Chapter 2

Integrated Manufacturing System for Complex Geometries:

Towards Zero Waste in Additive Manufacturing

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ABSTRACT

The chapter proposes an integrated manufacturing system consisting of three main components: digital prototyping, physical prototyping, and lost core technology. The integrated system combines the beneficial aspects of computer-aided design, computer-aided engineering, rapid prototyping, and rapid tooling. The proposed integrated system is an attempt to compress the product development time while saving cost. The system can be efficient in designing of mold, parts with complex ducts and cavities, and carrying out design analysis through optimization and simulations. The system is therefore an attempt to minimize the waste of material that occurs in the development of a product and is therefore an efficient green technology for the manufacturing industries.

INTRODUCTION

The escalating competition worldwide and the globalization have resulted in immense pressure on different manufacturing units to reduce the production time and cost of the product while meeting the quality requirements. The time-to-market the products have been now been reduced to weeks and therefore the new product must be made quickly and cheaply meeting the market requirements. One of the costly and time consuming phases in product development is the manufacturing of moulds for both the

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development of prototype part and production component manufacturing. The conventional machining approach to produce mould entails long lead times and costs. And therefore the sequential approach of conventional machining doesn't meet the requirement of rapid product development. Thus it has become imperative on the part of manufacturing units to research on to innovate new technologies that can aid in rapid product development.

Additive manufacturing has emerged as potential technology that has the ability to reduce the production development time. Rapid prototyping (RP) was the first of a kind process for creating a 3D object through layer by layer technique and computer-aided design (CAD). The RP process was developed in 1980's for production of models and prototypes and therefore help design engineers to create what they had in mind. The major advantages of the RP processes are the reduction in cost and time as well as the possibility to create any complex shape (Ashley, 1991). The versatile RP processes have been applied by medical doctors, scientists, professors, artists and market researchers (Noorani, 2006; Flowers & Moniz, 2002; Chua et al., 1998) for creation and analysis of models for various studies. For instance doctors create a model for a body part for which the operation is to be performed. They use the model to better plan the procedure. The prototypes made from rapid prototyping (RP) can be used for different evaluations such as visual inspection, ergonomic evaluations etc., thereby leading to comprehensive design analysis earlier in the product development cycle. Since its inception, RP has been used in different industries where both time and precision are of paramount importance. RP is however not used for large scale production.

RP is now evolving towards rapid tooling (RT) which has the capability to be used for commercial scale production. Therefore RT is used effectively for making of moulds for commercial purposes. Further, there are products that are required to be provided with complex cavities, bypass or even to completely close hollow bodies. There are other products in which case the assembly is to be avoided such as in the case of pneumatic and hydraulic parts. For such cases one of the evolving technologies is the Lost Core or Soluble Fusible metal core technology.

Industries are now looking for a feasible option to use the advantages of both the RT and RP. The present chapter proposes an integrated manufacturing system to produce complex shape products that have complex internal cavities.

RAPID PROTOTYPING PROCESSES

The different rapid prototyping processes can be categorized into: powder based, solid based and liquid based.

Liquid Based Processes

Stereolithography (SL)

The SL process was developed by 3D systems, Inc. and is one of the most widely used process of rapid prototyping. SL is a liquid based process wherein the ultraviolet light makes contact with the resin which leads to solidification or curing of photosensitive polymer. The SL process incepts with a 3D CAD model and is translated to STL file. In the STL format, the 3D CAD model is cut into slices and the information of each layer is stored. A platform supports the piece and other overhanging structures. The UV