Structural Beam Based Continuous Stereolithography (SBCS) for Rapid Continuous Additive Manufacturing

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1. RESEARCH QUESTION

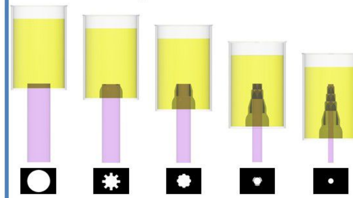
Additive Manufacturing (AM) also known as 3D printing is the technological advancement and a transformative approach that can bring flexibility and efficiency to manufacturing operations. The currently available additive manufacturing processes like Fused Deposition Modelling (FDM), Direct Ink Writing and Laser-based SLA, manufacture the part in a layer-by-layer basis. This layer-based approach results in a stair-case effect most evidently on curved and inclined surfaces of the built part. Porosity introduced by layered manufacturing leads to lower mechanical performance and surface anisotropy. Additionally, layer-based printing accounts for lower printing speeds. This proposed research addresses these problems by developing a continuous 3D printer that can print uniform parts within seconds with no surface irregularities.

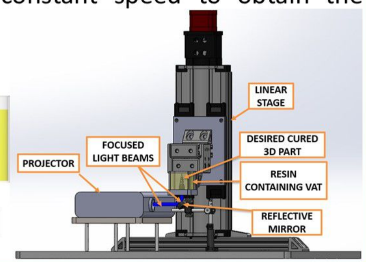
2. ABSTRACT

Conventional manufacturing involves enormous waste materials and consumes a lot of energy and time. Additive Manufacturing provides a sustainable manufacturing environment with zero waste and possesses the ability to produce parts within minutes. However, parts produced from currently available additive manufacturing systems are layer-based and demonstrate surface irregularities. The proposed research is focused on analyzing structural beam-based 3D printing that allows continuous, ultra-fast and defect-less printing of parts with a wide range of applications in biomedical and tissue engineering, bio-inspired structures, optics, electronics, and automotive engineering.

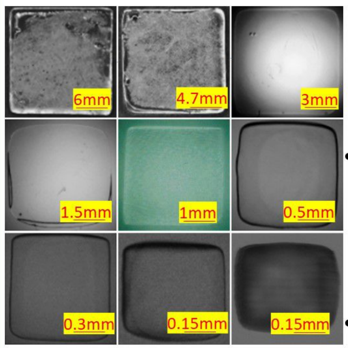
3. PRINCIPLE OF SBCS

As its name suggests SBCS is based on stereolithography (SLA). In SLA, the 2D cross-sectional image of a part to be produced is projected on the transparent vat containing liquid photopolymer resin. The projector produces the visible UV light and cures the resin to form one layer of a part. However, in SBCS to ensure continuous layer-less printing the vat is continuously lowered at a constant speed to obtain the desired 3D part.





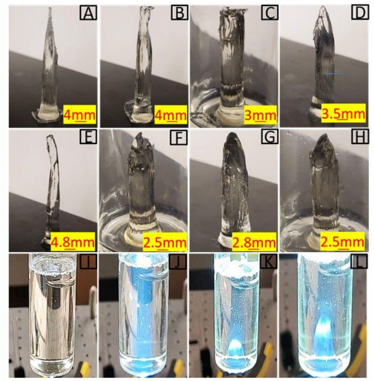
4. CURING DEPTH EXPERIMENT



- Curing Experiments were conducted to understand the curing characteristics of the resin and its behavior with the visible UV light.
- The exposure times required to cure the parts ranging from 10 pixels (70 microns) to 1000 pixels (7000 microns) were determined.
- The images demonstrate the accuracy of SBCS.

5. CONTINUOUS PRINTING EXPERIMENT

Continuous printing of parts was accomplished by optimizing printing speeds. Images A through H illustrate the printed parts with printing speeds ranging from 0.35 mm/s to 1.4mm/s to print a cylinder with a height of 25 mm. An optimum speed of 0.7mm/s was achieved to print the part. Video generated from the cross-sectional images is projected to ensure continuous printing of the 3D part.



- Light attenuation, light accumulation and thermal experiments were conducted to understand the energy absorption and dissipation properties of the resin.
- Images I through L were taken during an actual printing experiment.

6. SUMMARY AND FUTURE WORK

Two projectors, projecting lights of different wavelengths can be used to selectively cure the mixture of two materials providing a new research area in multi-material printing and applications in bio-inspired structures and tissue engineering.

7. ACKNOWLEDGEMENT

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