

Research Article

Determination of The Parameter Studies of Different Resins With DLP Production Technology, Which is an Additive Manufacturing Method, and Determination of Their Suitability for Production and Use

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Abstract

Additive manufacturing is used as a production method in many sectors nowadays. This method, which is used as an alternative to machining, is often preferred as an alternative to mass production lines in order to easily produce different geometries and different materials.

Additive manufacturing has diversified with different production methods and different materials. For example, FDA - SLA - FDM - LASER etc.

In our study, DLP (Digital Light Processing) production method, in which photopolymer resins are used as raw materials, was preferred.

There are different reasons why we prefer this method;

- 1) DLP devices of our own production have adjustable parameter infrastructure for different resins.
- 2) The mechanical and characteristic properties of the materials preferred in the moving parts of the products that we plan to commercialize within the company should have similar mechanical and characteristic properties with the resins evaluated in this study.

Within the scope of the planned study, 4 different resins were determined to meet the expected properties and parameter studies were carried out. As a result of the parameter studies, the desired results were obtained in 2 different resins and their suitability for use was confirmed.

Parameters and visuals of the resins studied are given in table 1-2.

With this work, we have developed the technological production infrastructure and incorporated a new material and production method into the company. In this way, we made a profit from mold - cutting tool, raw material etc. expenses.

Keywords: Additive Manufacturing, Photopolymer Resin, Digital Light Processing

1. Introduction

Nowadays, additive manufacturing technology is used to meet the needs of many different sectors. Additive manufacturing products, which are often used in personalized applications (dental prosthesis, maxillofacial defects, etc.) in the health sector, are increasingly being used as a production method in different sectors such as automotive, aviation and jewelry.

There are many reasons why additive manufacturing is preferred.

- Reduces cost while saving production time,
- Less material is used and reduces waste,
- Customized or boutique products are produced,
- It facilitates the production of designs with complex geometry,
- Provides freedom of design,
- It enables designs to be transformed into appropriate outputs by achieving precise productions,
- Production is made with a single device rather than multiple production flows and avoids the use of ancillary equipment (cutting tools, molds, lubricants used in production, apparatus and gauges, etc.),
- Saves energy,

The additive manufacturing method varies according to the preferred material, production technology and the targeted sector.

Additive Manufacturing Methods

A. Stereolithography (SLA)

SLA, enables the creation of three-dimensional objects from a pool of polymer resin that is selectively cured layer by layer by an ultraviolet (UV) laser beam (Kumar et al., 2025). This process takes place by polymerizing each layer in a pattern determined by the laser, then lowering the platform for the next layer and repeating the process.

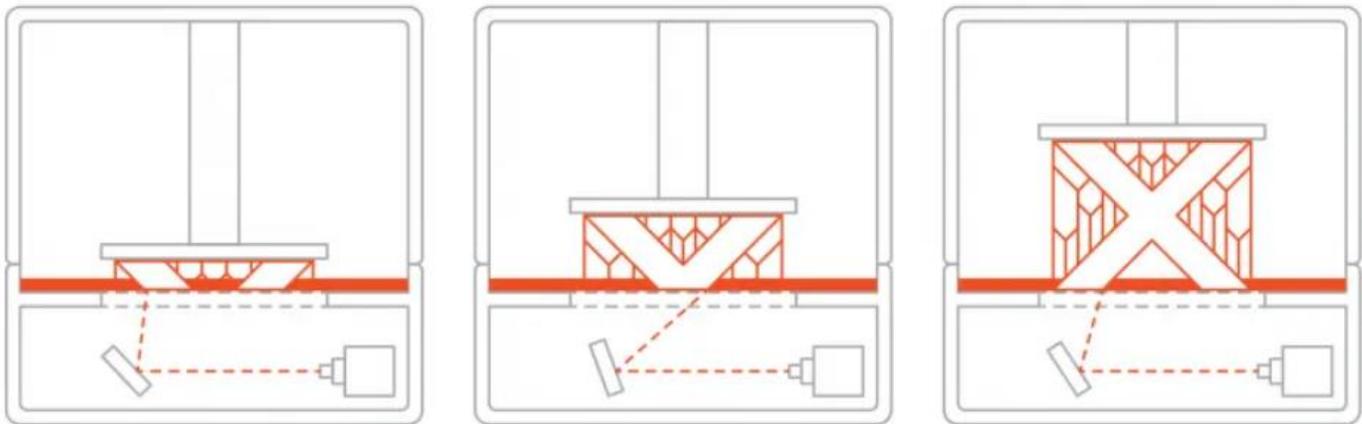


Figure 1. SLA Printer Working Principle (Fibilo., 2024)

B. Fused Deposition Modelling (FDM)

FDM process starts by melting a filament or plastic wire in a thermal print head (Siemiński., 2021). This head follows a specific pattern and applies the melted plastic material layer by layer onto the surface. These layers stick together and harden after cooling. This process is repeated layer by layer until the entire design is created.

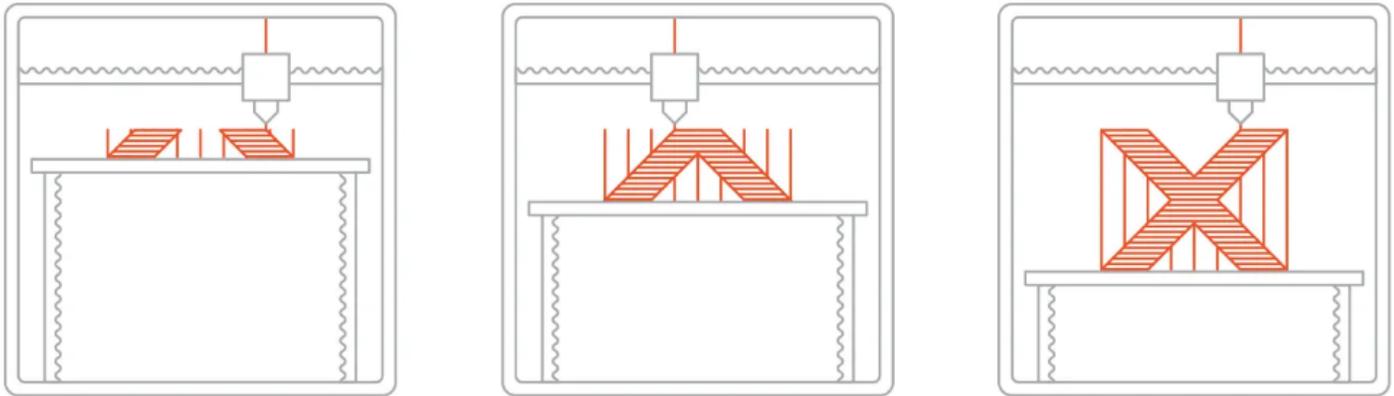


Figure 2. FDM Printer Working Principle (Fibilo., 2024)

C. Selective Laser Sintering (SLS)

In the SLS method, metal powders in the chamber of the 3D printer are solidified with a laser beam to obtain the print. Aluminum, CoCr, NiCr, Ti or stainless steel are used as metal powders (Kumar et al., 2021). One of the advantages over other printing methods is that it can be produced without the need for support, but supported production is the main principle. Another advantage is that metal products with higher strength than plastic and resin can be obtained.

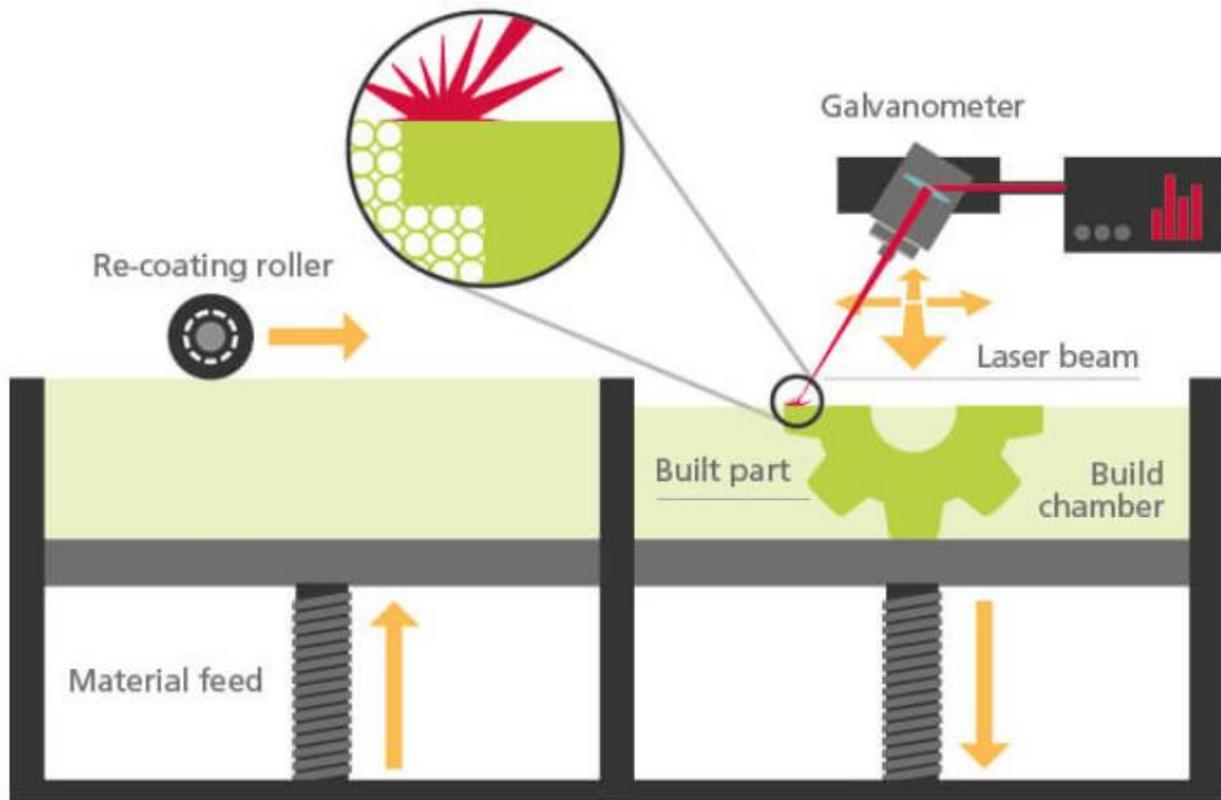


Figure 3. SLS Printer Working Principle (Olubummo et al., 2023)

D. Multi Jet Fusion (MJF)

Multi Jet Fusion (MJF), scans the print area with its inkjet nozzle and deposits “fusing agent” on a layer of white polymer powder. As the fusing agent thickens the white powder material, heat absorption increases and localized sintering of the powders occurs. At the same time, it deposits “detailing agent” on the borders of the part, which prevents sintering (Khorasani.,2024).

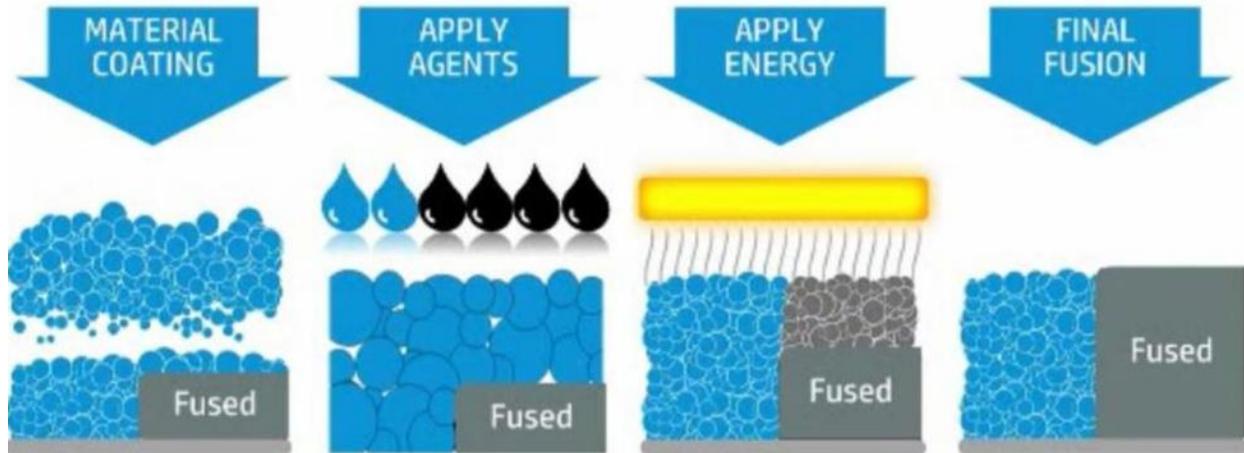


Figure 4. MJF Printer Working Principle (Olubummo et al., 2023)

E. Digital Light Processing (DLP)

DLP is similar to SLA but the light source is a projector. DLP 3D printers use a digital projector screen with a single image. DLP allows the entire layer to harden with a single flash. This technology has the advantage of fast and precise production (Chaudhary., 2023).

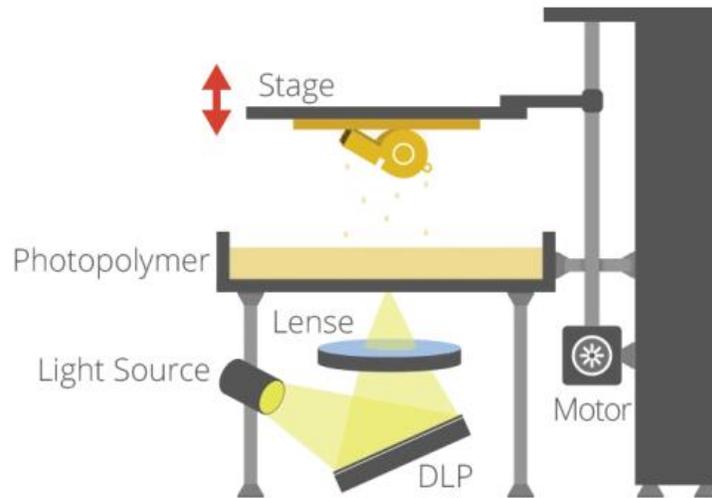


Figure 5. DLP Printer Working Principle (Sürmen., 2019)

Among the additive manufacturing methods mentioned above, the DLP method, which offers speed, cost and precision advantages and which we consider suitable for use in our products, was preferred.

2. Materials and Methods

2.1. Raw Material (Resin) + Domestic Production DLP Device

In our company, which manufactures for the automotive, aviation and medical sectors, the need for rapid modeling of prototype productions and production auxiliary materials needed before and during the production of these products has emerged.

For this reason, ESTAŞ A.Ş., which invested in additive manufacturing / rapid modeling technology, not only included DLP devices for rapid modeling in its production, but also produced DLP devices through the automation department within the company.

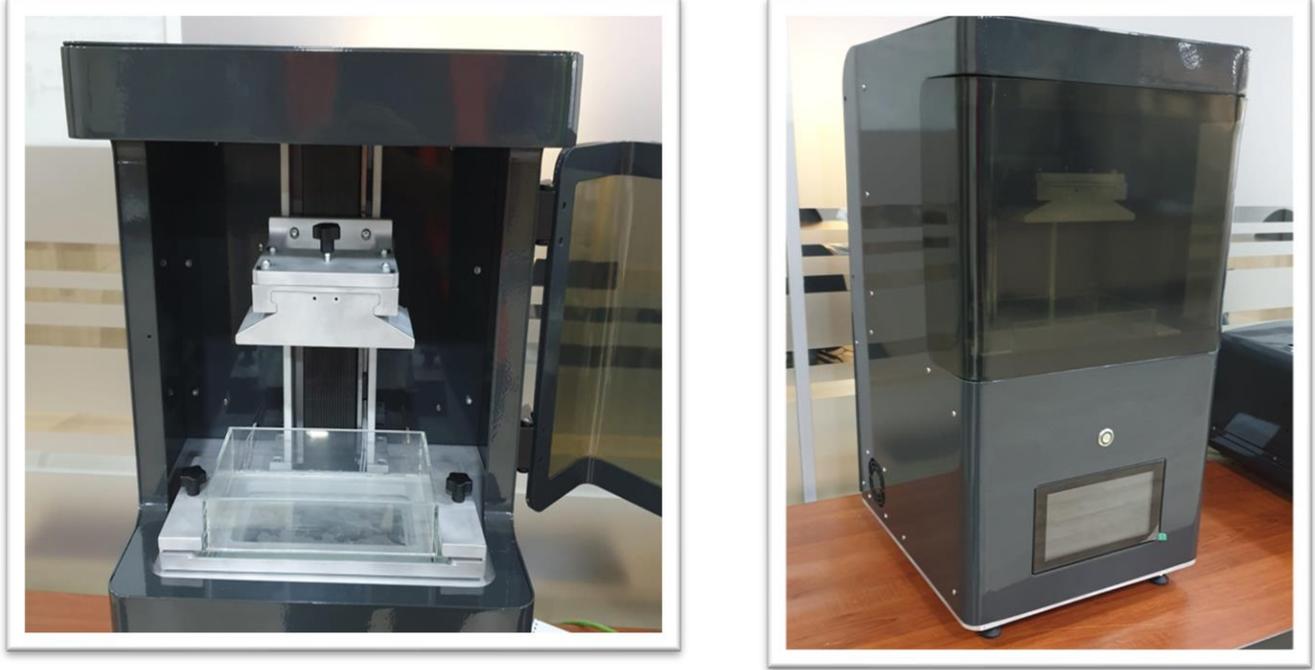


Figure 6. ESTAŞ A.Ş. Production DLP Printer



ESTECH
ESTAŞ OTOMATİK SİSTEMLER TASARIMI AR-GE

TECHNICAL SPECIFICATIONS PRINTING

TECHNOLOGY FAST DLP

Print Volume	: 12 cm x 6,8 cm
Z Layer Thickness	: 50 / 30 / 15 micron
Print Speed	: 60 mm / hour at 50 micron
Projector	: 385 nm / 405 nm options
Connectivity	: 5GHz Wi-Fi - USB Drive
Printer Control	: 7" Touch-screen
Printer Dimensions	: 32,5 cm x 32,5 cm x 56 cm
Printer Weight	: 22 Kg

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Figure 7. ESTAŞ A.Ş. Production DLP Printer Technical Details

In these devices, auxiliary products are produced that are planned to be offered to customers as final products and to be used in production as intermediate products.

Many raw materials (resins) produced as a result of R&D studies throughout the country are used in our company, as well as many raw materials are supplied from abroad and included in production.

These raw materials vary according to their intended use. Within the scope of this study, the parameters of some devices and resins working as a closed system have been studied for their use in our own production device.

Since there is no domestic production of the resins used in parameter studies, resins were obtained from abroad. In order to prevent foreign dependency on resins, local producers are contacted and R&D studies are carried out.

2.2. Why are these resins needed?

The resins for which parameter studies have been carried out have the properties to meet the needs of the sectors we serve by showing a stable resistance under high temperature and pressure.

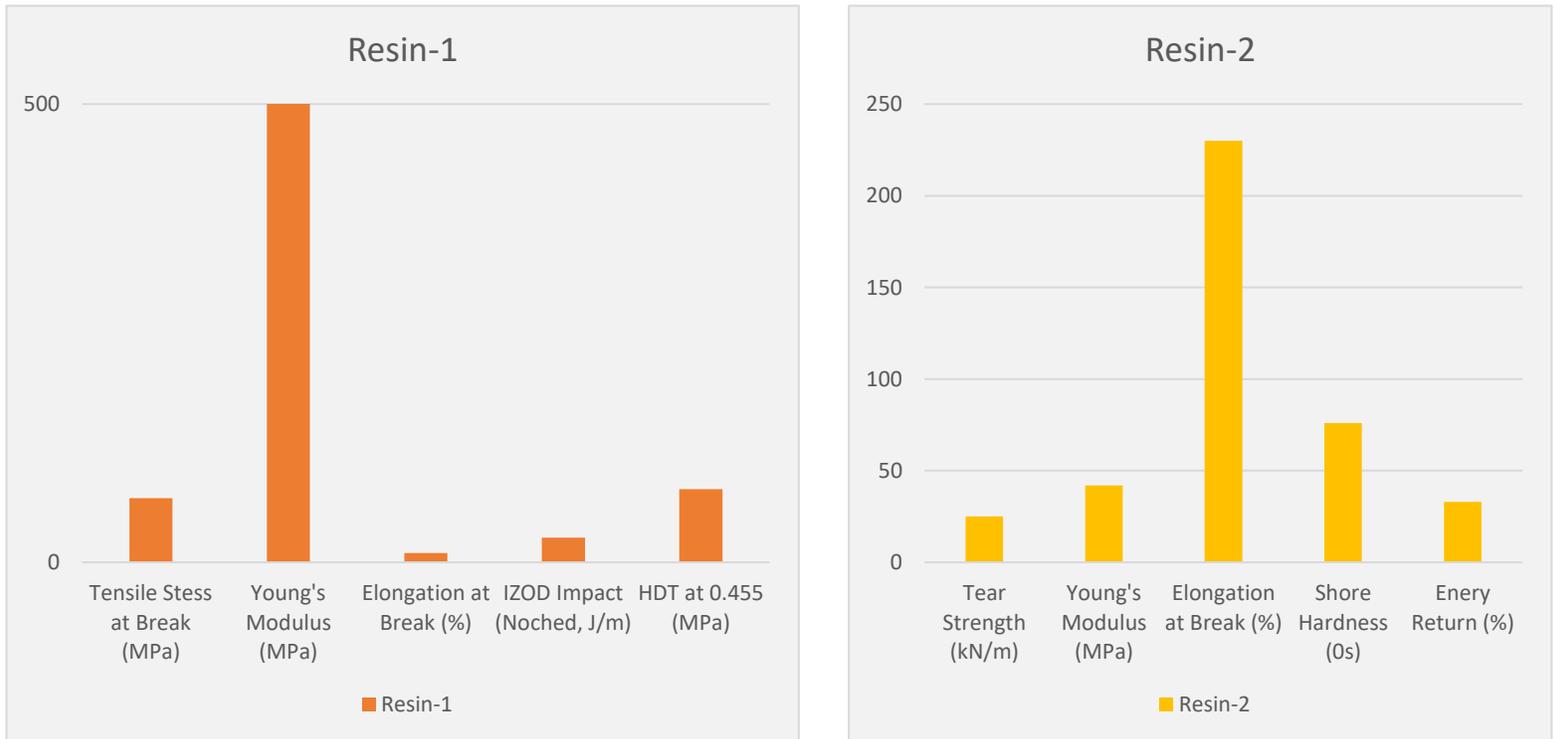


Figure 8 and Figure 9. Resin 1 and Resin 2 physical properties, respectively.

Due to the physical properties shown in Figure 8 and 9 it was deemed appropriate to be used as raw material in production.

3. Results

Parameter studies were carried out to be able to produce with these resins in our own made devices. Table 1 and Table 2 show the results of parameter studies of 2 different resins and these studies are supported by the following visuals.

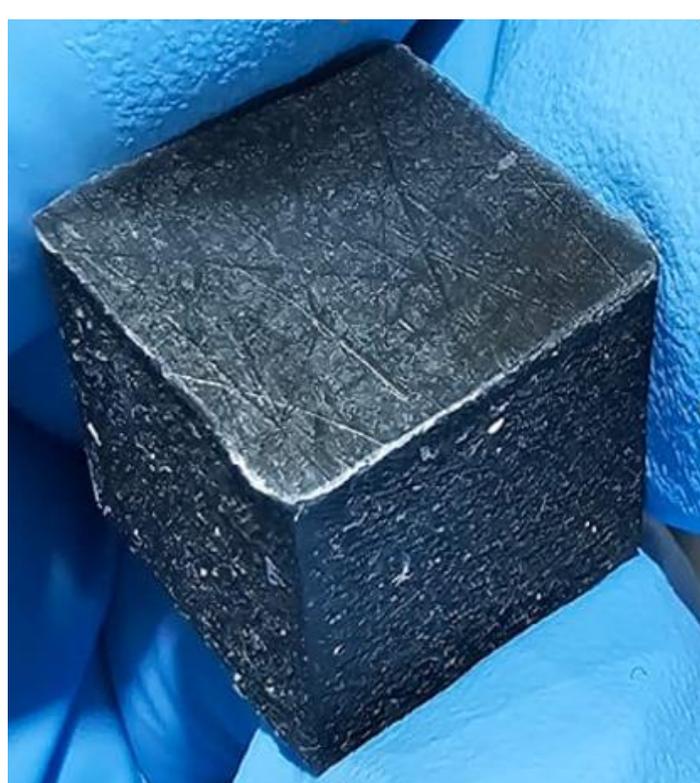
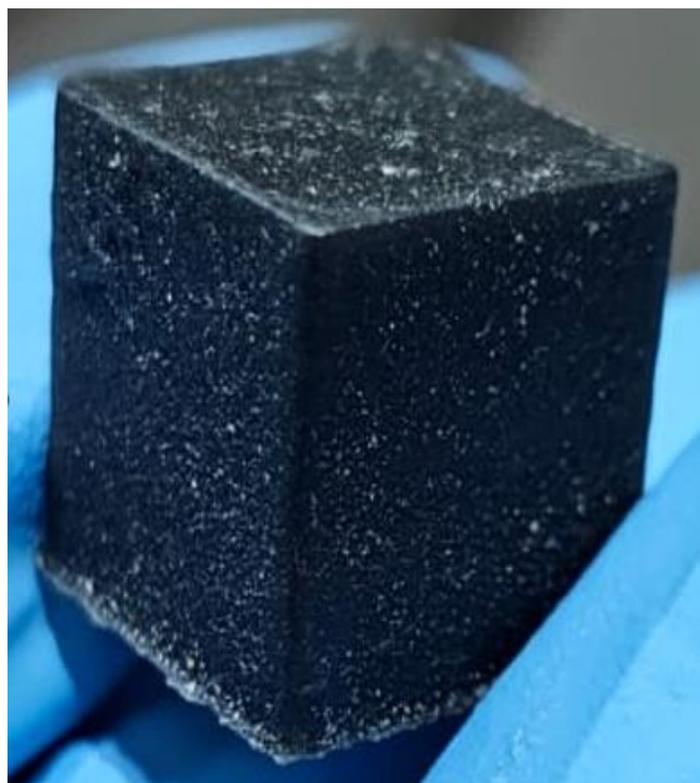
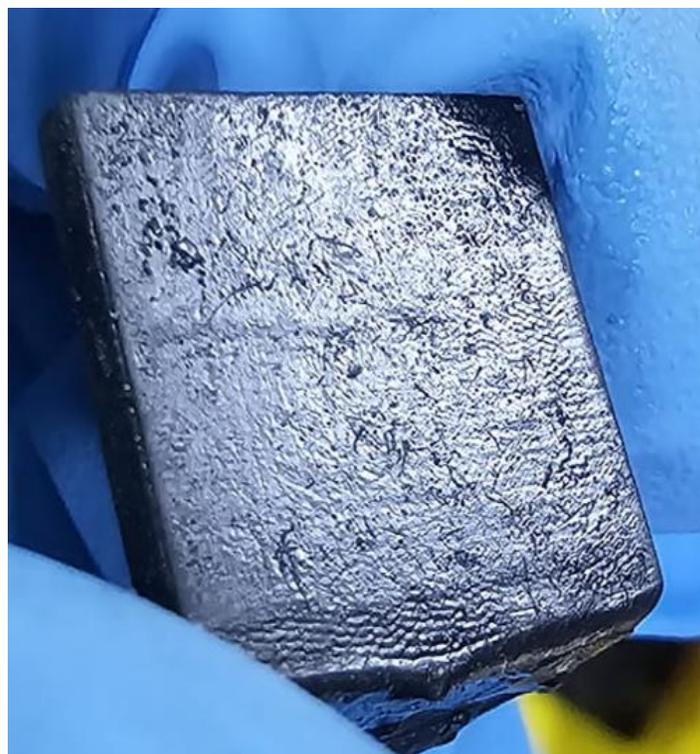
Table 1. ESTAŞ A.Ş. Production DLP Printer Parameter Study (Resin 1)

RESIN - 1 PARAMETER STUDIES								
TEST	LAYER THICKNESS (mm)	NUMBER OF BASE LAYERS	LIGHTING DURATION	BASE LIGHTING DURATION	SPEED OF RISE (mm)	WITHDRAWAL SPEED (mm)	INCREASE (mm)	RESULTS
TEST 1	0,1	10	6,5	6,5	20	120	1	Undesirable surface quality on the part
TEST 2	0,1	10	6,5	6,5	20	120	1	Undesirable surface quality on the part
TEST 3	0,1	10	6,5	6,5	20	120	1	Undesirable surface quality on the part
TEST 4	0,1	10	6,2	6,2	20	120	1	Undesirable surface quality on the part
TEST 5	0,1	10	6,2	6,2	20	100	1	Undesirable surface quality on the part
TEST 6	0,1	8	6,2	6,2	20	100	1	Undesirable surface quality on the part
TEST 7	0,1	8	6,2	6,2	20	100	1	Undesirable surface quality on the part
TEST 8	0,1	8	6	6	20	100	1	Undesirable surface quality on the part
TEST 9	0,1	8	6	6	20	100	1	Undesirable surface quality on the part
TEST 10	0,1	8	6	6	20	100	1	The product has the desired dimensions and surface quality.

Table 2. ESTAŞ A.Ş. Production DLP Printer Parameter Study (Resin 2)

RESIN - 2 PARAMETER STUDIES								
TEST	LAYER THICKNESS (mm)	NUMBER OF BASE LAYERS	LIGHTING DURATION	BASE LIGHTING DURATION	SPEED OF RISE (mm)	WITHDRAWAL SPEED (mm)	INCREASE (mm)	RESULTS
TEST 1	0,05	8	3	10	20	100	3	No parts formed
TEST 2	0,05	8	3	15	20	100	3	No parts formed
TEST 3	0,2	8	3	18	20	100	3	No parts formed
TEST 4	0,2	8	3	30	20	100	3	No parts formed
TEST 5	0,2	8	3	50	20	100	3	No parts formed
TEST 6	0,2	8	3	50	40	100	3	No parts formed
TEST 7	0,2	8	3	50	40	100	3	Undesirable surface quality on the part
TEST 8	0,2	8	3	50	40	100	3	Undesirable surface quality on the part
TEST 9	0,2	8	2	60	40	100	3	Undesirable surface quality on the part
TEST 10	0,1	8	2	60	40	100	3	The product has the desired dimensions and surface quality.

Sample images of the products received as a result of the productions are below.



4. Discussion and Conclusion

The parameters reached after the studies have been widely used in DLP devices produced by our company after it has been proven by measurements that the products produced by our company provide mechanical and dimensional accuracy.

In order to reduce foreign dependency on these resins, local resin producers were contacted and formulation studies were started.

Acknowledge

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