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# Risk reduction in new product launch: A hybrid approach combining direct digital and tool-based manufacturing

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ABSTRACT

The research contributes to the body of knowledge on new product development by considering the potential use of a major emerging production technology in the early phase of final production. Direct digital manufacturing (DDM) methods such as additive manufacturing (AM) have been introduced as a production method for some small and complicated parts, mostly in the aerospace and medical industries (in batches of one or a few). However, it still is not viewed as a suitable method for producing numerous parts in small batch sizes. In this study, we will utilize scenario-modeling based on real-world case data to illustrate the potential of a novel production method which we call "hybrid production" in new product launch. This production method combines DDM with conventional production methods over the product life-cycle. Our case study data is on a toolless production method called Incremental Sheet Forming (ISF) which is theoretically a DDM method. The cases have been analyzed to understand the economic feasibility and benefits of DDM utilization throughout new product life-cycle. Results of our study suggest, while implementation of conventional production from the beginning does not present a significant cost savings over the hybrid production, when product succeeds in the market, conventional method yields a high cost when the success does not materialize on the first attempt. This directly translates to investment risks (related to the cost of tool modification or replacement and inventory obsolescence), in addition to loss of flexibility to respond to market feedback and consequently lower chance of market acceptance. Additionally, DDM at the beginning of our proposed hybrid production can shorten the products' time to market which is considered to be an essential factor for success.



## 1. Introduction

In the process of new product development (NPD), the product launch is crucially important and risky, as it can influence the market success or failure [30,60]. Moreover, this step of NPD is often seen to be the costliest one [5,63] and imposes inherently high risks with regard to the market reaction [7,12,25,59]. It is because the product launch requires start of product manufacturing and marketing activities as well as setting the time and location of market roll-out [61]. Although the importance of marketing research and sales efforts are significant in the success of a new product launch [4,11], attention to risks mitigation is also essential [25] because demand forecasts are never certain, especially for novel products where historical data is not available.

The different scenarios in an uncertain demand situation for a new product launch are studied by Cui et al. [17]. Both over- and under-estimation of demand have unfavorable outcomes. In the over-estimation scenario, the manufacturer is left with a lot of invested capital in tooling and product inventory, while in the under-estimation scenario, lost sales (opportunity cost) is the problematic outcome. Therefore, if the manufacturer would have access to production technology that enabled it to postpone tooling costs until market demand was more highly visible while simultaneously being able to meet market demand, then a much more favorable outcome would be possible. Moreover, if this production technology enabled the company to tweak the design without high retooling costs, market information gathering actions (e.g., customer or distributor feedback) could be used to improve the chance of a successful product launch [5,62].

Another point of interest for manufacturers while launching a new product is shortening the time-to-market period. Every week

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or month of delay in market introduction for a new product concept can mean millions of dollars in lost sales and can help competitors in catching up by introducing their own products [10]. Moreover, first-movers introducing new products to the market are able to hold a larger market share [37,46]. Therefore, if a producer can cut a number of weeks from the production launch by reducing the tooling preparation period, the product time-to-market can be shortened, thus increasing the time advantage over the competition.

The emergence of direct digital manufacturing (DDM) technologies as a method of final parts production promises a fundamental change in the production landscape [26,39,57]. Technologies such as additive manufacturing (AM which is based on producing parts from a computer-aided design file without the need for tooling and independent from economies of scale to a very high extent) has been identified as ideal for manufacturing by the CEO of one of the biggest manufacturing companies, General Electric [23]. This method is attractive to manufacturers because it significantly reduces the time to market and reduces financial stress while at the same time improving flexibility [1,51]. On the other hand, this production method is not perfect and currently has its own limitations with regard to the range and combination of raw material, production speed, chamber size, labor dependence, precision and also very high costs (for production machines as well as raw material) [33].

However, it is important to understand the situations and criteria of DDM that can provide beneficial results for firms and organizations. In this article, we explore the potential improvements from utilization of DDM technology in a hybrid setting together with the conventional production method over the product lifecycle. The implementation of DDM is in the beginning of the production launch while the volumes are low. Conventional production is introduced later on when market demand picks up. The mechanism to benefit from DDM in production launches is the reduction of the major cost component in conventional production – the tooling cost. When DDM is available, it is not a cost-conscious decision to start the production with conventional methods while the demand level is highly uncertain. On the other hand, although the tooling cost for DDM is low, DDM is not cost-efficient for high production volumes since the production cost per part is much higher than for conventional methods.

In previous studies [6,38,31,47], the combination of AM and a conventional type of production method has been explored as a component of hybrid manufacturing systems. Moreover, researchers have compared conventional production methods with various AM methods from the cost aspect [3,28]. However, an understanding of the potential benefits of a combination of production methods over the product lifecycle is still lacking [42,55]. The aim of this paper is to analyze the economic feasibility of a hybrid production method (combining DDM with tool-based conventional methods) throughout the new product life-cycle. To accomplish this goal, we utilized case studies. Moreover, we intend to induce the factors that enable a beneficial use of this novel production method in different problem contexts.

The remainder of this paper is organized as follows: Section 2 presents a literature review; Section 3 explains the research methodology; and Section 4 presents the findings and results of our analysis. This paper ends with conclusions summarizing the research outcomes, and suggestions for future investigation are provided.

## 2. Literature review

### 2.1. Direct digital manufacturing

Also known as rapid manufacturing, DDM uses AM technologies for the production or manufacturing of end-use components [24]. Moreover, AM is the term used for three-dimensional (3D) printing in the manufacturing literature. This DDM technology, which produces objects from a computer-aided design file, starts with designing or scanning a three-dimensional object. Then the pre-production processes take place, which include the conversion of three dimensional design file to .STL (Stereolithography) file format, the virtual positioning of the parts on the printer's production chamber and producing the necessary support structure for the overhangs. The next steps, which include machine warm-up and production, are fully automatic. During the build phase, an AM machine produces the object layer-by-layer, utilizing different methods of raw material solidification, depending on the process technology. The last stage of this process includes post-production activities, which consist of removing the supports and for some processes, heat treatments and surface treatments to reach the final intended product (Fig. 1). The whole process from design to final part might take from a few hours to a few days, depending on the accuracy and size of the object, among other factors [24].

Toolless rapid prototyping was introduced during the 1980s to produce illustration parts and concept objects as well as prototypes [34]. The technology continued its development process, which lead to the adoption of its title (rapid manufacturing and AM) and began to be utilized in the manufacturing of final parts. Incremental sheet forming (ISF), another DDM method, is the process of forming large metal sheets layer by layer according to a digital model (a comparison between ISF and other DDM method, AM is presented in Table 1) [40].

ISF is used for prototyping and low-volume production purposes in the same way as the other AM methods when mass production is not economical [28,54]. Fig. 2 illustrates a schematic view of the ISF process.

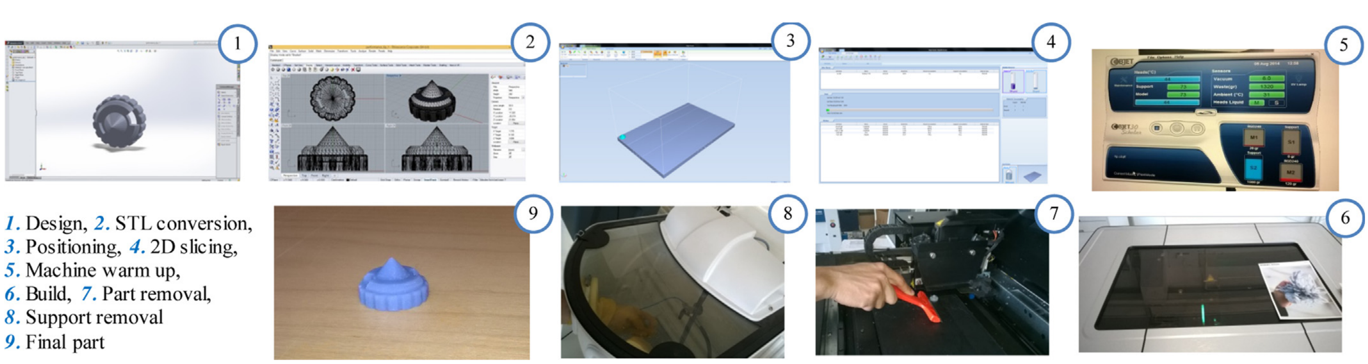


**Fig. 1.** The AM process stages.