

Chapter 12

Ceramic Industry 4.0: Paths of Revolution in Traditional Products

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ABSTRACT

Industry 4.0 presents new challenges for traditional sectors of the economy, for example, the production of ceramic products. This chapter reveals how traditional ceramic industries can (1) assess, (2) plan, and (3) execute Industry 4.0 adoption. The findings are based on the Portuguese ceramic sector. Three interrelated dimensions of the fourth industrial revolution are studied, namely, (1) digital ecosystems, (2) security and safety, and (3) digital sustainability. Industry 4.0 is not restricted to high-tech products and cannot be addressed by one-size-fits-all solutions. Moreover, it requires cooperation within business ecosystems. The authors propose a model for Ceramic Industry 4.0 and accessible guidelines for managers involved in global supply chains. This chapter suggests emergent research opportunities for (1) sectorial maturity models, (2) data quality and regulatory compliance, (3) cyber-security and risk management, and (4) an integrated vision of sustainability in the digital era.

INTRODUCTION

Industry 4.0 is changing traditional sectors of the economy (Brettel & Friederichsen, 2014). The impact of the fourth industrial revolution is particularly relevant in small and medium sized enterprises (SMEs) with high levels of manual work. This is the case of ceramic companies that export the majority of their production and must be prepared to compete at a global scale. The ceramic industry from the European Union (EU)-27 accounts for 23% of global ceramics production. According to the Eurostat, it represented a production value of 28 billion Euros in Europe and over 200.000 direct jobs in 2015.

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Ceramic industry could be divided in ten major sub-groups: bricks and tiles, floor and wall tiles, sanitaryware, pottery & tableware, refractories, abrasives, clay pipes, expanded clay, porcelain enamel, and technical ceramics. All these ceramic industry subsectors are energy intensive, namely due to the drying and firing processes, which involve firing temperatures between 800 and 2000 °C. The manufacture of ceramic products is a complex interaction of raw-materials, technological processes, people, and economic investments. It includes the transport and storage of raw materials, ancillary materials and additives (e.g. deflocculating agent – sodium silicate for preparation of raw materials), preparation of raw materials, shaping, drying, surface treatment, firing, and subsequent treatment (Quinteiro, Almeida, Dias, Araújo, & Arroja, 2014). Complexity of the production process is diverse and also the market requirements are different for each ceramic industry sub-group. Yet, the entire sector is affected by the fourth industrial revolution.

There are new technological opportunities for ceramic production. Recent examples include the use of mobile technologies in maintenance and product traceability (Barata, Cunha, Gonnagar, & Mendes, 2017), additive manufacturing, 3D printing, and simulation platforms (Smit, Kreutzer, Moeller, & Carlberg, 2016). However, Industry 4.0 in mineral non-metal manufacture raises many challenges for managers. We subscribe to the view of Oesterreich and Teuteberg (2016, p. 136) about the “urgent need for the development, understanding and assessment of frameworks, business models, reference models and maturity models for Industry 4.0 implementation with focus on technology, people and processes”. Industry 4.0 assessment models tailored for specific sectors of the economy will be essential. Other challenges include the creation of digital competencies (Prifti, Knigge, Kienegger, & Krcmar, 2017), the development of digital ecosystems (Andersen & Ross, 2016), improvement of work practices, and sustainable development (Chen et al., 2015). Moreover, there is an urgent need to identify and deploy pilot cases to guide the major changes towards industry of the future.

This chapter addresses Industry 4.0 in traditional sectors and specificities of mineral non-metal production in Portugal. The next section presents the background of our research. Afterwards, we identify challenges and opportunities in three key dimensions for the ongoing industrial revolution in ceramic, namely, digital ecosystems, safety and security, and digital sustainability. Next, we present the results of a field study and propose strategic recommendations. These developments emerged from a 120 participants’ workshop that mobilized the entire industry. The chapter concludes revealing future research directions in the scope of digital transformation of ceramic production.

Background

Industry 4.0 is gaining increasing attention by researchers worldwide. A keyword search made in Google Scholar using a combination of the terms “Industry 4.0”, “Industrie 4.0”, and “Fourth Industrial Revolution” reveals a constant growth in the recent years, especially since 2013. There are several databases available for scientific research (e.g. Scopus, EBSCO, B-on ...), but we decided to start with Google Scholar because it presents a broad search result of both academic and practitioners contributions. Figure 1 illustrates this trend.

Industry 4.0, *Industrie 4.0*, or *Usine du Futur* are examples of the terms used to identify a priority for Europe: Industry digitalization. The examples include the digital single market (European Commission, 2016c), the mobility of business processes within the entire supply chain and the upgrade for an integrated digital world with profound socio-technical implications. The term Industry 4.0 was initially coined as a reference for high tech policies of the German government. However, digitalization and

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