

# LIFECYCLE ANALYSIS FOR ENVIRONMENTALLY CONSCIOUS SOLID FREEFORM MANUFACTURING<sup>1</sup>

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## ABSTRACT

A lifecycle based process model for analyzing environmental performance of SFM processes and SFM based rapid tooling processes is presented for analyzing SFM based Rapid Tooling (RT) processes in this paper. The process environmental performance assessment model considers material, energy, and disposal scenarios. The material use, process parameters (e.g. scanning speed) and power use can affect the environmental consequence of a process when material resource, energy, human health and environmental damage are taken into account. The presented method is applied to the SLA process and two SLA based rapid tooling processes. The method can be used to compare different Rapid Prototyping (RP) and RT processes in terms of their environmental friendliness and for further multi-objective decision making.

## 1. INTRODUCTION

Solid Freeform Manufacturing (SFM), or often referred to as Rapid Prototyping/Manufacturing (RPM), can be used not only to generate rapid prototypes for design optimization and verification but also to create production tools or directly fabricate products. This new manufacturing technology has been experiencing tremendous development and growth since its introduction a little over one decade ago. SFM has been widely adopted in aerospace and automotive industries, and is quickly becoming an important production process in electronics industry.

In view of the fast growth and wide adoption of various SFM processes, it is important to study the lifecycle performance of SFM processes, including consumption of natural resources and energy, and impact on human health and the environment, together with other process attributes such as cost, accuracy, productivity, and functionality, so that the SFM technology can become more sustainable. SFM processes have many good environmental characteristics. The material utilization rate is much more higher (almost 100%) in material additive process adopted in SFM than in material removal process used in machining process. The waste streams are less in SFM processes than in

conventional manufacturing processes such as machining. Worn tools and scraps seldom occur in SFM processes and equipment. Cutting fluids, which are the major source of hazard in machining [5-7], are not used in SFM processes. Comparing with conventional manufacturing processes, SFM processes have distinguishing features in process mechanisms, materials, energy use, etc. It is essential to look into these processes, investigating how the process variables influence the environmental consequences, and apply a systematic method to assess the process environmental performance so that these processes can be optimized with consideration of their environmental properties.

In [14], we reported some preliminary results of our research towards a systematic approach that we developed for SFM processes based on lifecycle concept. In this paper, we extend the previous method to assess SFM based rapid tooling processes. The method holistically incorporates the entire process lifecycle, including material extraction, pattern fabrication, shape replication, post processing, and material disposal. The environmental performance is evaluated, based on Lifecycle Assessment (LCA) principle [1-3] and with an environmental impact index called the Eco-indicator [8]. Details of this method and an example illustrating its use will be given.

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