

BIBLIOMETRIC ANALYSIS FOR SIMULATING THE BEHAVIOR OF ADHESIVES USING THE MESHLESS METHOD

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Abstract: Structural adhesives have great power in replacing mechanical fasteners. Coupled with this, it is necessary to know the behavior of the adhesively bonded parts; therefore, the Meshless method can be an alternative to predict their behavior. To understand the academic production scenario on the subject, a bibliometric analysis was proposed. The results of the bibliometric analysis show that there is a disparity between when analyzing only the isolated bases and the merged database. In addition, it was possible to locate from the bibliometric analysis, especially the annual production on the theme, the primary productive authors and the most relevant Journal.

Keywords: Meshless method, Structural adhesive, Bibliometrics, Circular economy.

ANÁLISE BIBLIOMÉTRICA PARA SIMULAÇÃO DO COMPORTAMENTO DOS ADESIVOS PELO MÉTODO MESHLESS

Resumo: Os adesivos estruturais possuem grande potência na substituição de fixadores mecânicos, portanto é necessário conhecer o comportamento das peças adesivadas. Diante desse contexto, o método Meshless pode ser uma alternativa para prever o seu comportamento. Com objetivo de mapear o cenário da produção acadêmica sobre o tema, foi proposto uma análise bibliométrica. A partir da análise bibliométrica foi possível verificar a produção anual sobre o tema, os principais e os Journal mais relevantes.

Palavras-chave: Método Meshless, Adesivo estrutural, bibliometria, economia circular.

1. INTRODUCTION

Currently, the structural adhesives market is dominated by epoxy and polyurethane chemicals, which form terofixed resins when crosslinking their polymer networks, due to their high strength and fast application times [1]. The epoxy market is projected to be worth an estimated \$21.87 billion by 2031 [2].

Adhesives can be a viable alternative for replacing mechanical fasteners, for example, some aircraft manufacturers often install tens of thousands of redundant fasteners in an attempt to ensure safety in critical applications, however, also adding tremendous complexity, time and cost while significantly reducing aircraft performance [3]. Adhesives are increasingly being applied because they allow reducing the number of waste generated, optimize the cost and manufacturing time, and reduce the weight of the parts contributing to optimization with the energy expenditure, contributing to the circular economy.

The circular economy (CE) is defined as an economic model that aims to use resources efficiently by reducing waste, costs and raw materials, and promoting closed product and material cycles to promote sustainability and ensure socioeconomic benefits [4], thus, it is considered as a solution to a number of challenges such as waste generation, resource scarcity and sustainable economic benefits [5].

Numerical modeling of adhesive joints has been heavily developed over time. Today there are many variations of adhesives designed, specifically to meet the challenges of creating strong and durable, but also flexible joints for bonding composites, plastics and metals [6]. Therefore, it is necessary to investigate the behavior of adhesive bonds. The first analytical models, were proposed in 1938 by Volkersen in 1938 by Goland and Reissner (1944), whereas the finite element model applied to adhesives were proposed in 1998 by Penedo [7].

Meshless methods, on the other hand, initially appeared to solve astrophysical problems, but nowadays there are still few commercial softwares. However, they are able to eliminate the problems associated with the finite element method (FEM), such as meshing and processing time [7], [8]. Because it is an unusual method, a bibliometric review is suggested to assist the authors in prospecting adherent works. For, it is observed the difficulty of the authors to map publications specifically related to their research, select them according to specific criteria, treat the data obtained and then use the main references in the development of the project [9]. Thus, the use of bibliometric analysis tools is proposed.

Bibliometrics refers to a complex scientific mapping that is difficult to perform because it comprises multiple steps and uses several tools. Bibliometric analysis is capable of assessing the relevance of publications through indicators and guiding the author in the selection of references that are more adherent to the topic of interest in a quantitative way. Therefore, this methodology aims to develop a systematic, transparent and reproducible review process based on the statistical measurement of science, scientists or scientific activity [10].

[11], propose an open-source tool called bibliometrix. In this tool it is possible to perform comprehensive bibliometric analysis of scientific mapping, developed in the R

language. This tool is flexible and can be quickly updated and integrated with other statistical R packages, so it is constantly changing, like bibliometrics. Therefore, from bibliometric analysis it is possible to synthesize the findings of previous research to effectively use the existing knowledge base and advance a particular line of research. The proposed article aims to evaluate and compare the academic production of works developed from the analysis of the joints of parts by structural adhesives via numerical simulation using the Meshless method, strengthening and presenting a new technology that stimulates and promotes the development of a circular economy.

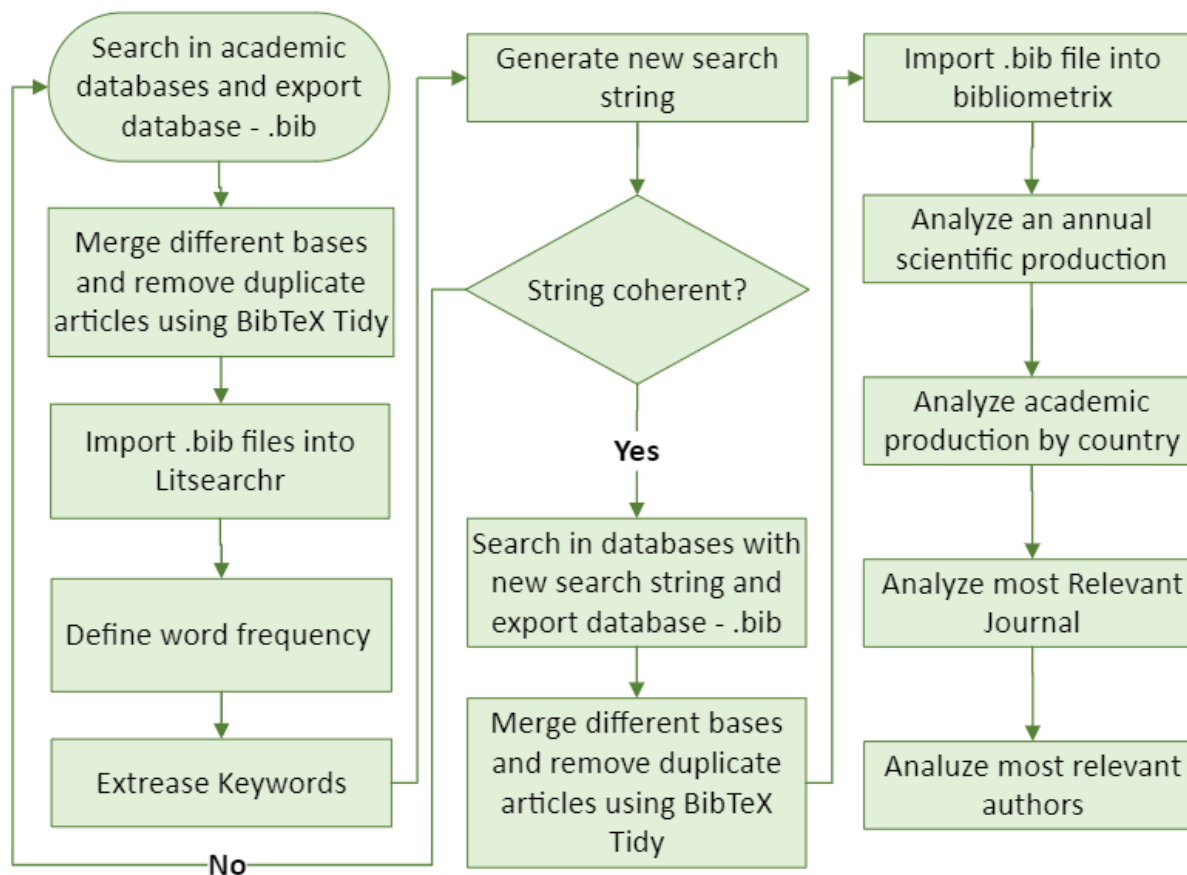
2. METHODOLOGY

The search strategy developed in this paper was adapted from the methodology developed by [12]. He proposed to use the Litsearchr tool, developed by [13], to develop a more assertive search string based on the development using text-mining and keyword co-occurrence networks to identify important terms to include in a search strategy. The other tool used by [12] was Bibliometrix, proposed by [11], which performs a bibliometric analysis based on data extracted from academic databases. The BibTeX Tidyessa tool developed by [14] was also used. In this way, a data matrices for co-citation, coupling, scientific collaboration analysis and co-word analysis can be assembled.

The methodology suggested and developed in this article has as its main objective to expand and optimize the process of research and analysis of the results obtained. Thus, it is possible to develop a mapping of the main focal points, main authors, countries of origin of the publications, and the most relevant journals on the theme.

Figure 1 shows a step-by-step flowchart of the methodology developed, in which the search bases for collecting articles were Scopus and Web of Science, both available at the CAPES PERIODICOS Portal, and most steps were implemented in R

Figure 1. Flowchart of the methodology developed to create the parameters for searching and analyzing the bibliometric data.

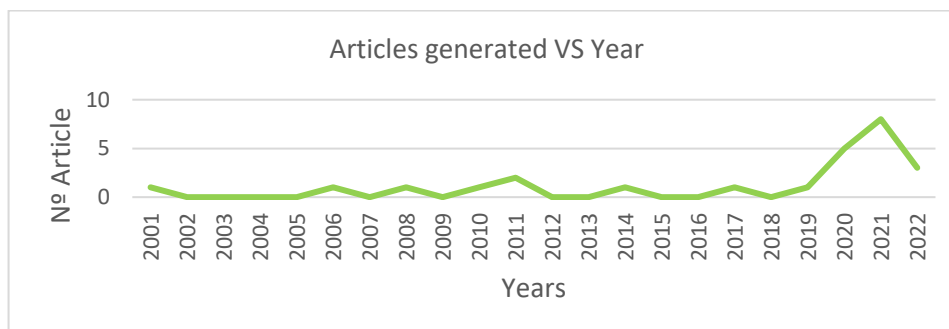


Soucer: Adapted from [12]

3. RESULTS AND DISCUSSION

Initially, to perform the search process, the string: ("structural adhesives " AND "meshless") was created, generating a total of 11 documents, which were exported in .bib format. Using the litsearchr tool developed by [13] it was possible to measure the interaction strength of the words and create groups with the terms extracted and provided by the tool. After this step, a new script was created, ("adhesive joints" OR "adhesively bonded" OR "bonded joints" OR "structural adhesive" OR "structural adhesives") AND ("meshless method" OR meshless). Thus, a new search was performed in the databases, totaling 25 documents in the Scopus search base and 18 in the Web of Science. This implementation of the keywords did not result in a significant increase in the number of documents found. This can be explained because it is a theme that has been explored with more emphasis in the last 3 years, as seen in Figure 2.

Figure 2. Número de artigos produzidos por ano.



Sourcer: Adapted from [15], [16]

3.1. Bibliometric analysis

From the expansion of the number of documents generated, it was possible to evaluate the most productive authors, development and growth of the research theme, the most relevant sources, and the most productive countries.

Table 1 presents data related to the publications identified in the Scopus, WOS and merged databases. The number of publications retrieved from Scopus was 39% higher than from WOS. The merged database also showed a disparity to the sum of Scopus and WOS, as 36% of the records were duplicate publications. Both platforms carry the beginning of the publication period as the year 2001. The number of author keywords and Keyword plus was more than double in Scopus.

Table 1. Overview results

	Scopus	WOS	Merged
Documents	23	18	26
Sources (journal, article, conference, proceeding)	15	11	18
Authors	29	26	36
Keywords plus (ID)	166	72	194
Author keywords (DE)	65	76	86
Period	2001-2022	2001-2022	2001-2022
Average citations by documents	5,92	6,79	6,39

Sourcer: Adapted from [15], [16]

Table 2 shows the 10 most relevant journals for both databases. The International Journal of Adhesion And Adhesives presents a higher number of published articles on the subject. However, the journal Composite Structures has a higher impact factor and citation score according to Scopus and presents the A1 classification, according to the Sucupira Portal.

Table 2. Main journal

Sources	Articles	Cite Score	Impact Factor	Classification
International journal of adhesion and adhesives	4	5,6	3,85	A2
Engineering analysis with boundary elements	3	5,0	3,25	A2
Procedia structural integrity	3	1,9	1,60	A2
Composite structures	2	9,7	6,60	A1
The journal of adhesion	2	4,9	2,92	B1
Journal of the brazilian society of mechanical sciences and engineering	2	3,6	2,22	B1

Soucer: Adapted from [15], [16]

Table 3 highlights the 4 most productive authors, a ranking based on the number of publications, number of citations and h-factor. The first ranking criterion is the number of publications, but if two or more authors have the same number of publications, the second criterion is the number of citations and lastly the h-factor. All authors are Portuguese. It is worth noting that in the last 5 years the Portuguese represent 100% of the articles published on the simulation of adhesive parts using the Meshless method.

Table 3. Main Authors

		Authors			
		Luís D.C.Ramalho	Raul D.S.G.Campilho	Jorge Belinha	Isidro J.Sánchez-Arce
Scopus	Articles	17	17	17	13
	N° Citations	98	56	49	44
	h-index	36	44	27	3
WOS	Articles	12	11	9	7
	N° Citations	18	14	14	6
	h-index	32	33	26	2

Soucer: Adapted from [15], [16]

4. CONCLUSION

These types of analysis allow researchers to gather statistical information in order to optimize their academic search process and locate more adherent works. Thus, it was possible to verify the trend of academic discussions about the simulation of adhesive parts using the meshless method; to establish the main Journal on the subject; the authors with the highest degree of expertise on the subject, as well as the most influential articles. In addition, it was possible to demonstrate that there are some differences between Scopus and WOS, confirming the importance of broadening the search.

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