

Analysis of Research Trends in the Field of Mechanical Engineering

Adrian Knapczyk

Department of Mechanical Engineering
and Agrophysics Faculty of Production
and Power Engineering,
University of Agriculture
Krakow, Poland
adrian.knapczyk@urk.edu.pl

Slawomir Francik

Department of Mechanical Engineering
and Agrophysics
Faculty of Production and Power
Engineering,
University of Agriculture
Krakow, Poland
slawomir.francik@urk.edu.pl

Abstract—The work includes a bibliometric analysis of the main topics and research trends within the discipline of Mechanical Engineering. On the basis of analysis of data from the Scopus database, the Applied Mechanics Reviews magazine was chosen, which is the only one conducting scientific activity exclusively in the field of Mechanical Engineering. In the years of analysis (2002-2017), it was pointed out that the main research topics are optimization issues, material engineering and mechanics.

Keywords—mechanical engineering, scientometrics, research trends, bibliometric analysis, literature review.

I. INTRODUCTION

Mechanical engineering is a complex and very broad field of scientific research that uses the achievements of other fields (mechanics, design and many others). The division and domains involved in mechanical engineering is well known [1] develop, manufacture, operate, and use mechanical artifacts. --Publisher description. Fundamentals of Mechanical Engineering -- Introduction to Mathematics for Mechanical Engineering -- Complex Analysis -- Differential Equations -- Laplace Transformation -- Fourier Analysis -- Linear Algebra -- Mechanics -- Statics of Rigid Bodies -- Dynamics -- Applications in Mechanical Engineering -- Materials Science and Engineering -- Atomic Structure and Microstructure -- Microstructure Characterization -- Mechanical Properties -- Physical Properties -- Nondestructive Inspection (NDI). However, it is necessary to indicate current themes and research trends. Such knowledge is needed to plan future research projects. Keeping track of current trends increases the effectiveness of research. It is necessary to define new global research trends that have evolved in this discipline to identify the main topics of research, discoveries and the global knowledge network. Bibliometric analysis is a statistical analysis, which can serve setting topics and research trends [2] etc. This method is characterised by a possibility of conducting extended quantitative analyses in an objectivised way. Bibliometric analyses are based on available, coherent, objectivised data. This tool is widely

used especially in setting trends and research topics in dedicated areas [3].

The aim of this work was to identify trends and main research topics in the field of mechanical engineering.

II. MATERIALS AND METHODS

The research was carried out in six stages, using elements of bibliometric techniques:

1.a. Creation of a set of journals based on searching for indexed items in the Scopus database for search: Subject area: Engineering => Mechanical Engineering.

1.b. Separating 10% of the top journals, do the subject area: Mechanical Engineering.

1.c. Separating journals, which in the subject area have only Mechanical Engineering.

1.d. Creation of set of publications based on separating journals. The search was carried out from 2002 to 2017 documents in English.

1.e. Construction and analysis of term maps (VOSviewer software) in during the period considered.

1.f. Quantitative analysis of the set of documents created in the aspect of: number of publications and number of citations, major countries.

VOS viewer is a free program that is used by researchers for bibliometric analysis, including analysis of research trends, but also to visualize selected areas of knowledge [4]–[7]. In this work, the program was used to create a map of terms: years of publication, intensity of quoting.

The key words with the highest occurrence frequency are displayed in a bigger circles. The words with the lower frequency of occurrence, on the other hand, have smaller circles and font.

III. RESULTS AND DISCUSSION

There are 585 sources in the Scopus database in the

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field of Mechanical Engineering, including 508 journals. The next step was the separation of 10% of scientific journals with the highest CiteScore index in 2017, which included 72 journals. The ranking of the top 10 journals with selected parameters has been presented in Table 1. It can be noticed that there are also journals in this group that also deal with the subject matter of materials engineering and energy.

Journals analysis was carried out in terms of areas of activity. Finally, the journal Applied Mechanics Reviews has been selected for further analysis, which is the only scientific activity conducted exclusively in the field of Mechanical Engineering.

Applied Mechanics Reviews (AMR) is an international journal that raises the subject of applied mechanics and engineering (eg fluid mechanics, dynamics and vibration, etc.) [8].

Applied Mechanics Reviews in the analyzed period (2002-2017) publishes an average of 20 publications per year. In 2012, the magazine did not have publications indexed in the Scopus database. The main research institutions publishing are: The Royal Institute of Technology KTH (10 documents), Texas A and M University (10), University of Michigan (8 documents), University of Illinois at Urbana-Champaign (7 documents) and Xi'an Jiaotong University (7 documents). Research centers come from such countries as: USA (137 documents), China (34 documents), UK (25 documents), Italy (23 documents) and Canada (20 documents). Most publications were published by the following authors: Dankowicz H. (6 documents), Rega G. (4 documents), Alfonsi G. (3 documents), Hanifi A. (3 documents), Karamanos S. A. (3 documents).

As part of the work, bibliometric data were collected in the analyzed period and a quantitative analysis was carried out for all key words (author and additional), and then they were summarized in separate periods: 2002-2006, 2007-2011, 2013-2017 (Fig.1). In the first period (Fig. 1a) one cluster of terms can be distinguish: “mathematical models”, “problem solving”, “structural analysis”, “finite element method”, “elastic module”. This proves that scientists are very interested in optimization issues.

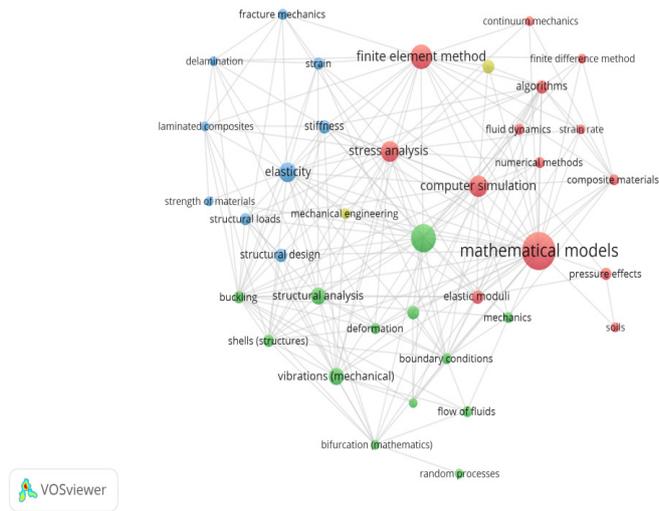
In the second period (Fig. 1b), you can see a much larger fragmentation of the clusters of keywords. The first

cluster of words is: “elasticity”, “mechanics”, “materials properties”, “programming theory”, “paltes (structural components)”, “structural analysis”. The second cluster includes: “finite element method”, “optimization”, “dynamics”, “models”, “laminates”. The third cluster of key words is: “failure analysis”, “mathematical models”, “fiber reinforced plastics”, “composite materials”. This proves that scientists are interested in issues related to material engineering and, as in the previous period, optimization issues.

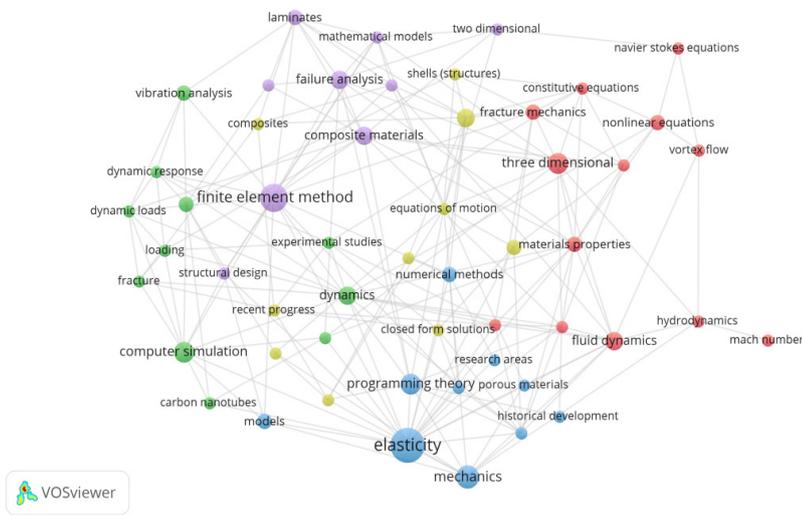
TABLE I. 10 SCIENTIFIC JOURNALS BY CITESCORE INDEX IN 2017 IN THE AREA OF MECHANICAL ENGINEERING

Source title	Rank 2017	CiteScore 2017	Publisher
Materials Science and Engineering: R: Reports	1/554	31.32	Elsevier
Nature Materials	2/554	25.47	Springer Nature
Advanced Materials	3/554	21.1	Wiley-Blackwell
Nano Letters	4/554	13.07	American chemical Society
International Materials Reviews	5/554	12.81	Taylor & Francis
Applied Energy	6/554	8.44	Elsevier
Applied Mechanics Reviews	7/554	7.62	ASME
Progress in Aerospace Sciences	8/554	7.25	Elsevier
Materials Today	9/554	6.8	Elsevier
Desalination	10/554	6.41	Elsevier

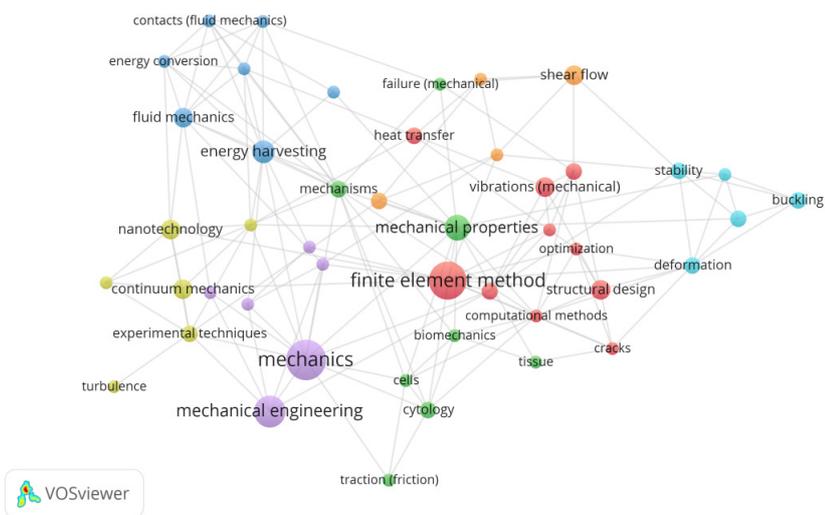
In the third period (Fig. 1c), as in the second period, there is a large fragmentation of clusters of keywords. The first group of entries can be distinguished: “mechanics”, “drilling platforms”, “mechanical engineering”, “linear systems”, “future research directions”. The second group includes only the term: “finite element method”, while the last group includes: “design”, “vibration analysis”, “vibrations (mechanical)”, engineering applications “and” shear flow “. It can be seen that the main research topics are: optimization, material engineering, design issues and mechanics (vibration analysis). In all separate periods the main groups of issues are material engineering (structure analysis, material properties research, etc.) and optimization problems (finite element method, computer simulations and others).



a)



b)



c)

Fig. 1. Set of term maps for the analysed periods: a) years 2002-2006, b) years 2007-2011, c) years 2013-2017.

Table 2 presents the most frequently quoted publications throughout the period of publishing the journal. Byun and Schere [9] in their publication, computational algorithms and functionality of the Community Multiscale Air Quality (CMAQ) system. This system is used to model the atmosphere of air including chemical and physical processes. Bert and Malik [10] use the differential quadrature method in computational mechanics. Qian et. al. [11] in their publication investigated mechanical properties (Young's modulus, bending test, tensile strength and compression) and presented examples of applications for carbon nanotubes. Raupach et. al. [12] experimental and theoretical knowledge of rough-wall turbulent boundary layers, drawing from both laboratory.

TABLE II. THE MOST CITED PUBLICATIONS IN JOURNAL APPLIED MECHANICS REVIEWS

Author	Year	Title	Citation
[9]	2006	Review of the governing equations, computational algorithms, and other components of the models-3 Community Multiscale Air Quality (CMAQ) modeling system	1153
[10]	1997	Differential quadrature method in computational mechanics: A review	950
[11]	2002	Mechanics of carbon nanotubes	853
[12]	1991	Rough-wall turbulent boundary layers	767

Examples of research topics in 2017:

- overview of the state of the art on the use of mechanical instabilities in solids [13],
- a review of experimental methods for determining the contact surface of nanometric particles [14], [15],
- a review of research on the use quadrature element method (QEM) in science and engineering [16],
- analysis of physical processes in the operation of ventilation and scaling capabilities, and the impact of these processes on the design of installations [17],
- a review of research on the analysis of the mechanical properties of lead-free solders [18],
- research review on contact modeling and the impact of this contact on material properties [19],
- review of research on mechanical properties and the applicability of crystalline nanowires [20],
- Morton Effect (ME) - symptoms, causes, theory of predictions and solutions [21],
- review of theoretical models, numerical and experimental tests [22];
- review of research on various types of nanocarbon polymers [23],
- review of modeling research and experimental measurements of dynamic forces occurring during the walking process [24],

- review of research on applied theory of continuous mechanics with non-local elastic response [25],
- a review of research on friction in the wheel-rail system [26],
- research review and experimental research on modeling of selected parameters during flat rolling [27].

IV. CONCLUSIONS

1. The analysis of journals in the Scopus database has been demonstrated by the Applied Mechanics Reviews magazine, which as the only conducts scientific activities exclusively in the field of Mechanical Engineering.
2. In the years 2002-2017, in the journal Applied Mechanics Reviews, they mainly concerned optimization, selected problems of mechanical engineering, mechanics and advanced material engineering
3. The paper shows that the use of VOSviewer program for bibliometric analysis focused on identifying.

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