Chapter 11

Design Knowledge Development and Additive Manufacturing Systems: How Does Design Knowledge Change With Design for AM?

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ABSTRACT

The adoption of new technology is key for any manufacturer wanting to stay relevant as the world transitions to Industry 4.0. The advance of additive manufacturing (AM) technologies—an important element of Industry 4.0—has become part of a globally accepted reality. However, conventional design practice and knowledge generation inside a manufacturing firm must evolve. Technology-driven innovation must embrace knowledge-directed design work that is aimed at forecasting and utilizing the potential of new technologies. The chapter includes two projects, both of which were manufactured using additive manufacturing laser sintering technology. Analysis of the projects positions them at either end of a wider spectrum of product design practice that more aptly captures the way design and industry must operate for technology-driven innovation and Industry 4.0. A place for conventional design for manufacture remains though the case studies indicate differences in the setting of values to inform practice, requiring new methods for creating and managing design knowledge in the future.

INTRODUCTION

This chapter explores the potential impact on product design practice, due to the technological changes associated with a move additive manufacturing (AM) as a key part of Industry 4.0. The term Industry 4.0 refers to a revolutionary step in the level of organisation and control over the entire value chain involving the manufacturing industry. Industry 4.0 represents an unprecedented degree of system inte-
The technological advance of an Industry 4.0 environment is a move toward self-aware, self-learning machines (smart manufacturing), creating a more open, flexible industrial network. Advanced (digital) manufacturing technologies such as Additive Manufacturing (AM), is central to this chapter. The networked industrial practice and integration of individualised customer requirements that contribute to define Industry 4.0 (Vaidya et al. 2018) can be functionally achieved through the optimisation of AM. Generally, the rapid technological change and innovation affecting production methods and consumption patterns drives forward the knowledge-based economy which places information and knowledge production at the centre of economic growth (OECD 2001).

Research provides appropriate ways of describing the connection between design practice and design knowledge based on conventional industrial situations, however technological change and the effect that’s having on the conduct of design and manufacturing organisations requires a review of those descriptions and their applicability in technology-driven innovation. The research presented here considers product design practice for AM noting that as the scope of opportunity increases with the technological benefits of AM so does the need for design to become better equipped at developing new design knowledge. Development of design knowledge should be improved to enable product design to be agile and effective in its relationship with future systems of manufacture.

The chapter begins with a background section that describes the nature of design knowledge and highlights the importance of practice in the creation of design knowledge and the importance of ‘values’ in the conduct of that practice. Technology-driven innovation has been related to design and business by Verganti (2009) though his term is technology-push innovation. Verganti identifies in his research the importance for companies that hope to achieve competitive advantage to use design to integrate new technologies to ‘push’ toward ‘radical’ innovations that come not from market analysis but from a deeper understanding of meanings and values. Essentially, the pace of change and the risk of ‘disruption’ means that if companies rely exclusively on what ‘the market’ is telling them, then they are already well behind the competition. Design knowledge relies on values to direct practice particularly in the pursuit of ‘radical’ innovations through technology-driven innovation because there are few if any precedents (products or practices) to build upon. And design knowledge and values can only be developed through practice.

The chapter proceeds to provide descriptions of design practice that are more knowledge-intensive in nature such as concepting (Keinonen, 2006) and research prototyping (Matthews and Wensveen, 2015) to support an organization’s ability to strategically forecast connections between emerging technology and emerging markets. Comparisons between conventional Design For Manufacturing (DFM) and technology-driven innovation serve to illustrate the way design practice must also change due to the way AM situates the production activity so ‘close’ to the end-user.

Two case studies are presented that demonstrate changes in the focus of product design work where AM has been the utilised production method. Both projects have been developed for manufacturing SMEs. AM is an intelligent production system considered to be an important part of the move to Industry 4.0 (Dilberoglu et al. 2017). As the level of sophistication and potential for application for AM steadily increases, technology-driven innovation as a design and manufacturing strategy is a key factor for the advancement of knowledge-based industries. The rationale for the study emanates from a concern for the product design industry and its ability to adapt to the pace of change associated with technology-driven innovation and Industry 4.0. The chapter seeks to demonstrate that the core competencies of product design practice hold true despite the significance of industrial-technological advances, though it requires