (MJF)

Multi Jet Fusion; as it is known, SLS is the 3D production technology used since the 1980s and is the most frequently preferred after FDM in the industry. After a long break, a new ambitious manufacturer has joined this production area. The differences between the HP Multi Jet Fusion MJF from the same family are as follows the differences between the Multijet Fusion (MJF) and Selective Laser Sintering (SLS) are as follows. In a study conducted by Mele et al. in 2019, they examined the capillary effects on the upper surface of 3d printed parts using MJF production technology [6].

Both technologies use PA material. But they diverge here on the issue of production. SLS sinters each section separately using a laser, while MJF produces a layer at each transition of the table [7]. The biggest difference when performing this operation is that it uses additives called “fusing agent” and “detail agent”. Thanks to the infrared heat source, the agent and PA material are cured to form a high-quality part, and the whole process takes 9 seconds, it takes. Obviously, MJF is much faster than SLS. Studies have shown that MJF is approximately 10 times faster [8].

Figure 3. Hp Jet Fusion 3D, used for scanning the prototype Maple seed 4200 Printer.

Our Maple prototype model has been scanned with the Breuckmann Smart Scan optical scanning device. After that, a scaling study was carried out at 12-14-16 cm. The prototype wing made of Polyamid12 material with HP 4200 3D Printer is manufactured using MJF(Multi jet fusion) technology.

Figure 4. Prototype aerodynamic bionic wing manufactured with 3D MJF Technology

Since the maple seed part is quite small in size and detailed in structure, MJF has been proven by experimenting as the most tolerant, precise manufacturing method when creating prototype aerodynamic wings. Other scanning methods have also been tried. However, it has been observed that the other FDM method is more suitable for larger car parts and engine components. In addition, the characteristics of the aerodynamic wing are such that such precise scans could not be obtained with other 3d printers.

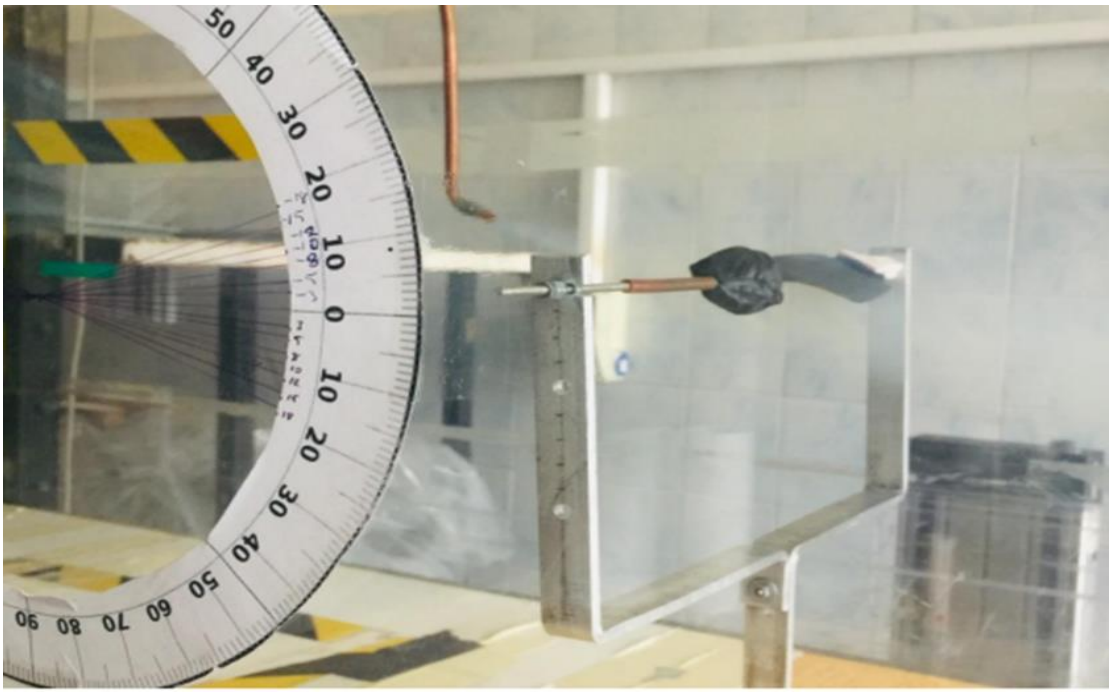

Figure 5. The use of a bionic wing in experimental equipment for the calculation of aerodynamic forces.

This bionic wing, scanned with a 3D printer MJF Technology, was mounted in a wind tunnel on an experimental set and aerodynamic forces were measured. Detailed one-to-one prototype production has been provided so that the dimensions of the aerodynamic wing are tested in the wind tunnel and optimal performance is ensured at the design point.

4.CONCLUSION

In this study, 3-D scanning of maple seed with 3-D printers and aerodynamic testing in a wind tunnel were studied to produce it. As a result of the studies carried out, it has been seen that MJF Technology from 3D printers provides faster and more detailed one-to-one prototyping than other SLA, FDM, SLS techniques. Finally, the achievements of MJF technology are as follows;

1. To provide isotropy in the produced models,
2. It has the lowest unit volume cost compared to competing technologies,
3. It can produce the desired number of products in the shortest time compared to other technologies.

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CONFLICT OF INTEREST

The author declares that she has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. In addition, all materials are available in the study. In addition, the author would like to state that there was no support or funding from any institution in the preparation of this study.

REFERENCES

[1] Celebi A, Tosun H, Oncag AÇ. Manufacturing A Damaged Skull with 3D Printer and Implant A Design, international Journal of 3d Printing Technologies And Digital Industry, 2017; 1(1): 27-35.

[2] Karaman A, Yıldırım MN, Yaşar ŞŞ. Determination of Bending Moment Capacity on "L" Type Furniture Corner Assembly Elements Produced by 3D Printers, Gümüşhane Üniversitesi Fen Bilimleri Dergisi, 2020; 10(4): 1057-1065.

[3] Ozgül HG, Tatlı O. 3d Printer Design, Manufacturing And Effect of Infill Patterns On Mechanical Properties. Icontech International Journal, 2020; 4(1), 13-24.

[4] Tagliaferri V, Trovalusci F, Guarino S, Venettacci, S. Environmental and Economic Analysis of FDM, SLS and MJF Additive Manufacturing Technologies. Materials, 2019;12(24), 4161.

[5] Rosso S, Meneghello R, Biasetto L, Grigolato L, Concheri G, Savio G. In-depth comparison of polyamide 12 parts manufactured by Multi Jet Fusion and Selective Laser Sintering. Additive Manufacturing. 2020;36. 1-13.

[6] Mele M, Campana G, Monti GL. Modelling of The Capillarity Effect in Multi Jet Fusion Technology, Additive Manufacturing, 2019;30, 100879.

[7] Habib FN, Iovenitti P, Masood SH, Nikzad M, Fabrication of Polymeric Lattice Structures for Optimum Energy Absorption Using Multi Jet Fusion Technology, Materials and Design, 2018;155. 86-98.

[8] Aydın N, Caliskan ME, Sabirli MU, Karagoz I. An experimental study of the aerodynamic performance of a maple wing model at low Reynolds numbers, Mechanics Research Communications, 2023;130. 104104.