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# Development of Wear Resistance Polymer Composites using Stereolithography Technique

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**ABSTRACT:** 3D Printing or Stereo lithography (SLA) Process is based on the principle of Additive Manufacturing (AM) that builds the plastic components in layer by layer process. It is a kind of process in which components are built like layer by layer. Stereolithography (SLA) is a layer-by-layer additive manufacturing technology that employs a liquid resin to construct three-dimensional objects. It is one of the most extensively used and oldest 3D printing technologies. Stereolithography works by selectively hardening a liquid photopolymer resin using ultraviolet (UV) light. Using computer-aided design (CAD) software, a 3D model of the desired product is created to begin the SLA process. After that, the model is cut into thin cross-sectional layers. A vat of liquid photopolymer resin is created, and the resin is generally UV light sensitive. Based on the sliced data, a construction platform is lowered into the resin tank, and a UV laser or projector selectively exposes the initial layer of resin. The exposed resin solidifies or polymerizes as a result of the UV radiation, but the unexposed resin stays liquid. When the first layer is finished, the construction platform is lifted slightly and a new layer of liquid resin is put over the previous layer. The UV light then hardens the new layer selectively, attaching it to the prior layer. This layer-by-layer construction procedure is repeated until the complete thing is formed. The item is carefully removed from the resin tank once the printing is completed. Excess resin is normally cleaned away before curing the product under UV light to attain its final mechanical qualities. This phase in the post-processing procedure assures the object's stability and strength. In comparison to other additive manufacturing technologies, stereolithography has various benefits. For starters, it produces extremely detailed parts with smooth surfaces while maintaining high accuracy and surface polish. This makes it appropriate for applications requiring accuracy and fine details, such as prototyping, jewellery creation, and dentistry models. SLA also works with a variety of materials with varying qualities, including as hard, flexible, translucent, and high-temperature resistant resins. This adaptability enables the development of functioning prototypes and end-use products for a variety of sectors. SLA is often quicker than other additive manufacturing technologies such as fused deposition modelling (FDM). It may use a laser or projector to harden a whole layer at once, saving printing time.

**KEYWORDS:** Photo polymer Resin , TiO<sub>2</sub> ,

## I. INTRODUCTION

The Stereolithography (SLA) technology, which is well-known for its capabilities in the field of additive manufacturing, is utilised extensively in the process of producing parts utilising a variety of materials. SLA has typically concentrated on thermoplastics and resins; however, broadening the variety of applications for this technology necessitates the creation of new materials that meet certain requirements for dimensional accuracy, mechanical strength, and other properties. The use of polymer-based composites with reinforcing fillers presents the opportunity to improve the qualities of the SLA parts and to broaden the range of applications for which they can be used.

In engineering applications, polymer composites are preferred due to the lightweight nature of the material and the cost-effectiveness of the material. The mechanical properties of the polymer matrix can be greatly improved with the incorporation of reinforcement elements like as ceramics, metals, fibreglass, or carbon fibre, which can also increase the potential uses of the polymer matrix. Titanium Dioxide (TiO<sub>2</sub>) is one type of reinforcing material that has attracted a lot of attention recently.

TiO<sub>2</sub> is a multipurpose material that is recognised for its high strength and stiffness as well as its exceptional tribological qualities. The use of titanium dioxide (TiO<sub>2</sub>) as a filler in selective laser sintering (SLA) resins enables the production of SLA parts that have improved tribological and mechanical qualities. This becomes absolutely important

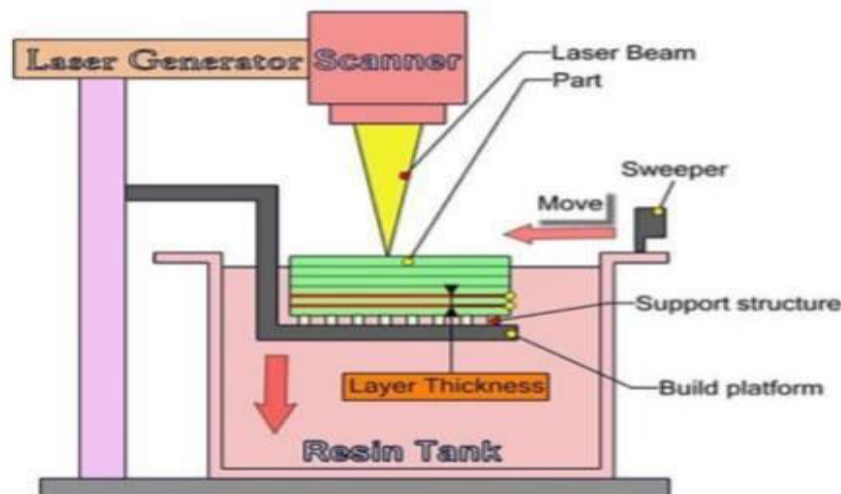
in industries such as aircraft and electronics, as well as medical professions, which need to adhere to high performance requirements.

## II. RELATED WORK

### Stereo lithography Process

Based on the review presented in the previous section, it is clear that there is a wide range of liquid materials that can be used by AM technologies. SL Process has a variety of liquid resin that are available; in addition, it has been one of the most significant AM technologies as it has the best part accuracy compared to other AM processes. It is one of the technologies that is considered to be suitable as a future manufacturing process. That's why it was selected in this work and this section provides further details about the technology. SL is a photo polymerization process which changes the liquid photopolymer resin into solid by using an ultra violet (UV) laser beam, thus it relies on laser power to convert a liquid resin into solid.

In 1987, 3D Systems introduced the first commercialized Rapid manufacturing technology system based on stereolithography (SL), and the system called Stereolithography Apparatus (SLA). Although many other techniques have been developed, SL remains one of the most powerful and versatile of all AM processes. It has the highest fabrication accuracy and an increasing number of materials that can be processed is becoming available.



Three Stages in Stereo lithography Process The three stages in the SL process are:

1. Pre-build stage: in which several preparation tasks before fabrication are performed like STL Conversion, slicing and support generation (if needed).
2. Build stage: in which the building process of the part is carried out.
3. Post processing stage: in which cleaning, removing excessive resin and postcuring process (if needed) takes place.
4. In the second stage, the part building process in SL. Takes place on a movable platform which is positioned below the liquid resin surface as shown in Figure.

## III. METHODOLOGY

Following the experimental procedure indicated below, polymer composite constructed using the stereo lithography (SLA) process, with a UV resin serving as the matrix material and titanium dioxide (TiO) serving as the filler material.

Based on the intended qualities and the needs of the application, the desired loading level of titanium dioxide inside the resin matrix (Owt%, Iwt %). After determining the desired loading level, the right quantity of UV resin. Measured by weight, and the required quantity of titanium dioxide was determined through measurement. In order to guarantee consistent outcomes, accurate ratios were kept throughout. After measuring out the required quantity of UV resin, it was transferred to an appropriate container before the mixture was mixed. The powdered titanium dioxide mixed into the resin in a slow and steady stream while stirring was maintained throughout. A thorough mixing process assured that

the filler would be distributed uniformly throughout the resin matrix. The use of sonication or mechanical mixing was employed in order to facilitate consistent blending.

In order to eliminate any air bubbles that may have been produced as a result of the mixing operation, the resin mixture sometimes degassed in a vacuum chamber. This process improved the overall quality of the composite as well as its properties. Before beginning the procedure, the SLA equipment was readied, and the build platform was calibrated to its specific dimensions. The vat of the SLA printer was loaded with the newly mixed resin, which also included titanium dioxide at this point. Initiation of the SLA process was carried out in accordance with the instructions supplied by the printer manufacturer. While being subjected to UV light, the resin became more rigid and began to build up layers.

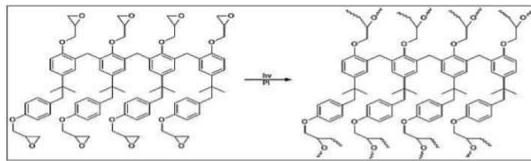


Fig 4.1 Chemical structure of Photopolymer resin



Fig Photopolymer Resin

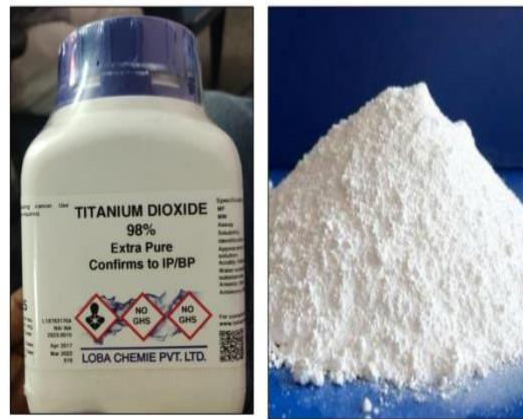


Fig. Titanium dioxide powder

#### IV. EXPERIMENTAL RESULTS

##### Morphology of SIA parts

When evaluating the quality and properties of SLA (stereolithography) parts that have been generated under a variety of printing settings, including those that use titanium dioxide filler material, macrostructure analysis plays a vital role. In order to provide an encompassing evaluation of these components, microstructural investigations are also carried out. These investigations provide vital insights into the general structure and internal aspects of the printed parts, which contribute to the evaluation of the printed goods' mechanical

Properties, dimensional correctness, and surface quality. When conducting an analysis of the macrostructure, particular attention is paid to the overarching structure as well as the exterior qualities of the printed elements. This analysis includes both a visual inspection and the measurement of several different macroscopic characteristics. In the case of SLA parts filled with titanium dioxide, the inspection seeks to

Locate any obvious flaws that may have an effect on the components' overall quality as well as their ability to perform their intended functions.

The process of measuring and comparing the dimensions of the printed item with the specifications of the intended design is an essential component of the macrostructure analysis. This verifies the accuracy of the part's dimensions by ensuring that their measurements correspond to the output that is expected. In addition, the exterior characteristics of the object, such as its surface finish and layer adhesion, as well as the presence of any obvious flaws or imperfections, are scrutinized. In the case of both unfilled and titanium dioxide-filled SLA parts, the purpose of the study is to verify that there are no obvious flaws that could compromise the components' overall quality as well as their performance. With the use of macrostructure analysis, any inconsistencies or irregularities in the printed parts can be located and pinpointed. This opens the door for modifications to be made to the printing process or the parameters of the design in order to improve the overall quality and attributes of the finished product. It gives critical input on the overall structure, dimensional accuracy, and exterior appearance of SLA components, ensuring that they fulfill the needed requirements and display the desired mechanical qualities and surface quality. Specifically, it ensures that the parts have a smooth surface and accurate dimensions.



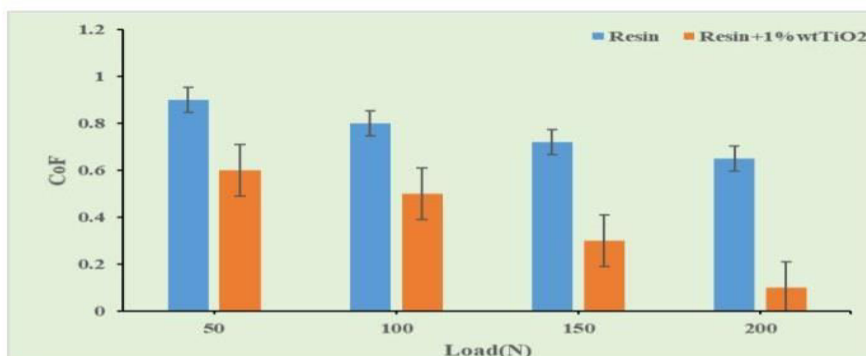


Fig. Effect of Titanium oxide filler on hardness

Table-1: Experimental Reading details

Samples	Shore D Hardness
Resin	58
Resin+1%wtTiO <sub>2</sub>	72

**Effect of Load**



Effect of Load on COF

Table-3: Experimental Reading details

	Resin	Resin+1%wtTiO <sub>2</sub>
50	0.9	0.6
100	0.8	0.5
150	0.72	0.3
200	0.65	0.1

**V. CONCLUSION**

1. The incorporation of TiO<sub>2</sub> fillers into SLA parts improves wear resistance and lowers the coefficient of friction significantly. This improvement suggests that TiO<sub>2</sub> reinforcement is important in improving the tribological performance of composites.
2. There is an increase in wear loss when the load applied to both unfilled and TiO<sub>2</sub>- filled SLA parts increases. This result suggests that higher loads impose greater mechanical stresses on the materials, resulting in more material removal during sliding. As a result, wear loss is accentuated.
3. In contrast, the coefficient of friction of both unfilled and TiO<sub>2</sub>-filled SLA parts decreases with increasing load. The lower coefficient of friction can be attributed to the larger contact area and lower contact pressure caused by higher loads. The larger contact area spreads the applied load over a larger surface, reducing frictional resistance and lowering the coefficient of friction.

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