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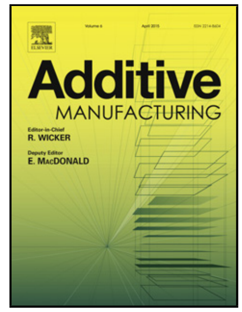


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# Additive Technology of Soluble Mold Tooling for Embedded Devices in Composite Structures: A Study on Manufactured Tolerances

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**Abstract:**

Composite textiles have found widespread use and advantages in various industries and applications. The constant demand for high-quality products and services requires companies to minimize their manufacturing costs, and delivery time in order to compete in general and niche marketplaces. Creation of molding and tooling options for advanced composites encompasses a large portion of fabrication time, making it a costly process and a restraining factor. This research discusses a preliminary investigation into the use and control of soluble polymer compounds and additive manufacturing to fabricate sacrificial molds. These molds suffer from dimensional errors due to several factors, which have also been characterized. The basic soluble mold of a composite is 3D printed to meet the desired dimensions and geometry of holistic structures or spliced components. The time taken to dissolve the mold depends on the rate of agitation of the solvent. This process is steered towards enabling the implantation of optoelectronic devices within the composite to provide a sensing capability for structural health monitoring. The shape deviation of the 3D printed mold is also studied and compared to its original dimensions to optimize the dimensional quality to produce dimensionally accurate parts of up to 0.02% error.

**Keywords:** Additive manufacturing; soluble mold; dimensional analysis; high impact polystyrene; embedded devices; composite

**Introduction:**

With the rapid development in aerospace and automotive industries, the proper choice of structural materials has become an essential aspect of state-of-the-art designs. These industries have always been seeking ways to reduce the cost and weight of materials used in their production. Hence, composites have been introduced into such applications [1-3]. Fiber reinforced composites are ideal for part and device integration, for example, on and within aircraft. However, the manufacturing process can be tedious, expensive and time-consuming [4]. The use of woven, braided and knitted forms of reinforcement have gained popularity over the years of composite manufacture using manual layup techniques to obtain desired geometry [5]. Short fiber composite applications have also been growing in the transportation industry with their ability to be molded into complex shapes with injection molding technology and at a significantly lower cost than continuous fiber composites [6]. However, the molds used for manufacturing short fiber composites are expensive to make and replace, and the process of non-destructive demolding can be relatively difficult and troublesome [7-9].

According to a survey conducted by Christman and Naysmith, an increase in demand for reducing the mold manufacturing times was observed [10]. Additive manufacturing (AM), also known as rapid prototyping (RP) is a powerful tool that allows higher flexibility and greater efficiency to meet all the requirements of today's productions [11, 12]. Rapid tooling (RT) is an extension of RP, which makes use of various AM technologies such as material jetting, stereolithography, layer object manufacturing etc. to manufacture molds. This enables the creation of molds with intricate patterns in a short amount of time. The use of soft materials in RP, however, limits their applications for direct tooling, to one-time use molds [13, 14]. Utilizing the AM technology with a soluble compound enables manufacturers to reduce post-machining