Disruptive Innovation through Additive Manufacturing in India: A Case Study Approach

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Abstract

Known by most as 3D printing, Additive Manufacturing (AM) has become a revolutionary technology that is changing industries worldwide. India has seen a significant uptick in the adoption and application of additive manufacturing in several sectors in recent years, which has resulted in a radical change in production procedures and product creation. The field of additive manufacturing has grown by a strong 9.34% over the past few years. This trend indicates a rebirth of disruptive innovation that is changing production. Application of additive manufacturing can be integrated with Industry 4.0 technologies: big data, AI, and IoT. This will create a growing need for robust digital asset management frameworks. This paper presents a case study of Jayanthi Tooling, an MSME in Pune. The case study highlights the importance of AM adoption among MSMEs, its advantages and challenges, and its impact on the manufacturing landscape in India.

Keywords: Additive Manufacturing, Digital Asset Management Frameworks, MSME, National Strategy, Public Technology Strategy

Introduction

Three-dimensional printing (3DP), also known as additive manufacturing, fast manufacturing, or direct digital manufacturing, is a potentially revolutionary technique in digital manufacturing (Berman, 2012).

Gaining a 5% market share and contributing close to $1 billion to the country's GDP by 2025 are two goals of the strategy to improve India's standing in the global 3D manufacturing scene. Industry 5.0 aims to place human well-being at the centre of the industrial manufacturing system, strives to achieve social goals beyond employment and growth, and provides strong support for all people's sustainable development and prosperity, sounding a call for a new round of global industrial transformation (Xu. et al., 2021). In India, MSME now adds AM to save cost, reduce prototyping time, and increase design flexibility to the palette, thereby making them a serious contender for larger players. This paper investigates the strategic factors driving the adoption of AM in Indian industries, focusing on the role of MSME in particular.

India's Journey into 3D printing is a testament to its adaptability and forward-looking approach, from its nascent stages to its growing presence today.

Early years (1990s-2000s): Early AM prototypes in India date back to the late 1990's, when the global industry began to rapidly explore the prototype. During this period, many Indian companies and academic institutions started importing 3D printers, mainly for research and prototyping. The Indian Institute of Technology (IIT) in Bombay was one of the pioneers in setting up an AM Laboratory to explore the potential of this new technology.

Rise of domestic manufacturers (2000-2010): The first 3D printer manufacturers appeared in India in the mid-2000s. Companies such as divide by Zero and Altem Technologies began offering 3D machines at home, challenging the market dominance of imported machines. These machines, which primarily use deposition modelling (FDM), have met the growing demand from academic institutions and small businesses.

The 2010s represented a significant shift in India's AM journey in India. There has been a tremendous expansion in the number of independent 3D printing firms offering a variety of services, from prototypes to final items. Companies such as Imaginarium, Think3D, and Sahas Softech have made important advancements in the area. During this time, 3D metal Printing gained popularity in industries like aircraft, medicine, and automobiles. The Indian government has started the "Make in India" campaign to boost local production and R&D in 3D printing, recognizing additive manufacturing (CoE-AM) in conjunction with applied research international. This is a significant step forward.

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The most recent years have seen a significant transformation in India's AM journey. The decade saw the fast use of 3D printing in various sectors, driven by technology improvements, lower costs, and a rising understanding of AM's possibilities.

To make India a global hub for additive manufacturing, the Ministry of Electronics and Information Technology (MeitY) released the "National Strategy for Additive Manufacturing" in February 2022. This strategy aims to improve the environment that supports the development and deployment of AM technologies while also encouraging local manufacturers to adopt them. Additionally, it projects that by 2025, India will have 5% of the global AM market, increasing its GDP by almost $1 billion. To do this among other things, the strategy calls for the development of 50 technologies unique to India, 100 new businesses, and 100,000 additional skilled workers. Major obstacles to the national strategy for additive manufacturing are Additive manufacturing technologies, which include printers, materials, and post-processing equipment, which are more expensive than traditional production processes. This pricing barrier may limit the accessibility and acceptance of additive manufacturing, particularly among small and medium-sized firms, which is predicted to slow market growth. High material and equipment prices due to reliance on imports. Lack of established industrial skilled labour, and an uncertain regulatory environment. Advancements in technology may reduce the demand for skilled workers, thus leading to job losses.

In the conventional process of producing mechanical parts, a mold is created, and thousands of parts are stamped out every day. The cost of the first 100 units is high since the machinery needed to create these parts and the molds are expensive. Only in mass production costs per unit costs decline only when they are mass-produced. Traditional manufacturing leads to high inventory costs of multiple parts that need to be produced and stored before being assembled. This makes the design phase complex and costly rendering it expensive to redesign to correct initial mistakes or innovate to meet changing consumer needs. AM represents a departure from traditional manufacturing methods, this change presents an AM as a disruptive innovation that will disrupt several industries by directly challenging traditional manufacturing methods. AM technology builds many small parts which are later on assembled as a line using unskilled labour or robots to build an entire system.

In the electronics business, in this area, AM techniques often use material jetting cemented by UV light with conductive and insulating inks. India's aerospace and defense sectors are using additive manufacturing to prototype, produce lightweight components, and improve operational efficiency. AM enables the production of complicated airplane parts with minimal waste, resulting in cost savings and increased performance.

In healthcare, 3D printing is transforming patient care by allowing for the creation of customized implants, prosthetics, surgical equipment, and anatomical models. This technology enables more individualized healthcare solutions, faster recovery periods, and better medical outcomes.

India's automobile sector is adopting manufacturing for rapid prototyping, tooling, and the production of lightweight components. AM enables automotive businesses to rapidly iterate designs, shorten lead times, and improve vehicle performance and fuel efficiency.

India's educational institutions and research organizations use 3D printing for teaching, research, and innovation. AM allows students and researchers to gain hands-on experience, produce prototypes more easily, and stimulate creativity and experimentation.

Additive manufacturing is also making an impact in the consumer goods industry, allowing for the creation of bespoke products such as jewellery, fashion accessories, and fashion accessories, and home decor items. This customization flexibility increases consumer involvement and happiness while lowering inventory costs for enterprises.

Digital Assets in Additive Manufacturing

Digital Manufacturing Process: Additive manufacturing is based largely on digital assets, from digital blueprints and 3D models to CAD files used in prototyping.

Data-driven innovation: AM is a physical production process of object parts; the entire process is also about working with and manipulating digital design files to generate complex, custom parts. This is a prime digital asset management area, in which the efficient manipulation of digital designs, the use of digital twins, and data-driven customization become the heart of AM workflows.

Research Question

What strategic factors are driving the adoption of additive manufacturing in MSMEs in India, and how is it contributing to the growth of the industry?

Research Methodology

Using qualitative and secondary sources of information sources, this research employs a single case study methodology. The choice of the case method was made since it is a popular and practical approach

to investigating "how" or "why" issues pertaining to current events (Yin, 2009). Documentation, archival records, physical artefacts. This paper highlights a case study approach to MSMEs' adoption of additive manufacturing, which fills a research gap where the findings contribute to both academic knowledge and industrial implications. Thus, creates a novelty in research.

Findings of the Study

Jayanthi Tooling: A Small-to-Medium Enterprise (MSME) Success Story

Jayanthi Tooling is a small-to-medium enterprise (MSME) located in the manufacturing hub of Pune, India. The company specializes in producing precision tools, dies, and molds for various industries, including automotive, consumer electronics, and industrial equipment. Like many MSMEs in India, Jayanthi Tooling was traditionally reliant on conventional manufacturing processes but has recently adopted additive manufacturing (AM) to improve production capabilities.

Objectives for AM Implementation

1. *Cost reduction*: AM reduces the wastage of materials as well as the design and development cost of tools.

2. *Lead time improvement*: Improve the speed with which the product prototypes can be produced and custom tools designed for customers.

3. *Design flexibility*: Enables complex designs or difficult shapes using conventional manufacturing.

4. *Small batch production*: Produce small lots of speciality parts with optimized efficiency and minimal cost without using expensive tooling.

AM Technologies Employed

Jayanthi Tooling made a minor investment in Fused Deposition Modelling (FDM), an affordable 3D printing technique that is perfect for a small business wishing to experiment with additive manufacturing. Later, in order to produce more intricate components and tools, the business made an investment in Selective Laser Sintering (SLS).

Applications Employed

(i) *Tools and die manufacturing*: Jayanthi has long used CNC machining along with other conventional techniques to make metal tools and dies. They started using SLS technology to create plastic molds and dies after adopting AM, which greatly shortened the production time. Additionally, they used AM to make conformal cooling channels inside of molds, something that is challenging to accomplish using conventional techniques. Through increased mold cooling efficiency, these cooling tubes shortened plastic injection molding cycle times.

(ii) *Automotive client prototyping*: The business works with a number of Indian Tier 2 and Tier 3 car suppliers. They were able to provide fast prototyping services using additive manufacturing, enabling customers to test new designs and parts before deciding to go ahead with large-scale production. Jayanthi Tooling assisted its clients in cutting the length of the product development cycle from months to weeks by creating prototypes in a fraction of the time previously needed.

(iii) *Low-volume, high-complexity production*: Conventional methods for small-batch production can be costly and inefficient, which presents a barrier for MSMEs such as Jayathi Tooling. Jayanthi tooling was able to create customized parts in small quantities for customers without having to spend a lot of money on expensive equipment by utilizing manufacturing.

Post AM-implementation achievements

Reduction in lead times: By removing numerous phases from the production process and enabling on-site printing of prototypes and small parts, lead times were reduced by 50%.

Cost savings: greatly decreased material waste, especially for small-batch production and prototyping.

Increased design flexibility using AM, the business was able to produce intricate geometrices that would have been difficult to produce using conventional techniques. The AM adoption challenges faced by Jayanthi Tooling are the initial cost of AM equipment which was high, insufficient skilled labour, limited materials, particularly for 3D printing metal impact on business. Business benefits of AM are decreased inventory levels, increased income stream diversity, and increased competitiveness for Jayanthi tooling. Although there are still obstacles to overcome, such as a large upfront cost and worker training, the long-term advantages exceed these difficulties. Jayanthi tooling is the success case of an MSME in the AM industry sector. This case study focuses on additive manufacturing's transformation of existing industries, particularly for MSMEs and its potential to alter production, design, and manufacturing processes in India makes it a perfect fit within the disruptive innovation paradigm. Scaling of AM technology in India is considered a prominent challenge, particularly concerning unclearly prescribed regulatory frameworks, training infrastructure, and access to high-quality materials. These barriers reflect the kind of emerging challenges in enabling disruptive innovations such as AM to thrive.

Conclusion

India's journey in the field of 3D printing is inspirational and portends a bright future. From its humble beginnings in the 1990s to the huge ecosystem that flourishes today, India's AM environment has been influenced by innovation, strategic planning, and a flurry of governmental and private efforts. The strategic connection with national efforts, such as 'Make in India, demonstrates the government's commitment to leveraging AM's economic development and self-reliance potential. The future forecast for additive manufacturing in India looks good, with projections predicting significant development across industries. Improving material capabilities, building strong supply chains, increasing AM infrastructure, fostering talent development, and boosting research and innovation are all key areas of focus.

The Jayanthi case study demonstrates how Additive Manufacturing (AM) may improve design flexibility, cut costs, and shorten lead times for small and Medium-Sized Enterprises (MSMEs). India's industrial policy that matches the "Make in India" program and the national strategy for additive manufacturing influences policymakers, businesses, or MSMEs towards embracing AM technologies.

In addition, government support is required for manufacturing facilities to expand into smaller towns and for the IT sector to expand its platforms in order to satisfy the demands of the consumer. However, in this area, India is at the same stage as the rest of the globe. India's skills in software, electronics, Electronics System Design and Manufacturing (ESDM), and Artificial Intelligence (AI) are well-suited for additive manufacturing.

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