Chapter 37
Laser Additive Manufacturing in Industry 4.0:
Overview, Applications, and Scenario in Developing Economies

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ABSTRACT

Additive manufacturing is one of the nine technologies fuelling the fourth industrial revolution (Industry 4.0). High power lasers augmented with allied digital technologies is changing the entire manufacturing scenario through metal additive manufacturing by providing feature-based design and manufacturing with the technology called laser additive manufacturing (LAM). It enables the fabrication of customized components having complex and lightweight designs with high performance in a short period. The chapter compiles the evolution and global status of LAM technology highlighting its advantages and freedoms for various industrial applications. It discusses how LAM is contributing to Industry 4.0 for the fabrication of customized engineering and prosthetic components through case studies. It compiles research, development, and deployment scenarios of this new technology in developing economies along with the future scope of the technology.

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INTRODUCTION

Industrial revolution witnesses a marked era, where innovations or inventions change the way products and services are produced for faster delivery with increased profitability at a lower cost. The first (1760-1840), second (1870-1914) and third (1969 onwards) industrial revolutions are characterized by massive changes in industrial operations mainly due to the introduction of innovations in the steam engine, electricity and automation, respectively (Horn, Rosenband, & Smith, 2010), (Reisman, 1996), (Engelman, 2020), (Meak, 2020)]. These three industrial revolutions were centred on mass production for increasing profits and the market was extraordinarily driven by sellers. Subsequently, the market took a U-turn and shifted from sellers' driven market to buyers' market. It pushed industries to adopt the policy of supplying the best quality products and services at the lowest possible price immediately meeting all possible consumer's expectations. Industries coming with more innovations and better after-sales support started dominating the market. The trend is evident nowadays too; it is recognized as the commencement of the fourth industrial revolution or Industry 4.0. In this period, industries are toiling to bring "first product in the market" and there was not much market share for "me-too-products" (a product that is designed with same design philosophy/ feature as another existing product in the market) in this unending race. In this way, the period of mass production is translating into mass customization with a fine balance between customer satisfaction and mass production. It is expected that autonomous there will be a breakthrough in the field of robotics, nanotechnology, quantum computing, internet of things, biotechnology, artificial intelligence (AI), autonomous vehicles and additive manufacturing (AM) (Quintanilla, Hope, Darnton, & Hunter, 2019). As per literature, nine different sectors are recognized as pillars of Industry 4.0 (Cheng, Liu, Qiang, & Liu, 2016) (Vaidya, Ambad, & Bhosle, 2018):

1. Big Data: It deals with the analysis of large volume, velocity, veracity, variety and value (Tao, Tang, Zou, & Qi, 2019) of data being collected over time from different operations in a company/institution/population. This analysis would lead to useful insights into the input parameters, processes and output by identifying trends, patterns, and relationships among them. These insights would be later useful in adjusting parameters to improve production processes across different platforms. In the period of smart manufacturing supported by big data, researchers are trying to assimilate various technologies and stimulate new ideas (Tao, Tang, Zou, & Qi, 2019).
2. Augmented Reality: This technology will enable showcasing a product in the natural environment without creating an actual physical copy of the product (augmented imagery in a real-world) and running the product and its augmented image interactively in real-time). It will allow manufacturers to indicate how their products would look like in a real environment to their prospective customers and allow controlling the product by using augmented image (Palmarini, Erkoyuncu, Roy, & Torabmostaedi, 2018).
3. Simulation: It means playing out a scenario of an actual situation, process or environment. 3D simulation of component development, material development, and production processes are used extensively (Vieira, Dias, Santos, Pereira, & Oliveira, 2018) (Mordor Intelligence LLP, 2020). It will obtain the real-time data to replicate the real world in a virtual model, which includes machines, process, products, and humans.
4. Internet of Things (IoT): It is the network of physical devices with electronics, software, sensors, actuators and internet connectivity enabling data exchange for direct integration of the real world into computer-based systems for monitoring and control ensuing improved efficiency, cost-effectiveness,