GREEN MANUFACTURING HOT RESEARCH TOPICS: A CO-WORD ANALYSIS

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RESUMO
Embora o conceito de Manufatura Verde (GM) tenha surgido na década de 1980, o tema ainda desperta muita atenção de acadêmicos e profissionais. Este artigo apresenta um panorama recente da pesquisa GM. Baseado na análise das palavras chaves de 115 documentos publicados entre 2015 e 2019, são identificados os principais tópicos de pesquisa. Estes resultados poderão direcionar futuras pesquisa sobre GM.

PALAVRAS-CHAVE: Manufatura Verde, Produção Verde, Análise Bibliométrica.

ABSTRACT
Although the concept of Green Manufacturing (GM) emerged in the 1980s, the topic still attracts a lot of attention from academics and professionals. This article presents a recent overview of GM research. Based on the analysis of the keywords of 115 documents published between 2015 and 2019, the main research topics are identified. These results could direct future research on GM.

KEY WORDS: Green Manufacturing, Green Production, Bibliometric Analysis.

INTRODUCTION

The concept of GM originated in Germany in the late 1980's and early 1990's (REHMAN and SHRIVASTAVA, 2013). However, the topic still arouses the interest of many researchers and manufacturing engineering professionals. There is a non-consensual on GM concept (PANG and ZHAN, 2019; SETYANINGSIH, INDARTI and JIE, 2018), that includes comprehensive set of processes in all business activities that impact the environment (REHMAN and SHRIVASTAVA, 2013) or system to promote sustainability and reduce environmental impact, minimizing resources and reducing pollution, recycling or developing green products (DORNFELD, DAVID ET AL. 2013). The highest level of consensus on the definition of GM is related to the idea that it reduces the adverse effects of manufacturing processes on the environment through their operations, use and disposal (SETYANINGSIH, INDARTI and JIE, 2018; CHUANG AND YANG, 2014). The strategies that can improve resource efficiency and effectiveness (GOVINDAN ET AL., 2015). Although there are many authors discussing the innovation and adoption of the GM model (PRASAD, KHANDUJA and SHARMA, 2016; REHMAN and SHRIVASTAVA, 2013), no studies have been found that highlight the hot topics in this field of research.

OBJECTIVE

Provide ample content on the green manufacturing model

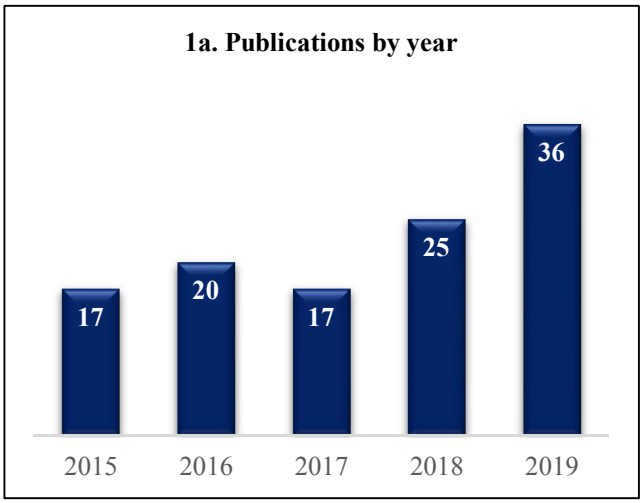
METHODS

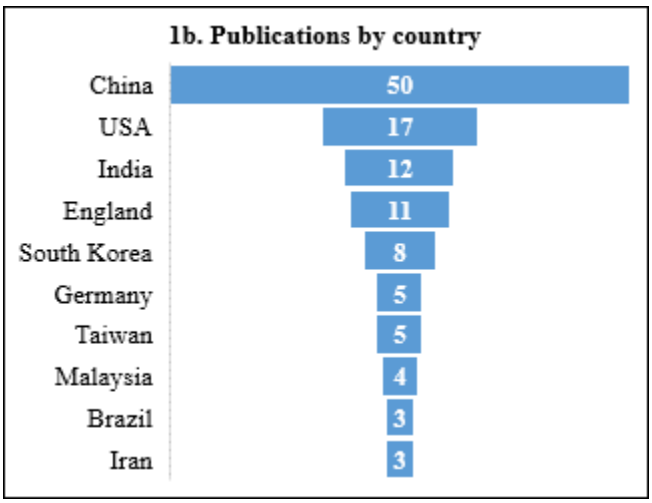
The Web of Science (WoS) database was consulted on April 19, 2020 to retrieve bibliometric records of documents related to Green Manufacturing research. In line with Rehman and Shrisvastava (2013), Abualfaraa, et al. (2020) and Rajput, Sarvesh PS; Datta (2020), the search expression (*("green manufacturing") OR ("green production")*) were used was applied to gather all the publications with those terms in their titles, abstracts, or keywords. The search restricts the articles published between 2015 and 2019. Were refined the search to "manufacturing engineering" subject area, as it is a category where the GM model has a considerable impact.

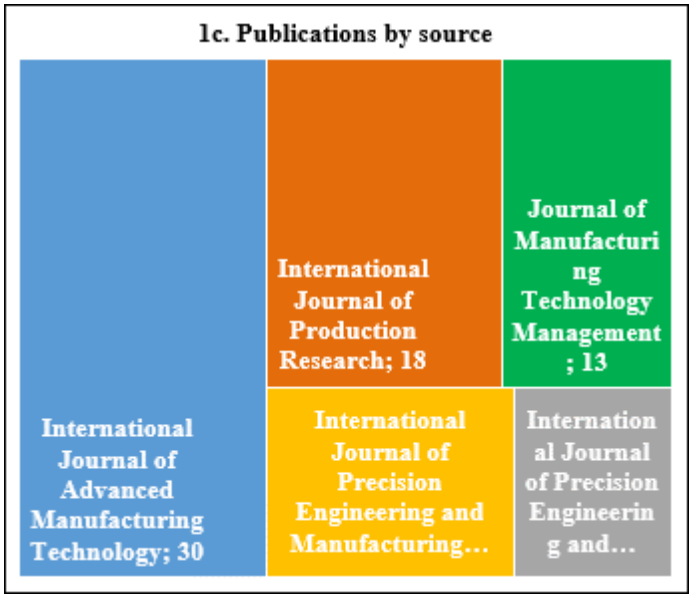
To identify the hot topics in GM research were used the co-word analysis method, which is the only approach to construct a similarity measure using the actual content of documents (NÁJERA-SÁNCHEZ, 2020). Using VOSviewer software (www.vosviewer.com) were produced keywords maps, in which strongly related terms are located close to each other and the weaker the relationship is between terms Keywords are used to express the theme of the academic documents, and the clustering analysis of these co-occurrence keywords can reveal the knowledge structure and hotspots in this research field (SHI e MIAO, 2019).

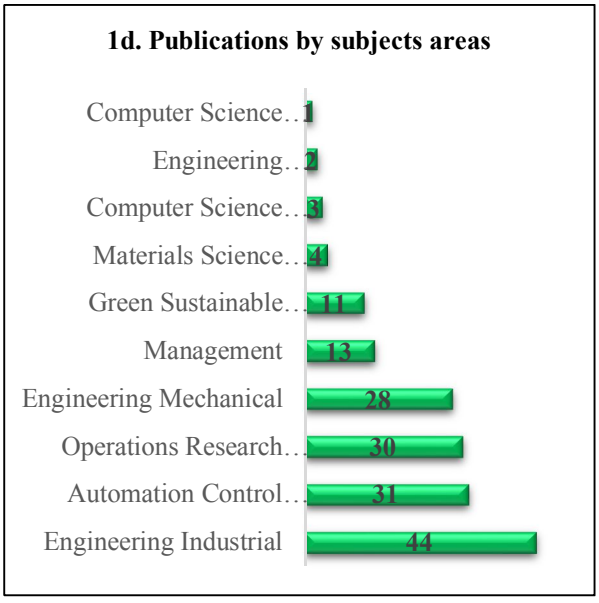
RESULTS AND DISCUSSION

Were identified 115 articles in the Green Manufacturing research. Figure 1a reveals an exponential growth in the number of scientific publications in the last five years (2015-2019). With 50 publications (43.48%), China is the country with the largest number of articles (Figure 1b), the International Journal of Advanced Manufacturing Technology was the most productive source, with 30 articles (26.09%) (Figure 1c), and Industrial Engineering was the most common study area, 44 articles (38.26%) (Figure 1d). The timeline (Figure 1e) shows that in the last 5 years (2015-2019) the number of publications was higher compared to the previous 32 years (1983-2014), with a percentage of 56.91 (787 publications).









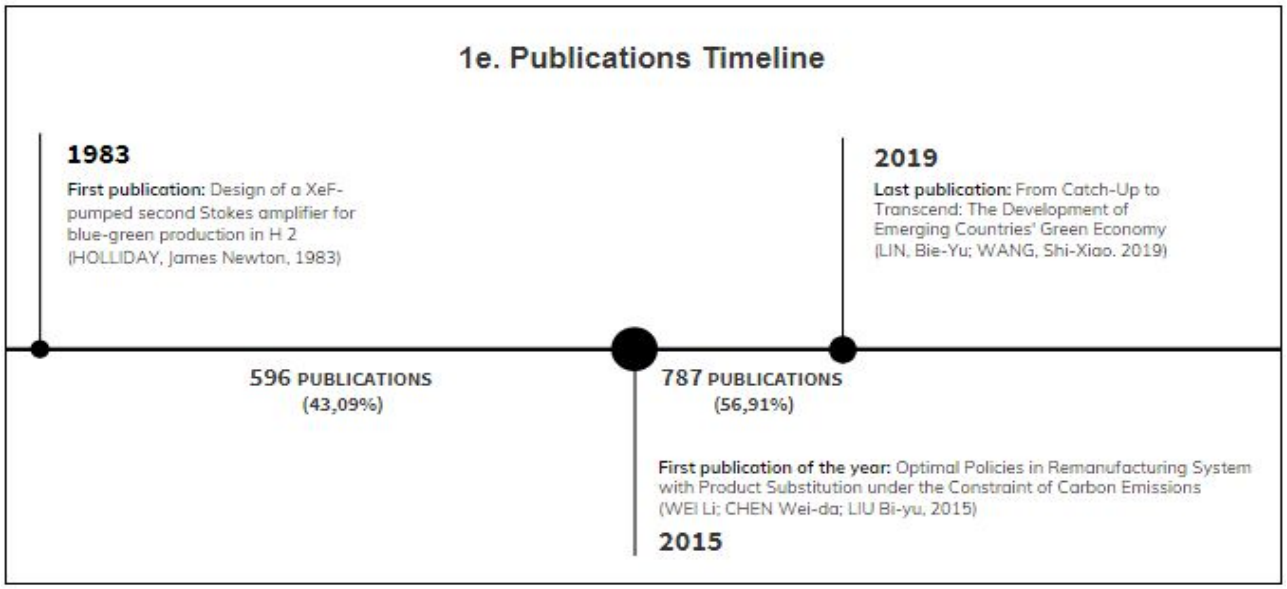


Figure 1: Dashboard of Green Manufacturing hot research topics

Of the 115 publications, 413 keywords were extracted. Before analysis, we programmed VOSviewer to select keywords that have been cited at least 4 times; when there were two or more synonyms, they were replaced by the more general term, such as green production and green operation by green manufacture, resulting in 9 keywords cited in at least 2 articles. Figure 2 makes this representation.

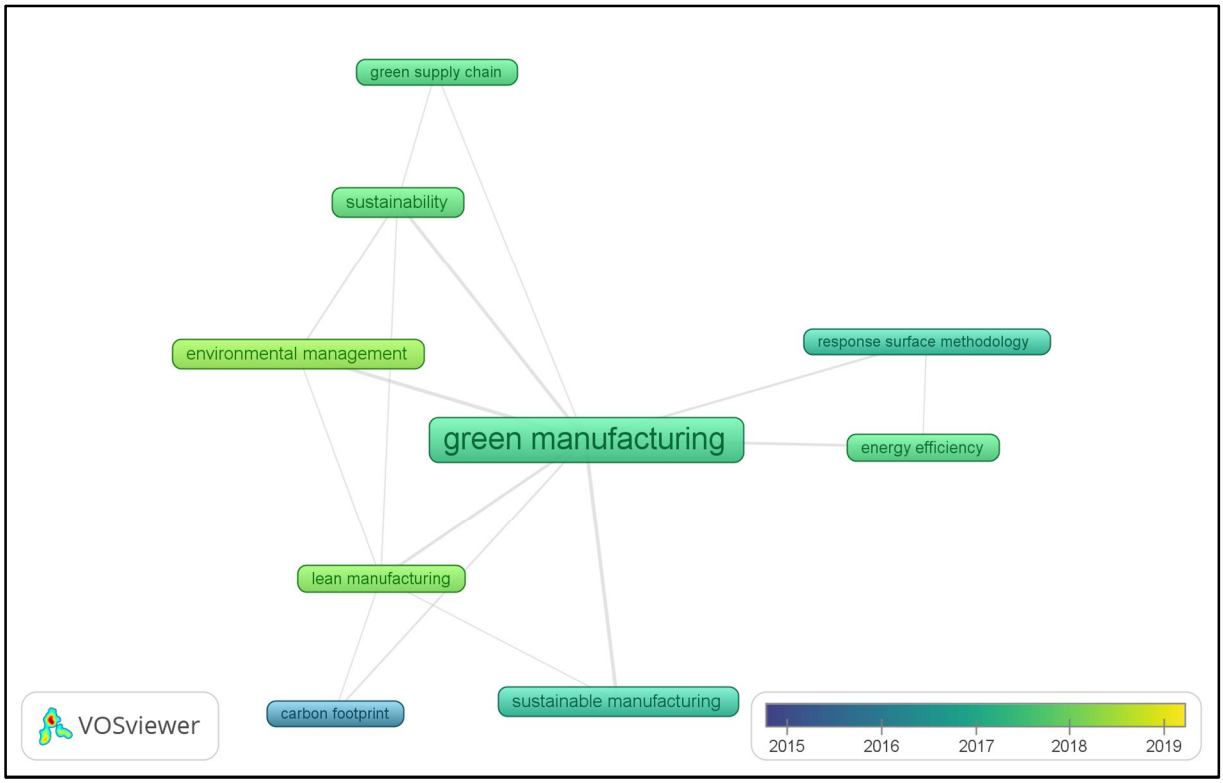


Figure 2: Co-occurrence network of keywords in publications on Green Manufacturing.

The figure suggests that the current debate is around lean manufacturing and environmental management. In the case of lean, in particular, positive relationships are likely to support previous empirical studies, showing that lean practices are moderately interrelated to ecological practices and must be linked to improve the environmental performance of industries (FLORIDA, 1996; KING AND LENOX , 2001; YANG et al., 2011; TORIELLI et al., 2011). In addition, the goals of lean and green manufacturing are synergistic in terms of focusing on eliminating waste and reducing inefficiency (PRASAD, KHANDUJA, SHARMA, 2016). The researchers recognize that the success of integrating environmental

issues into the organization cannot be easily achieved, if a concern with green innovation is not clearly addressed in the development of business processes for companies (CHEN et al., 2006; CHEN, 2008; ZIEGLER and NOGAREDA, 2009).

CONCLUSIONS

Although widely commented on, green manufacturing is a subject that has started to be applied recently, and the need to be applied and the positive results it offers are visible. The reasons include regulatory requirements, product management, public image and possible competitive advantages. The trend is for industries to enter this sustainable world in the coming years, with a focus on reducing the degradation of natural resources. The International Journal of Advanced Manufacturing Technology, together with China, leads the largest number of studies and research. Although the topics Green Manufacturing and Sustainability are among the most popular topics, Lean Manufacturing and Environmental Management are the most recent points and may direct research in the coming years. The number of publications has increased significantly in the last 5 years compared to the previous 32 years, showing interest in the topic. This article not only presents results of research on GM today, but everything can also contribute to future research.

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