Abstract

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MODELLING STEREOLITHOGRAPHY PROCESS PARAMETERS USING SYSTEM DYNAMICS

Stereolithography is one of the most popular processes in additive manufacturing technology. One of the major issues that face researchers and practitioners is the inefficiency of setting the different process parameters of the stereolithography process that affect the built parts quality and characteristics. Although researchers studied the effect of different building strategies on part characteristics yet, they only reported the effect of the parameters without taking into consideration the interrelationships of these parameters that are mostly conflicting in nature. Hence, a systems approach is needed that can identify these interrelationships and enhance learning and understanding of this system of interacting parameters. System dynamics is a method to describe, model, analyse and simulate dynamically complex systems. This work has used two of the most popular system dynamics tools which are the causal loop diagrams (qualitative tool) and the stock and flow diagrams (quantitative tool). Causal loop diagrams are used to capture the interactions between the stereolithography process parameters. The causes and effects of the most significant parameters reported in literature are modelled such as laser power, exposure energy, critical exposure, depth penetration, hatch spacing, cure depth, over-cure and their effect on part dimensional accuracy, surface roughness, part completion time and tensile strength. Moreover, stock and flow diagrams are used to simulate how different variables such as the exposure energy and the part building time would change with time. The developed qualitative model has shown to be very useful in understanding the interactions between the building parameters. Whereas, the quantitative model with the introduction of the mathematical relationships between the different variables has shown the interactions between the different process parameters of stereolithography process in a measurable way and how they affect the part surface roughness and completion time. Finally, the behaviour of the system is effectively simulated over time and empirical relationships are developed between some parameters and response variables like layer thickness with the building time and surface roughness, laser power with exposure time and building time, beam spot radius with building time and surface angle with surface roughness. Modelling stereolithogtaphy by using system dynamics approach is a novel methodology used in the additive manufacturing field which has shown the relationship between different variables with the whole system, instead of investigating the effect of specific parameters.