RAISE3D

Raise3D DF2: Enhancing Resin Printing Success Using RFID Traceble Workflow and Advanced Software Features

White Paper

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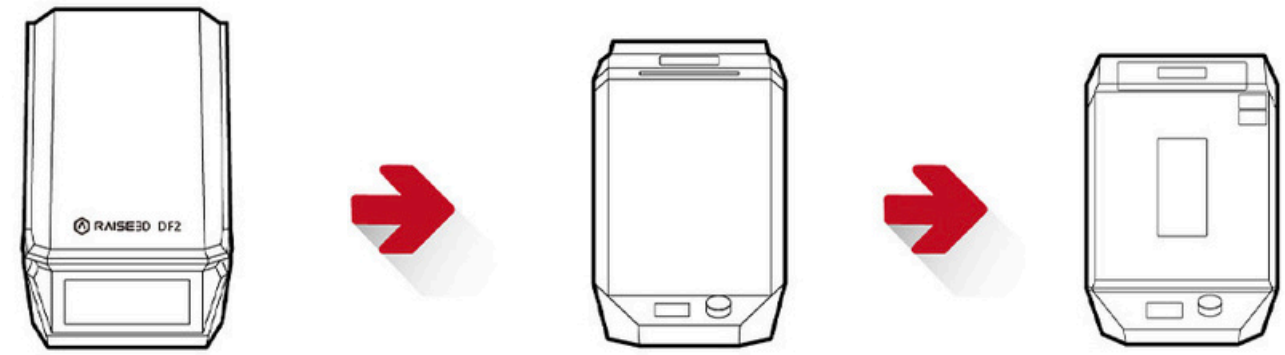
1 Abstract

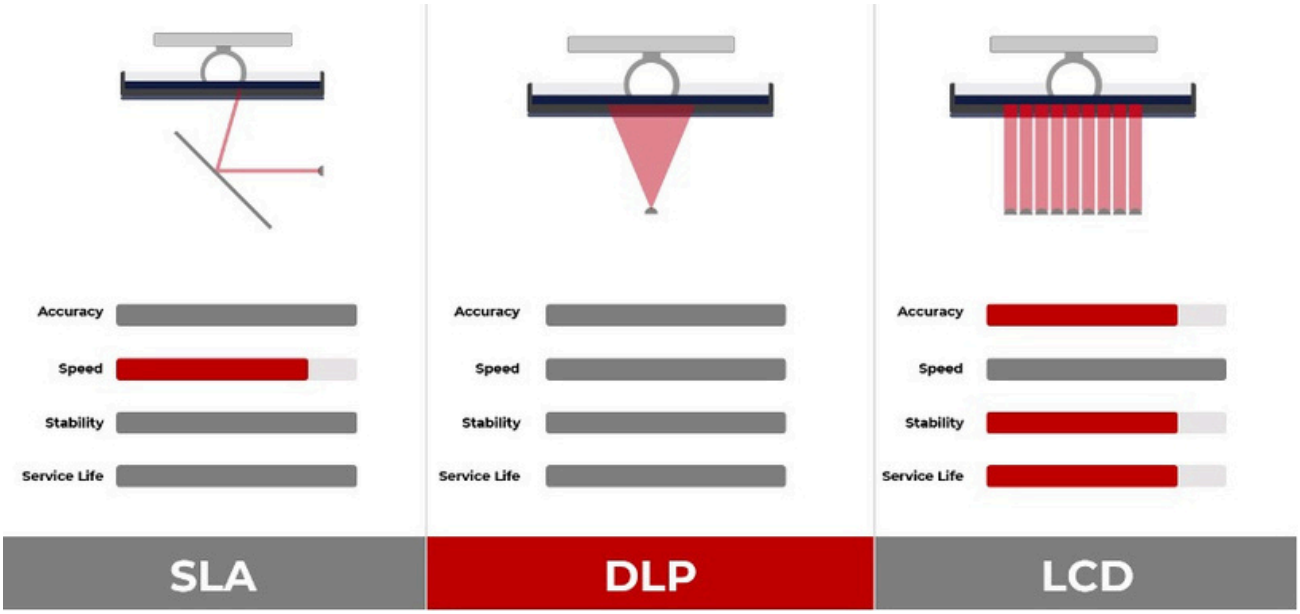
- Resin 3D printing offers many benefits and opportunities for engineers, manufacturers, and dental and medical applications, including high printing speeds, smooth surface quality, fine details, and a wide variety of material selections. However, resin 3D printing has also traditionally been a complicated process which requires frequent manual intervention and a high level of operational expertise. This can be inefficient to manage and inconsistent for scaling up. This white paper will discuss how the Raise3D DF2 Solution mitigates the many challenges of resin printing, particularly Digital Light Processing (DLP), with a focus on software and post-processing improvements that includes slicing software, the printer's terminal touch software, and RFID workflow.

2 Opportunities

- DLP (Digital Light Processing) is a 3D printing process that uses photopolymerization to create highly detailed and smooth models. Liquid resin is cured layer by layer with a UV light source, resulting in prints with a high resolution. As with other types of resin printing, such as SLA and LCD, the DLP process offers the benefits of intricate detail, better accuracy, machine stability and service life. However, as with any resin 3D printing process, it is also hindered by a variety of challenges.



Printing Washing Curing



3 Challenges

- Resin 3D printing yields precise and detailed results when successful but is often at risk for print failure due to its complexity. It also requires additional time and labor compared to other 3D printing processes due to the many steps involved in post-processing after printing the green parts, such as washing and curing. The parameters for washing and curing must be continually adjusted and manually entered depending on the resin material, which can lead to inconsistencies and errors from human intervention. Such complexity also makes it difficult to scale up production.

If the resin 3D printing process could be streamlined, with a higher first print success rate, it would be a much more viable technology for both engineering and end-use parts. With this in mind, the Raise3D DF2 Solution was designed to mitigate the many challenges of the resin printing process, improving printing efficiency, first print success rate, and the final quality of printed parts.

The DF2 hardware, software, material, and printing and post-processing parameters have been specially optimized to increase printing efficiency and ensure the best possible chance of DLP first print success. In addition, the RFID-powered smart build plate provides a traceable workflow for a faster, more efficient process with reduced chances of manual error.

This article will focus on the key role of DF2 software in simplifying and improving the resin printing process, including the slicing software ideaMaker and the terminal touch software RaiseTouch in combination with the RFID-powered smart build plate.

4 Increasing Resin First Print Success Rate

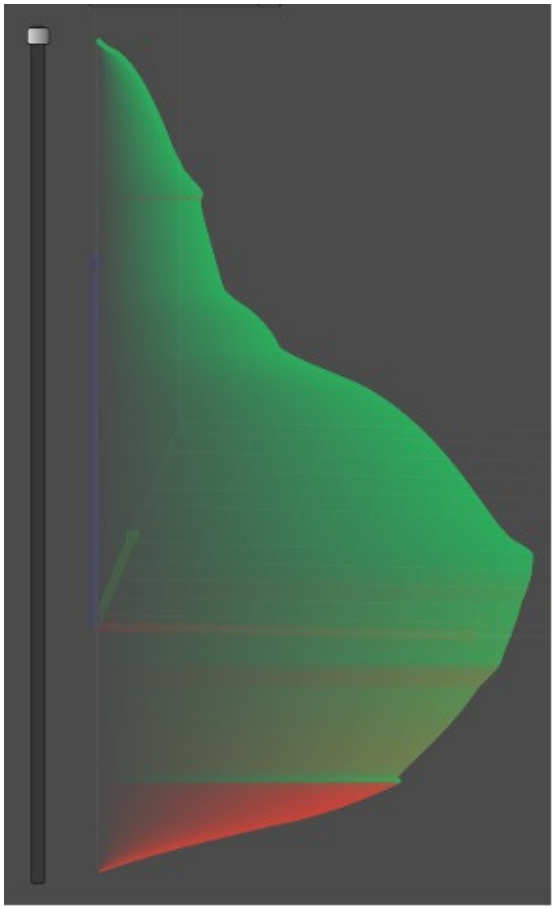
- Slicing software is the most commonly used software in the 3D printing process. The main purpose of slicing software is to output machine processing commands (usually Gcode files) to control the printer to print out the preset parts. However, in addition to this, slicing software can integrate a variety of pre-test simulations, print planning, and other features to improve print results.

The following is an example of applications using some of the most common features of ideaMaker slicing software. These features are designed to mitigate certain challenges and complications of DLP printing in the software stage for more efficient printing, higher quality prints, and a higher first print success rate.

Failure Risk Detection:

There are multiple points in the traditional DLP process where print failure can occur. The following algorithmic detections have been implemented in ideaMaker to catch these potential failures and increase first print success rate:

Auto Orientation: One of the most important considerations when planning a resin print is positioning the model in an appropriate orientation to improve print results. This can be difficult for novice users who don't have much experience with resin printing. The **Auto-Orientation** feature, currently in beta, was implemented to shorten the learning curve for these users in achieving successful prints. Auto-Orientation algorithmically detects several printing failure risks and calculates how to avoid print problems such as cupping and uneven cross-sections by suggesting a safer model orientation.



Cross-Section Analysis:

Peel forces occur as the build platform rises and the cured layer separates from the resin tank before starting a new layer. This can lead to print defects such as warping, delamination, or distortion.

This is especially critical when the model has sudden cross-sectional area changes. To assist the user, the ideaMaker slicing software calculates cross-sectional areas and displays them in a graphical form, as it can be observed in the picture below.

ideaMaker's **Cross-Section Analyze** function visualizes cross-section sizes, highlighting layers with sudden changes so that the user can adjust the model accordingly. This detection feature is integrated into One-Click Print for novice users and offers fine-tuning capabilities for advanced users.

Suction Cup Detection:
Print failures can result from cavities inside the model that create vacuums between the model and resin film, disrupting resin flow and causing failures. ideaMaker's **Detect Suction Cup** feature detects and alerts users to inverted cupping when slicing manually or automatically. Once alerted, the user can optimize the model orientation to avoid the issue.

Shrinkage Compensation:

DLP is often used to print parts for precision assembly purposes because of its very high printing accuracy. However, the resin material itself has a tendency to shrink after curing, making the tolerance of the part too large and leading to assembly failure.

Resin curing occurs in both the printing and the curing procedure. Compensation for shrinkage in the digital model before printing can prevent this defect.

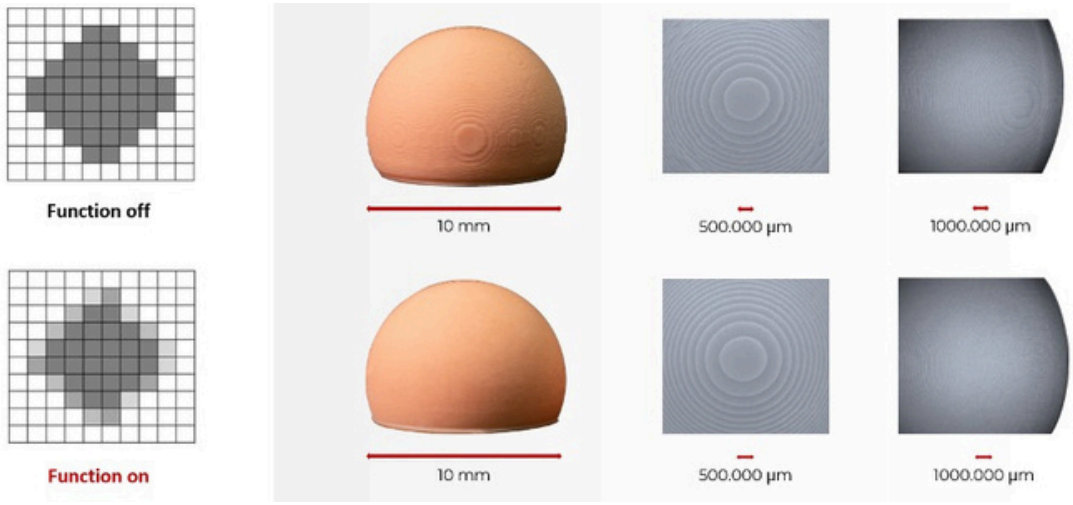
There are currently two dominant strategies for shrinkage compensation. One is to globally scale the original dimensions of the digital model, which is commonly used with entry-level light-curing printing devices. This is simpler to implement and more limited in effect, as the shrinkage rate of curing is different for different wall thicknesses.

The other is to perform size compensation based on the outline of each layer when slicing. While the average resin shrinkage is about 3%, each resin material is actually slightly different, so the specific parameters of the shrinkage compensation in the slicing software need to be tailored for every material.

In ideaMaker, the compensation parameters are nested within each material template and can be additionally adjusted by the user at to ensure that each material matches the exact shrinkage compensation parameters at print time.

Anti-Aliasing:

When a pixel is activated during the resin printing process, it directs light onto the resin, causing it to harden and form a specific part of the object being printed. Conversely, when a pixel is inactive, no light reaches the resin, so that area remains soft. As a result, when examining a resin 3D-printed object up close, a pixelated appearance on its surface will be noticeable, similar to how images appear pixelated when zoomed in on a digital screen.



Anti-Aliasing was developed to smooth out these pixelated edges by setting the pixels on the edges of the model to a gray color, creating smoother transitions between layers. In ideaMaker, this function is integrated into the material profile. **Anti-Aliasing** blurs the edges of the cross-section of each layer to improve the surface smoothness, and at the same time automatically retains the details of the small model. This ensures that the continuous surface area is relatively smoother while the detailed surface area matches its original contour.

Hollow & Drainage:

When using FFF technology, users can optimize material usage by lowering the infill percentage. To reduce material usage in resin printing and lower the cost of resin parts, the part can be hollowed. For models with hollow spaces, it is essential to incorporate drainage holes to avoid suction cupping. Drainage holes are also useful when rinsing the printed part.

ideaMaker's Hollow automatically creates a shell with a user-defined wall thickness, while the Drainage tool adds drainage holes to the hollowed shell. Users can customize the position and diameter of these holes to better suit their needs.

Lattice Support

Resin printing requires caution in three areas when generating supports:

- **Stability During Peeling**: For resin printing, each cured section needs enough tension to overcome the peel force from the resin tank and the weight of the printed part.
- **Surface Smoothness**: Areas needing support structures can be rough after removal. Supports must be placed and designed to minimize surface roughness.
- **Material Efficiency**: Resin is expensive, making dot structure support ideal for resin printing. However, pillar supports made from resin are harder to remove than the sheet supports used for FFF. Optimizing the amount of support improves slicing and post-processing efficiency

ideaMaker's automated support generation algorithm boosts efficiency by considering parameters like support position, density, angle, and strength. Users can also adjust the algorithm parameters manually.

Lattice Support in ideaMaker reduces support density while maintaining support strength. It uses less material and is easier to remove without leaving significant marks.

5 Creating an End-to-End Traceable DLP Workflow

- Any 3D printing process requires the material, equipment, and printing parameters to be consistent with one another. DLP printing requires extra steps to ensure this consistency because of the additional washing and curing stages. Due to the complexity of the workflow, there is a great need for traceability throughout production.

The operating parameters of DLP printer, washing equipment, and curing equipment need to match the material being used. Efficient traceability of all procedure parameters is a necessary demand. To meet this need, the Raise3D DF2 Solution uses a self-contained RFID build platform as the only channel for parameter exchange throughout the process. Combined with the DF2 Printer's terminal touch software RaiseTouch, this technology allows users to verify that all correct parameters are in order and to trace the workflow through the printing, washing, and curing stages.

Full Process Parameter Generation & RFID Workflow:

Depending on the application, users will use different resin materials with different properties to print parts. The choice of material is at the source of the DF2 workflow. The downstream hardware process must be adjusted in accordance with each new material; this includes parameters such as the curing time of each layer, printing chamber temperature, washing time, curing band, and more.

This adjustment involves many more parameters compared to the FFF printing workflow. As such, the software's material profile is critical, because it can generate the machine code for downstream procedures. The wider the parameter coverage of the material profile, the more efficient and effective the workflow will be.

ideaMaker provides a material profile for each resin material product from Raise3D. After the user selects the corresponding profile with a single click, ideaMaker automatically locks all the parameters for downstream printing, washing and curing.

The cleaning and curing parameters in the profile are subsequently written onto the RFID tag on the smart build platform via RaiseTouch. This reduces the manual intervention necessary for each step of the process while also ensuring consistency and compliance across the entire workflow.

Automatic Pilot Pre-Check:

A prerequisite for resin printing success is the precise alignment of multiple conditions. This includes:

- Printer functions are running correctly
- The print chamber hatch is closed to filter external UV light
- Resin type matches slicing parameters
- Resin tanks have enough resin for a single print task
- Resin tank and build platform are accurately installed

For successful prints, the DLP software should gather the data related to the above conditions and confirm whether they are all set and ready to start printing.

RaiseTouch collects data on the status of the relevant components on the machine and performs an inspection after the user confirms the print job, indicating to the user whether each condition is met or not. Before printing, RaiseTouch software also verifies resin tank and bottle data, ensuring the printer has the correct resin loaded to prevent failed prints.

Magic Layout:

After the slicing process, the RaiseTouch terminal on the DF2 Printer becomes a tool for users to fine-tune prints. The Magic Layout feature allows users to confidently analyze the print film status, move parts within the print area, and even duplicate or delete models.

This type of modification can make a significant difference boosting productivity. The operator can quickly adapt the file to meet the company's production needs in the printer itself. These changes do not require the operator to have an in-depth knowledge of 3D printing, and can be implemented without needing to re-slice all the models. This not only simplifies the process but also drastically reduces the total labor time, making the operator's job more efficient and less time-consuming.

6 Overview of the Raise3D DF2 Solution

- The DF2 Solution was designed for end-to-end traceability and greater first print success for resin prints. A walkthrough the workflow after slicing shows the effectiveness of both software and hardware in creating an effective traceable workflow that minimizes the amount of required labor:

DF2 Printer:

The DF2 resin printer is a high-performance machine. When combined with the feeding station, it constitutes an ideal setup for prototype printing and small batch productions.

The DF2 printer has a build volume of 200x112x300 mm and a print speed of 25 mm/hour, allowing for efficient production runs, which makes it ideal for both small-batch production and rapid prototyping. In addition, the printer can handle parts with a maximum weight of 10 kg, expanding its versatility for various applications.

The heated chamber makes the printer more environment temperature-independent, reliable, and compatible with a greater number of resins. The printer is equipped with a smart tank that stores information about the resin previously used, ensuring consistency and reducing operational errors during resin changes.

The DF2 printer comes factory-calibrated and is ready for immediate use, saving labor time. It also has a built-in resin level detection and a smart build plate that stores all the parameters for the printing process, simplifying the workflow and reducing the chance of manual errors.

The terminal touch software RaiseTouch is used to verify that all printing conditions are met before printing, and can also be used to adjust models without returning to the slicing software.

Resin Auto-Feeding Station:

During the pre-check process, the resin volume required by the print task and remaining resin volume in the machine are validated by the RaiseTouch software. If refilling is required, it will be done through the Auto-Feeding Station before printing, or it will remind the user to manually refill the resin and prepare more resin ahead of time. This feature avoids a break in the middle of a print run which may ultimately affect the quality of the model.

DF Wash:

The DF Wash is compatible with solvents such as Isopropyl alcohol (IPA), water, and TPM. For an efficient washing process, the machine has a twin-turbo propeller and incorporates a dryer system.

After the print process, all the necessary parameters to complete the process are saved in the smart build plate. This feature facilitates the operator's work during the wash and curing process, ensuring optimal settings with just a touch between the smart build plate and the wash and cure machines. This reduces the chance of selecting incorrect parameters and minimizes the need for manual adjustments.

DF Cure:

The cure station is the final part of the DLP process. Similar to the DF Wash, the operator does not need to remember the parameters for curing. All the necessary information is stored in the smart build plate. With just a touch between the smart build plate and the curing station, all the parameters are instantaneously downloaded to the curing station. As with the wash station, the operator can always fine-tune the parameters if needed.

The cure station has a heated chamber reaching up to 120°C. It also has three light sources with different wavelengths: 365nm, 385nm, and 405nm combined. This combination allows for the curing of all Raise3D resins and most resins available on the market.

Open Source Materials:

Because material profiles are so integral to a traceable DLP process, the design of the print profiles themselves require much more rigorous testing for each step than FFF printing. The Raise3D DF2 offers an open platform to expand the number of material profiles via the Open Resin Program (ORP). Additionally, collaborations with professional material manufacturers such as LOCTITE and BASF Forward AM allow the validation of more resins and material profiles, allowing customers to print with a greater variety of materials and supporting more applications.

ideaMaker slicing software allows user to adjust and modify the printing profiles for their unique application needs.

7 Conclusion

- The Raise3D DF2 Solution represents a significant advancement in resin printing technology, offering a streamlined and precise workflow. The DF2 printer is optimized for rapid prototyping and small-batch production, combining high-speed printing capabilities and efficient production runs. The printer's smart features, such as the smart tank and smart build plate, ensure consistent performance and minimize operational errors.

The solution integrates feeding, wash, and cure stations, which automate and optimize post-processing. These stations support a wide range of resins, including both Raise3D's engineering resins and third-party options through the Open Resin Program, offering flexibility in material selection.

ideaMaker slicing software enhances print quality and first print success with features like automated support generation, automated orientation features, and layer-by-layer shrinkage compensation, tailored to the specific properties of each resin. The terminal software RaiseTouch is used to verify printing parameters and reduce the chance of printing error. The emphasis on production traceability, facilitated by RFID technology, ensures reliable and consistent outcomes throughout the printing, washing, and curing stages.

In summary, the Raise3D DF2 Solution provides a robust and versatile platform for applications requiring high-resolution and detailed prints, making it well-suited for fields such as dental modeling, engineering prototyping, and low-volume production.

RAISE3D

13310 Pike Rd, Stafford
TX 77477
+1-888 963 9028

Stationsplein 45
Unit A4.004 3013AK
Rotterdam the Netherlands

Floor 4 B5, 1688 North Guoquan
Road, Yangpu District Shanghai
200438
China

inquiry@raise3d.com