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Materials Engineering within the scope of Industry 4.0

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CHAVES JUNIOR, Wankes Solony de Carvalho[1]

Summary

Industry 4.0 has been substantially present in manufacturing industries, and its processes can be associated with so-called smart factories, in which technology is used to optimize activities, seeking, therefore, to guarantee accurate results compared to companies that are not included. in the industry 4.0 model. This article aims to carry out an integrative review of the literature with a view to outlining the changes possibly required by industry 4.0 in the area of materials engineering to adapt it to this scenario of a new industrial revolution (fourth). The operationalization of the research corresponding to what is proposed includes carrying out a consultation in the Capes, Google Scholar and Scielo databases through information on the following keywords: Industry 4.0, Fourth Industrial Revolution,Materials Engineering. **Key words:** Engineering. Materials. Industry 4.0

Abstract

Industry 4.0 has shown itself to be substantially present in manufacturing industries, and its processes can be associated with so-called smart factories, with technology used to optimize activities, seeking, therefore, to guarantee accurate results in comparison with companies that are not included. in the model of industry 4.0. The objective of this article is to carry out an integrative review of the literature with a view to outlining the changes possibly required for Industry 4.0 in the area of material engineering to adapt it to this new industrial revolution (fourth) scenario. The operationalization of the research corresponding to or that is proposed contemplates the realization of consultation of the Capes, Google Academic and Science databases by means of information on the following keywords: Industry 4.0, Fourth Industrial Revolution, Materials Engineering.
Keywords: Engineering. Materials. Industry 4.0

1. Introduction

The development of new technologies, associated with the increasing use of digital mechanisms, has led organizations to adapt their processes as a way to stand out in the competitive market. This need is related to the globalization scenario, in which companies seek to obtain lasting competitive advantages to differentiate themselves in relation to their competitors. It is, therefore, based on these strategies that the industry 4.0 process

[1]UFPA-Federal University of Pará. Master's student in Civil Engineering with an emphasis on Materials and Civil Construction. Email: wankesj@gmail.com

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has been gaining prominence, being also called the fourth industrial revolution (OLIVEIRA; SIMÕES, 2016; ALMEIDA, 2019).

According to Stock and Seliger (2016), industry 4.0 can be characterized by the use of processes that involve the manipulation of machines managed by technological intelligence, such as collaborative robotics. Cavalcanti and Nogueira (2017), in turn, highlight that industry 4.0 has been substantially present in manufacturing industries, and its processes can be associated with so-called smart factories, in which technology is used to optimize activities, seeking, therefore ensuring accurate results compared to companies that are not included in the industry 4.0 model.

When analyzing the technologies applied by industry 4.0, it appears that disruptiveness and irreversibility are their basic characteristics, substantially impacting different areas of knowledge (CAVALCANTI; NOGUEIRA, 2017; ALMEIDA, 2019), including Engineering.

Therefore, this article aims to carry out an integrative review of the literature with a view to outlining the changes possibly required by industry 4.0 in the area of materials engineering to adapt it to this scenario of a new (fourth) industrial revolution.

2 Methods

The operationalization of the research corresponding to what is proposed includes querying the Capes, Google Scholar and Scielo databases through information on the following keywords: Industry 4.0, Fourth Industrial Revolution, Materials Engineering.

The inclusion criteria for the texts found were the following: articles written in Portuguese or English, published in full electronically; that address the theme "Industry 4.0 in the area of Materials Engineering". Dissertations and theses were excluded, as well as articles written in a language other than Portuguese or English. The deadline for publications was set between 2011 and 2021, to ensure the current nature of the integrative review. Between May 2nd and 31st, 2021, searches were carried out in the following databases: Capes, Google Scholar and Scielo. In Capes, 104 were found, articles that were returned after providing keywords; in Google Scholar, 54; in Capes, 30; and on Scielo, 20.

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In the first stage of the data collection process, an advanced search was carried out in the databases consulted, detailing the following number of articles: 34 on Google Scholar; 18, in Capes; and 17, in Scielo, thus totaling 69 studies. After this first moment, the titles, summaries or abstracts of the texts were read, 51 of which were excluded from the following databases: 41 on Google Scholar; 7 in Capes; and 3 on Scielo. After

this first screening, in the second stage, the selected texts were read in full. At this time, 4 articles were excluded, as indexing was identified in more than one database. Thus, duplicate studies were computed in only one of the databases, resulting in 12 articles, which were included in the present integrative literature review. The data relating to each of them are identified in Tables 1 and 2, which include, respectively, the distribution of selected articles, considering the year of publication, author(s) of the text, title, objective and method (type of study) (Table 1), and main results (Table 2).

3 Results

Tables 1 and 2 present an overview of the articles selected for this integrative review of the literature related to the topic under analysis.

Table 1 – Distribution of references included in the integrative review, 2011-2021

Article/ Year	Author(s)	Title	goal	Kind of study
1/	ALMEIDA, PR	Brazil and the nanotechnology: towards fourth revolution industrial.	Analyze the relationship between nanotechnology and the fourth industrial revolution.	bibliographic
two/	BRYNJOLFSSON, AND.; MCAFEE, A.	The second machine ages: Work, progress, and prosperity in a time of brilliant technologies.	Elucidate on the second machine age and its technologies.	bibliographic
3/	CAVALCANTI, L. L.; WALNUT, MS	Futurism, Innovation and Logistics 4.0: challenges and opportunities.	Check the challenges and opportunities of logistics 4.0	bibliographic
4/	HELLINGER, A.; SEEGER, H.	Cyber-Physical Systems - Driving force for innovation in mobility, health, energy and production. Acatech Position Paper.	Address the driving force of innovation.	Analysis documentary
5/	KANG, H.S.	Smart manufacturing: Past research, present findings, and future directions.	Analyze research that deals with smart manufacturing	Revision bibliographic

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6/	LASI, H.*et. al*.	Industry 4.0. Business and Information Systems Engineering.	Explain about industry 4.0 and its relationship with business engineering	Revision bibliographic
7/	OLIVEIRA, TF; SIMÕES, WL	Industry 4.0 and production in the context of engineering students.	Identify how engineering students have performed research on industry 4.0.	Analysis documentary
8/	RUSSWURM, S.	Industry 4.0 - from vision to reality.	Carry out a broad approach to the future of industry 4.0	Revision bibliographic
9/	SCHRÖDER, R.*et. al*.	Implementation Analysis of a Process Automated in one Footwear Company: One Case Study of the Hyundai System Light Production and Industry 4.0.	Analyze the automated implementation process in a footwear company.	Study of case.
10/	SCHWAB, Klaus.	A fourth revolution industrial.	Approach to the impacts caused by the fourth industrial revolution.	Bibliographic.
11/	STOCK, T.; SELIGER, G.	Opportunities of sustainable manufacturing in industry 4.0.	Identify sustainable manufacturing opportunities in Industry 4.0.	bibliographic
12/	VDE-DKE	TheGerman Standardization Roadmap Industry 4.0.	Present the German standardization roadmap for Industry 4.0.	bibliographic

Table 2 – Main results of selected articles, 2011-2021

Article/Year	Main results
1/	The technologies applied by industry 4.0 are characterized by disruptiveness and irreversibility, impacting engineering.
two/	The company's production network, which integrates Manufacturing Execution Systems (MES) and Enterprise Resource Planning (ERP), are integrated into the company's production network, allowing real-time management of information.
3/	Industry 4.0 is present in manufacturing industries and can be associated with so-called smart factories, ensuring accurate results compared to companies that are not included in the industry 4.0 model.
4/	SCFs can be essential to solving global problems, being supported by the rapid development of global network technology such as the Internet and the easy access to information through the data cloud.
5/	The term industry 4.0 is the program created by the government to support the automation of production, creating greater competitiveness with international industry through intelligent manufacturing, using a large set of stored data, called Big Data.
6/	The fourth industrial revolution has a very broad scope, being fundamentally different from previous ones due to the interaction between the physical, digital and biological domains.
7/	The development of new technologies is related to the globalization scenario, making the industry 4.0 process gain prominence.
8/	Industry 4.0 allows the exchange of information with sensors and RFID chips, fully managing development, sales, logistics and others.
9/	Product and production life cycles must be based on a unified model to meet all shrink cycle requirements.
10/	The required levels of leadership and understanding of the changes occurring are low given the need to rethink our economic, social and political systems.
11/	Industry 4.0 makes use of processes that involve the manipulation of machines managed by technological intelligence, such as collaborative robotics.
12/	Cyber-Physical Systems (SCF) increase the functionality of factory processes by supporting the dynamic connection between the virtual and physical worlds, with easy access to information through the data cloud.

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In view of the above, it was clear that the selected articles address the current topic, industry 4.0, highlighting its characteristics, functionalities and advantages for engineering.

4 Analysis and Discussion

According to Kang*et. al*. (2016), the term industry 4.0 was first introduced in Germany at the Hannover fair in 2011. The term, also known as the program created by the government to support the automation of production and thus increase production line productivity , creating greater competitiveness with international industry through intelligent manufacturing, is also known as the fourth industrial revolution, characterized by the digital information era. Information technology is becoming more and more an integral part of industrial processes every day and decisions are made automatically using a large set of stored data, called Big Data (FIRJAN, 2016).

The term Industry 4.0 includes the expectations from corporate policy and practice that industrial production follows the fourth industrial revolution. The three previous industrial revolutions achieved high productivity gains caused by a few rapidly expanding universal technologies such as mechanization, electricity and IT.

Industry 4.0 (I4.0) is called the New Industrial Era, characterized by the use of intelligent systems with a high degree of automation and decision-making capacity. I4.0 comes with the increasing automation of manufacturing processes along with the development of Internet technology and technologies developed in the field of smart objects (products and machines). This new industrial revolution would have three main elements: product and product network, product life cycle and cyber-physical systems.

The company's production network, which integrates Manufacturing Execution Systems (MES) and Enterprise Resource Planning (ERP), increases the level of factory automation and allows the complete exchange of management information in real time (BRYNJOLFSSON; MCAFEE, 2014 ;LASI*et. al*., 2014; RUSSWURM, 2014).

The second element would be related to the combination of product and production life cycles based on a unified data model. Only in this way will the requirements

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resulting from contraction cycles can be controlled technically and economically (SCHRÖDER*et. al.*, 2015; SUGAYAMA; NEGRELLI, 2015).

Cyber-Physical systems (SCF) are an integration between the virtual and physical worlds. With sensors and actuators, the software is integrated into all parts of the process, enabling rapid information exchange, high process flexibility and precise control of the manufacturing process. SCFs increase the functionality of factory processes and allow for much safer and more efficient operations (VDE-DKE, 2014; NEGRELLI, 2015).

SCFs support this dynamic connection between the virtual and physical worlds and, when used correctly, can be essential to solving global problems such as climate change interpretation, security issues, health issues, genuine management, among others. This development is supported by the rapid development of global network technology, such as the Internet, and the easy access to information through the data cloud (HELLINGER; SEEGER, 2011; VDE-DKE, 2014).

The objective of I4.0 is to capitalize on the progress made in the area of communication and information technology applied to the industrial environment (VDE-DKE 2014). For Russwurm (2014), I4.0 has tremendous potential, with products, tools and manufacturing as it means exchanging information with sensors and RFID chips, with information beyond the limits of the factory, with integrated management of development, production, sales, logistics and operations (SCHRÖDER*et. al.* (2015).

There are important Industry 4.0 intermediaries, such as collaboration mechanisms, to increase productivity. In the literature, in most cases, industrial changes are motivated by high productivity growth potential, but the manufacturing industry itself is responsible for initiating measures to profit from social and technological changes. In the production system, the necessary preconditions must be created, divided into two levels, allocated in the cyber or physical world and differentiated between rigid or flexible components. This categorization leads to four main premises: globalization of information technologies, the only source of truth, automation and cooperation (SCHUM, 2015).

The fourth industrial revolution is not just about smart, connected systems and machines. Its scope is much broader. Waves of new discoveries occur simultaneously in areas ranging from genetic sequencing to nanotechnology, from renewable energy to quantum computing. What makes the fourth industrial revolution fundamentally

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different from the previous ones is the fusion of these technologies and the interaction between the physical, digital and biological domains (LASI*et. al*,2014).

In this revolution, emerging technologies and widespread innovations are spreading faster and more widely than in previous ones, which continue to occur in some parts of the world (NEGRELLI, 2015).

According to Schwab (2016), there are two major concerns about the factors that may limit the effective and consistent realization of the fourth industrial revolution. First of all, the author believes that the required levels of leadership and understanding of the changes occurring in all sectors are low given the need, in response to the fourth industrial revolution, to rethink our economic, social and political systems (SCHWAB, 2016) .

Consequently, according to Schwab (2016), at a national and global level, the institutional structure necessary to govern the dissemination of innovations and mitigate disturbances is, at best, inadequate and, at worst, completely absent.

Secondly, the author asserts that the world lacks a coherent, positive and common narrative that describes the opportunities and challenges of the fourth industrial revolution, or an essential narrative, if we are to strengthen a heterogeneous group of individuals and communities and avoid a backlash popular against fundamental changes underway (SCHWAB, 2016).

According to Schwab (2016), there are three objectives for this: (a) make people aware of the size, speed and impact of the revolution; (b) outline possible responses; (c) and provide a platform for public-private partnerships to address challenges and unlock opportunities. The digital revolution is leading to profound changes in customer consumption habits, including increased access to data and the increasing evolution of new technologies. All of this requires a profound reassessment of current business models.

The basic lever for transforming the business model is Data Science, which is based on the combined use of machine learning, artificial intelligence, mathematics, statistics, databases and optimization techniques.

5 Final Considerations

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From what has been discussed here, it can be understood that the advancement of technology in machines, equipment and *software* competition has become increasingly fierce. Every day, companies, industries and sectors seek to optimize production processes, as well as reduce their costs, with a view to maintaining and winning new customers. Thus, we have industry 4.0, which refers to the fourth industrial revolution, and was originated from a high-technology strategy project by the German government, promoting the computerization of an industry.

It was clarified that in industry 4.0, decision-making can be more assertive and autonomous, always based on internal (inside the factory) and external (outside the factory) data. Its growth was due to the exponential advancement of computer capacity, Big data and new innovation strategies such as research, people and technologies.

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