



MECHANICAL STRESS MODELING OF A COMPOSITE MATERIAL OF RESIN, POLYESTER AND NATURAL FIBERS

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Abstract

A documentary review was carried out on the production and publication of research papers related to studying the variables Material Tension and Polyester Resin. The bibliometric analysis proposed in this document was to know the main characteristics of the volume of publications registered in the Scopus database during the period 2017-2022, achieving the identification of 32 publications in total. The information provided by the said platform was organized using tables and figures, categorizing the information by Year of Publication, Country of Origin, Area of Knowledge and Type of Publication. Once these characteristics were described, a qualitative analysis was used to refer to the position of different authors on the proposed topic. Among the main findings of this research, it is found that China, with 6 publications, was the country with the highest scientific production registered in the name of authors affiliated with institutions of that country. The area of knowledge that made the greatest contribution to the construction of bibliographic material referring to the study of the mechanical stress modeling of resin, polyester and natural fiber composite materials was Engineering with 21 published documents, and the type of publication that was most used during the above mentioned period was the journal article, which represents 53% of the total scientific production.

Keywords: Mechanical Modeling, Material Stress, Resin, Polyester, Natural Fibers.

1. Introduction

Composite materials have made it possible for important developments in different areas of knowledge, based on these significant advantages in weight and mechanical resistance, and managing to offer cost-efficient solutions according to the application. Clear examples of the presence of composite materials can be found in the construction of buildings to identify the union of two primary materials: steel and concrete. The characteristics of each material fulfill different functions, resulting in a material that can support different types of loads.

The mechanical modeling of a composite material usually has mechanical properties superior to those of its separate components. When a composite material has superior properties to its composites, it is said to have synergy, a fundamental property to identify which materials are susceptible to be used to create composites. In general, the use of natural reinforcement materials

has presented an easy detachment from the matrix, indicating a weak synergy bond between resin composites and natural fiber derivatives, one of the main reasons they are not frequently used.

From another approach to structural engineering, composite materials offer several decisive advantages compared to conventional structural materials or those derived from raw materials, such as, among other things, the possibility of generating metallic and rigid matrix structures. The basis for this structural superiority is based on the high modulus of rigidity and higher specific strength and the heterogeneous nature, which provides greater freedom for design and optimal configuration of the structural material. For such reason, this paper seeks to describe the main characteristics of the compendium of publications indexed in the Scopus database related to the variables Material Tension and Polyester Resin, as well as the description of the position of specific authors affiliated with institutions during the period between the years 2017 and 2022.

2. General Objective

To analyze from a bibliometric and bibliographic perspective, the production of research papers on the variables Emotional Development, Cognitive Development and Virtual Learning registered in Scopus during the years from 2017 to 2022.

3. Methodology

Quantitative analysis of the information provided by Scopus is performed under a bibliometric approach to the scientific production related to studying the variables of Material Tension and Polyester Resin. Also, from a qualitative perspective, examples of some research works published in the area of the study mentioned above are analyzed from a bibliographic approach to describe the position of different authors on the proposed topic.

The search is performed through the tool provided by Scopus, and the parameters referenced in Figure 1 are established.

3.1 Methodological design

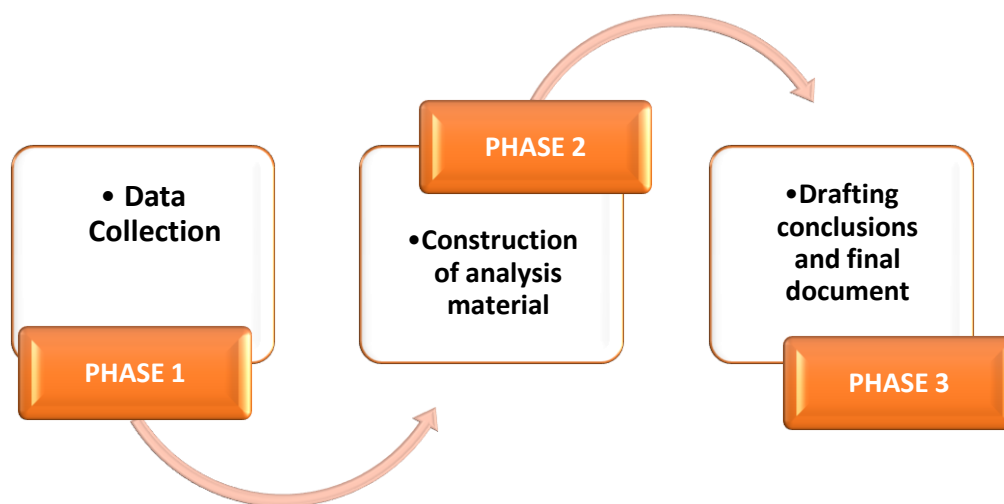


Figure 1. Methodological design

Source: Own elaboration

3.1.1 Phase 1: Data Collection

The data collection was carried out using the Scopus web page search tool, which identified a total of 32 publications. For this purpose, search filters were established consisting of:

TITLE-ABS-KEY (tension AND of AND materials, AND polyester AND resin) AND (LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2017))

- ✓ Published papers whose study variables are related to the study of the variables Material Tension and Polyester Resin.
- ✓ Without distinction of country of origin.
- ✓ Without distinction of area of knowledge.
- ✓ Without distinction of type of publication.

3.1.2 Phase 2: Construction of analysis material

The information identified in the previous phase is organized. The classification will be made through graphs, figures and tables based on data provided by Scopus.

- ✓ Word Co-occurrence.
- ✓ Year of publication
- ✓ Country of origin of the publication.
- ✓ Knowledge area.
- ✓ Type of Publication

3.1.3 Phase 3: Drafting conclusions and final document

After the analysis carried out in the previous phase, the study drafted the conclusions and prepared the final document.

4. Results

4.1 Co-occurrence of words

Figure 2 shows the co-occurrence of keywords within the publications identified in the Scopus database.

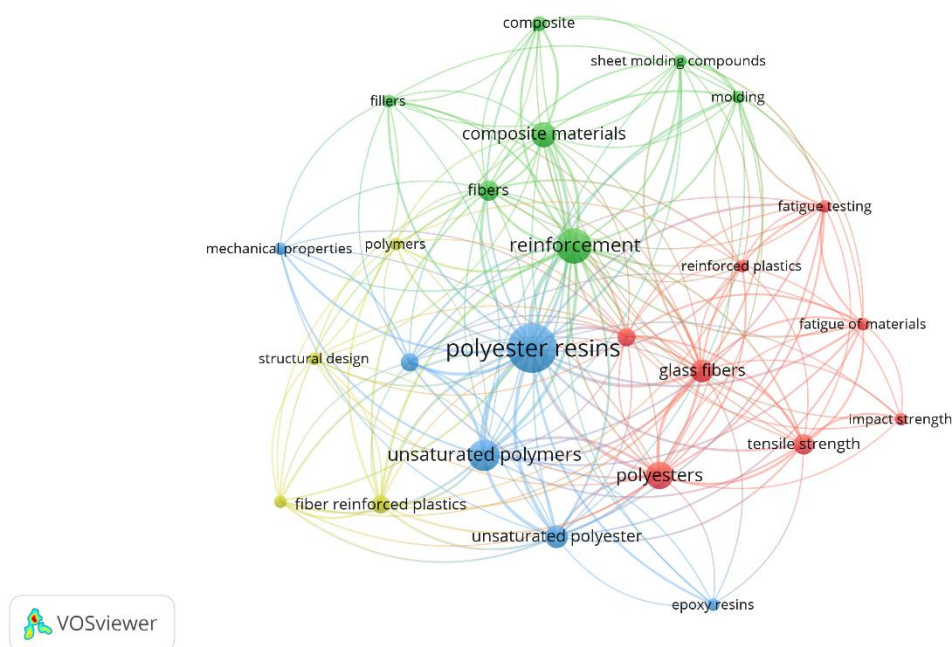


Figure 2. Cooccurrence of words

Source: Own elaboration (2023); based on data provided by Scopus.

Within the study of the research reported by the Scopus platform, referring to the variables Tension of Materials and Polyester Resin, the object of this scientific debit, it is counted that the composite materials given to its anisotropic and heterogeneous nature, the number of variables is notably superior to the conventional materials since the effort only provides a marked rigidity and a growth of the local resistance, being this the matrix that constituent that governs the global mechanical properties of the matter. It is for this reason that through the interpretation of Figure 2, it is possible to determine how key words of the publications reported in Scopus, Polyester Resin, Composites Materials, Reinforcement, in attention to improve the material composites and the reinforcement of the same and improve the properties of the manufacture of vegetable origin, these treatments can be used to improve the compatibility of the fibers derived from the resin and with this achieve a better composite. Composite materials are widely used due to their light weight and good mechanical properties. To obtain high-performance parts of advanced composite material, the curing process should be performed by autoclave technique because with this method, the best results are obtained for aeronautical applications due to the time-consuming manufacturing process, the high cost and complexity of the system and the same time providing a level of quality and the required functionality.

4.2 Distribution of scientific production by year of publication.

Figure 3 shows how the scientific production is distributed according to the year of publication, considering the period from 2017 to 2022.

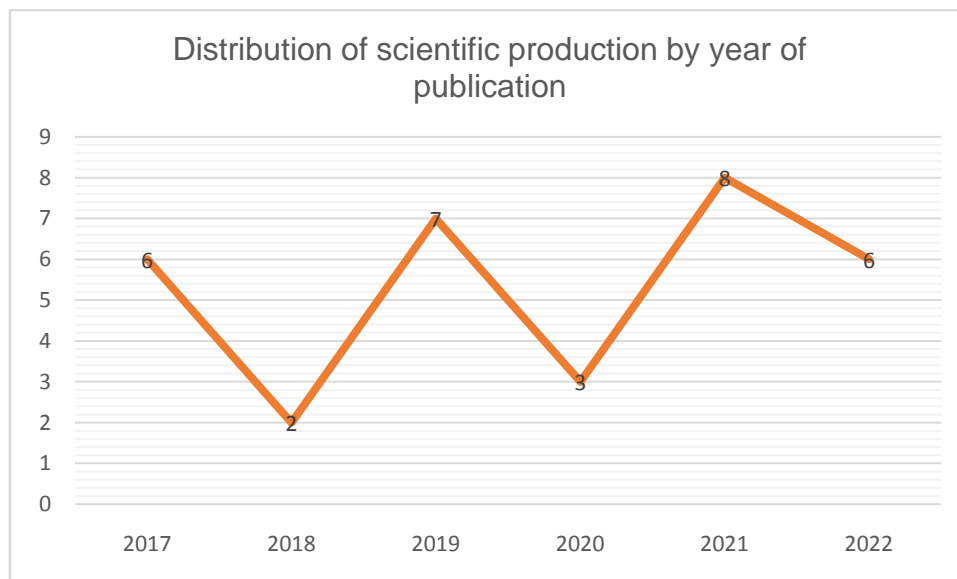


Figure 3. Distribution of scientific production by year of publication.
Source: Own elaboration (2023); based on data provided by Scopus.

Figure 3 shows the scientific production around the variables Material Stress and Polyester Resin in the period from 2017 to 2022, where the increase in production volume in the year 2021 is evidenced, with a total of 8 publications related to the keywords, among which the article entitled “Multi-scale damage analysis of the stress-strain fatigue behavior of a low-density sheet molding compound” stands out (Shirinbayan, 2021). This paper presents the experimental findings of stress-strain controlled fatigue tests performed on a low-density sheet molding composite (LD-SMC). The LD-SMC composite is a type of SMC that includes a polyester resin reinforced with chopped glass fiber bundles and hollow glass spheres. Frequency-amplitude coupling affects the nature of the overall fatigue response, which can be controlled by accumulating damage mechanisms and self-heating. Self-heating resulted in material softening and decreased fatigue life. For fatigue loading at 80 Hz, self-heating was observed and resulted in a temperature rise of 65 °C, which is more than the glass transition temperature of the polyester. Thus, the polyester matrix is subject to remarkable thermally activated modifications of its physical state. Multi-scale damage analysis of the randomly oriented sample in fatigue showed that the first damage phenomenon observed corresponds to the disunion of hollow glass microspheres occurring in the fiber-depleted zones.

4.3 Distribution of scientific production by country of origin.

Figure 4 shows the distribution of scientific production according to the nationality of the authors.

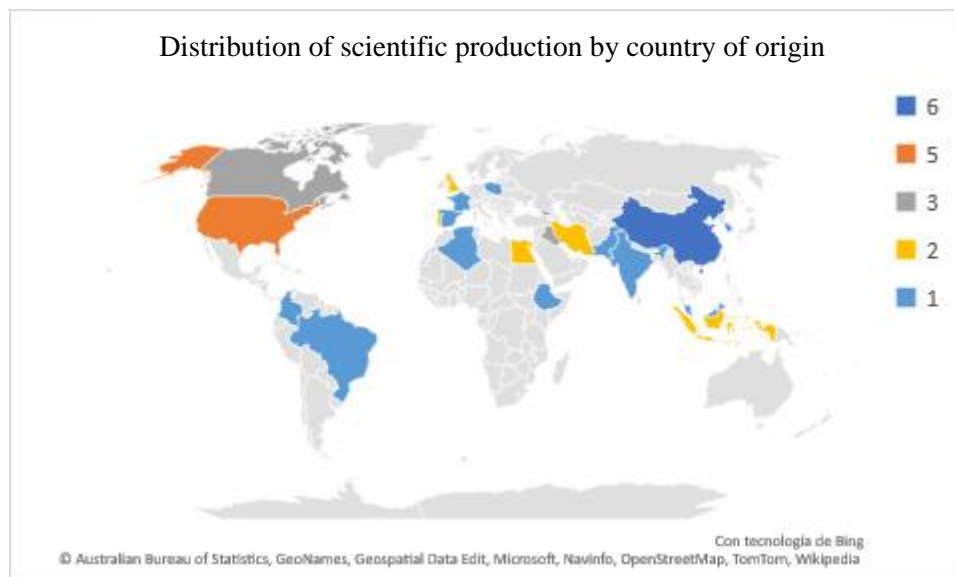


Figure 4. Distribution of scientific production by country of origin.
Source: Own elaboration (2023); based on data provided by Scopus.

China was the country with the highest number of publications registered in Scopus referring to variables of *Material Stress* and *Polyester Resin* during the period 2017-2022 with a total of 6 publications, followed by the United States with 5 registrations and Canada with 3. Of the latter, the article entitled “A neural network based on cuckoo search for predicting fatigue life in rotor blade composite materials” is noteworthy (Ziane, 2020). The purpose of this paper is to identify materials that have appropriate fiber orientations to improve fatigue life. Using Cuckoo Search-based Neural Network (CSNN), a model was developed to predict the fatigue life under stress-strain loads for five composite materials, with different fiber stacking sequences embedded in three types of resin matrices (epoxy, polyester, and vinylester), which are all suitable for wind turbine blade design. In the CSNN approach used in this work, the cost function was evaluated using the mean square error (MSE) calculated as the squared difference between predicted and target values for a series of training set samples obtained from an experimental fatigue database. The results illustrate that CSNN can accurately predict fatigue life for different MD/UD composite laminates under different fiber orientation angles.

4.4 Distribution of scientific production by area of knowledge

Figure 5 shows how the production of scientific publications is distributed according to the area of knowledge through which the different research methodologies are executed.

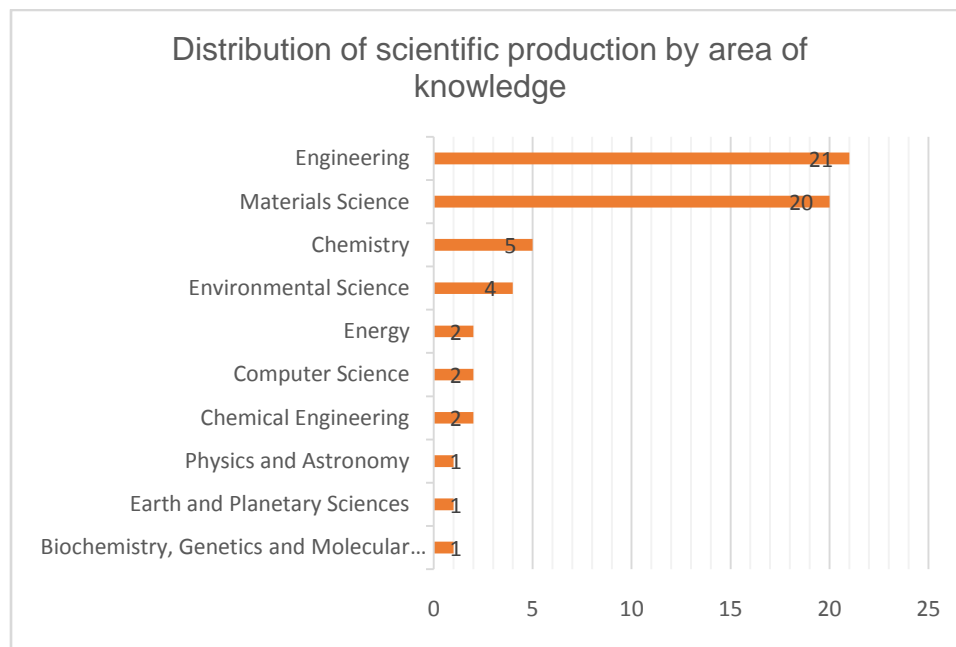


Figure 5. Distribution of scientific production by area of knowledge.
Source: Own elaboration (2023); based on data provided by Scopus.

Engineering was the area of knowledge with the highest number of publications registered in Scopus, with 21 papers that have based their methodologies on the impact of Materials Tension and Polyester Resin referents. In second place, Materials Science, with 20 papers. The above can be explained thanks to the contribution and study of different branches; the article with the highest impact was registered by the Engineering area entitled “Investigation of hybrid tensile lap splice hybrid steel bars used in RC beams under bending”(Gnedy, 2022). The main objective of this research using the concept of material hybridization is to investigate the effect of bar diameter after adding fibers and code equation coefficients for the best efficient development length for tensile splicing in beams under flexure. Nine RC beams with dimensions of (250*400*4200) mm and concrete strength of 30 MPa were cast. The beams were divided into three groups according to the fiber thickness added to the 10 mm steel bars. The first group contained three beams reinforced with 12 mm diameter hybrid bars, 10 mm steel coated with 2 mm fiber. Beam one was cast using 1.3*50 ϕ lap-spliced bars, and beam two was cast using 1.3 x 55 ϕ lap-spliced bars and beam three was cast using 1.3 x 60 ϕ lap-spliced bars. The second group contained three beams strengthened with 14 mm diameter hybrid bars, 10 mm steel clad with 4 mm fiber, beam one was cast using 50 ϕ lap splice bars, beam two was cast using 55 ϕ lap splice bars and beam three casts using 60 ϕ lap splice bars. The third group contained three beams strengthened with 16 mm diameter hybrid bars, 10 mm steel clad with 6 mm fiber, beam one was cast with 1.3*50 ϕ lap spliced bars, beam two was cast using 1.3*55 ϕ lap spliced bars & beam three was cast using 1.3*60 ϕ lap spliced bars. The beams were tested under four-point loading to create a region of pure bending stress. The load-deflection curves are presented along with the percentage differences. Finally, conclusions were drawn and presented in this paper.

4.5 Type of publication

Figure 6 shows how the bibliographic production is distributed according to the author's chosen publication type.

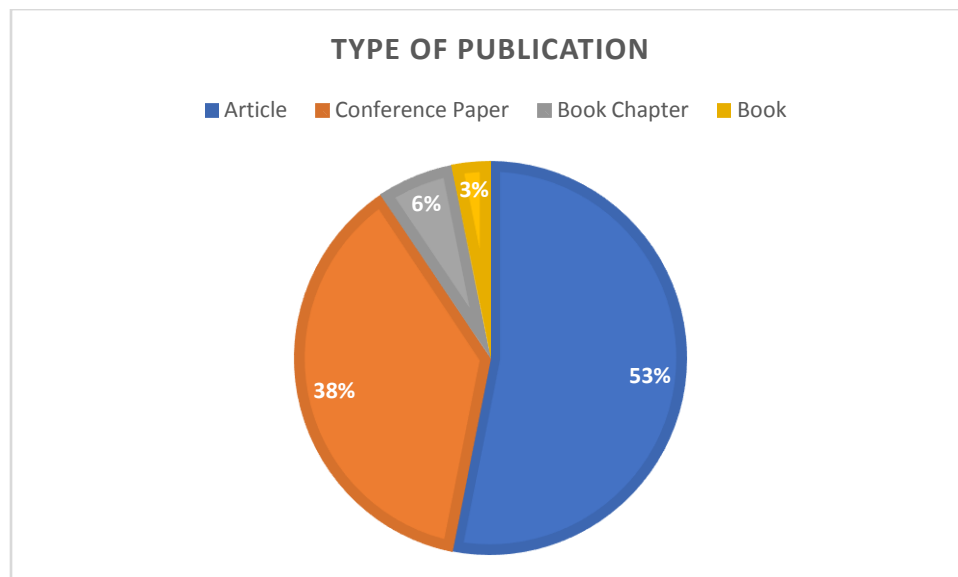


Figure 6. Type of publication

Source: Own elaboration (2023); based on data provided by Scopus.

The type of publication most frequently used by researchers was the article; 53% of the total scientific production corresponds to this document type. In the second place, Session Papers with 38% and Book Chapters with 6%. In this last category, the one entitled “Development of a soil moisture sensor using the principle of electrical resistance” (Pereira, 2021) stands out. This study aimed to evaluate the types of electrodes and the filling and encapsulation materials on the performance of soil moisture sensors. Based on the principle of electrical resistance, different sensors were fabricated and evaluated in a randomized block design in a 2 x 5 factorial scheme with two electrodes (20 x 5 and 15 x 5 mm) and five filler and encapsulation materials (coarse sand + gypsum with 30% marble dust, 30% fine sand + 30% marble sand, 30% sand and gypsum with 30% sand) with four replicates. The results indicated that concentric stainless steel mesh ring electrodes fixed with polyester resin maintain uniform electrical conductivity readings in soil water tension measurement. The 20 x 5 electrodes filled with fine sand and encapsulated with gypsum + marble powder were more sensitive to low voltages and with more accurate soil moisture readings.

5. Conclusions

Through the bibliometric analysis carried out in this research work, it was possible to establish that China was the country with the highest number of published records regarding the variables Material Tension and Polyester Resin with a total of 6 publications in the Scopus database during the period 2017-2022. In the same way, it was possible to establish that the application of fibers and natural composites can be used as reinforcement base for polymeric matrix composite materials in applications where high mechanical performance is required; however, the fundamental aspects that end the behaviors of those composite materials are the non-homogeneity and anisotropy, these are the ones in charge of determining the stiffness and strength of the mechanical modeling of composite material, in this sense, we determined that the stiffness which is in a phase of maturity notably higher than the evaluation of the strength. In the experimental field, it should be noted that,

among many others, the advances in characterization, the development of advanced non-destructive techniques of mechanical characterization and the use of optical fibers for structural monitoring allow us to stand out in the corresponding fields such as civil engineering and building.

However, the implementation of a vacuum system for the production of composite materials can be an excellent tool to increase the saturation of materials, and it is essential to note that it is possible to produce products whose mechanical strength is within the patterns highlighted for the improvement of the manufacturability of the parts, highlight that the orientation of the natural fibers is of vital importance in the mechanical properties of the composites, as this depending on the direction of the load these work in a better way and turn to maintain a greater synergy with the matrix reducing the detachments.

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