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Trends in Failure Studies of Generation Engines based on Statistical Models from 2007 to 2017

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Abstract

The diagnosis of failures in Internal Combustion Engines (ICM)-generation engines, has been considering one of the principal thematic axes of academic and industrial Research, Development and Innovation (R&D&I) based on the analysis of the specialized engineering literature within the Distributed Generation (DG) paradigm. With the aim of presenting the characteristics of the work related to failures in ICM and recognizing the global research focuses, a scientometric methodological approach of a systematic review of the publications indexed in Web of Science (WoS) has been carrying out from the perspective of bibliometric analysis for the period from 2007 to 2017. The H-index has been incorporating into this analysis to assess the visibility and impact of journals, authors, countries, and institutions with the highest levels of production and recognition in the field under study. The systematic review also made it possible to analyze the interaction between knowledge groups and networks with the authors and institutions identified in the ranking. The results show a significant increase in the number of publications, especially between 2012 and 2016, which allow the main dimensions of R&D&I related to the study of failures in ICM to be characterized and illustrated at a holistic level and provide added value to researchers interested in establishing cooperation and publication processes with journals, authors, institutions and potential actors in the study of ICM failures.

Keywords: Internal Combustion Engines, Scientometrics, Bibliometric Analysis, Web of Science, H-index.

1. Introduction

Energy Sustainability has become a significant issue on the international policy and research schedule [1-2] due to its close relationship with climate change, and the predicted increase in energy demand [3-6]. Electricity generation is one of the activities with the highest Green House Gas (GHG) emissions, as it depends on more than three-quarters of the totality of its available fossil fuel energy. Therefore, the use of Renewable Energy Sources (RES) for this purpose is one of the leading ways to reduce and eventually eliminate GHG emissions associated with electricity generation. Parallel to its development has emerged the new Distributed Generation (DG) paradigm, which is defined by the Institute of Electrical and Electronic Engineering (IEEE) as the generation of electricity by facilities that are considerably smaller than centralized generation to allow interconnection at any point in the network and supply power to other facilities[7]. The production of electric power from Internal Combustion Engines (ICM) has played a leading role in DG, due to its low operating costs, high efficiency, being a known technology and easy to use, relatively inexpensive and quick installation without requiring major construction work. In the operation of ICM generating plants, stability in their process and the non-occurrence of sudden failures is of vital importance [8], which produce unplanned shutdowns that cause high costs, so avoiding them, and to act accordingly is a task of precaution.

In the operation of ICM power plants, fault diagnosis models are frequently used; one of the most commonly used being multivariate statistical analysis [11], which allows the measurement of variables identifying their normality or abnormality [12-13]. A direct approach to diagnosing various probabilities of failure is to introduce new models for each combination of possible shortcomings [14] by performing a Principal Component Analysis (PCA) that groups together variables that represent the population in percentage terms [15-16]. Due to the extensive use of this model, research has been developing to improve and develop monitoring based on statistical data models. A successful case study was carried out on turbine engines based on the follow-up condition or monitoring condition and the Analysis of independent Components (ICA)[17], another case was presented in Thailand in the feasibility study of engines for the generation of energy from methane from a landfill using an organic Rankine cycle[18].

This article, presents a bibliometric analysis derived from the systematic review of studies in publications that have a high level of visibility and impact between 2007 and 2017 on the subject under investigation, which corresponds to the diagnosis of failures in ICM-driven power generation units; incorporating the analysis of different scientometric indicators and statistical techniques supported with the use of HisCite software, to generate new knowledge with systematic and useful information within the research, development and innovation processes at a global level.

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2. Methodology

2.1. Bibliometric analysis

Bibliometric analysis is a systematic approach to conducting a quantitative review of scientific literature to identify research trends in the most developed countries in the field of study[19]. The application of bibliometric analysis has encompassed high levels of inclusion from information science to industry[20]. Currently, this technique, which is executed through statistical methods and mathematical models, is based on the study of field information in a given time cycle[21-22].

2.2. Impact factor H-index

The impact factor was initially proposed in research science by Garfield[23], in order to know the impact of citations in the different Journals on a specific topic[24], the impact factor indicator is calculated by dividing the total citations of the articles in the various Journal Citation Reports (JCR) by the total number of articles published in the various Journals exposed[20]. The H-index is another indicator that evaluates an author's progress in research, both qualitatively and quantitatively [25] and was proposed by Hirsch in 2005, according to Hirsh [34] the definition of the h index is based on the citation of each of the articles that the author publishes. In this study, the index was used to assess the influence of journals, countries/territories, authors, and institutes[25].

2.3. Reference Network Analysis – SNA

Social Network Analysis (SNA) is a quantitative indicator that evaluates the citation relationship between authors[21], this indicator has been used globally to know the authors working in the field[26].

2.4. Database of information

The Scientific Information Institute (ISI) and Web of Science (WoS) databases published by Clarivate Analytics are widely used for scientific literature searches [27], as a widely accepted database of different scientific fields, WoS has been considered an essential source of data for bibliometric analysis[28-29], including more than 1000 types of documents, WoS is a tool that provides consistent and standardized records[30-31] in addition, in the Science Citation Index Expanded (SCIE) and Social Sciences Citation Index (SSCI) subfield database include the most influential publications, some so-called "grey" publications (e.g., reports and conference proceedings) are not covered. [21]. Therefore, SCI, SSCI, Conference Proceedings Citation Index-Science (CPCI-S) and Conference Proceedings Citation Index-Social Science Humanities (CPCI-SSH) are all selected as data sources in this study [32].

2.5 Aim of the study

The study proposes to identify the main actors in research related to the detection and diagnosis of failures in ICM used by electricity generation based on statistical models. The results of research reported through articles registered in the WoS database were processed with Hiscite software, to obtain the behavior of the bibliometric indicators in the study period, 2007 - 2017. An analysis of the bibliometric indicators is also performed, extracting information filtered using refined search criteria in specialized databases to obtain inputs to characterize the environment in which it is found and the trends in the topic of study, managing to carry out the treatment of information and compare bibliometric indicators.

2.6. Sample population

The sample studied is made up of 801 documents, distributed in Articles, documents, and review of minutes, this population was obtained from searches with keywords such as fault detection, statistical method, combustion engines etc.

2.7. Procedimiento

Initially, the information was obtained from the WoS database, filtering by keywords; Internal Combustion Engines, statistical models, failures in Internal Combustion Engines, temporarily delimited from 2007 to 2017, obtaining metadata that was later read with the HiteCite software where the data was read in tables, which were subsequently read in a qualitative manner.

3. Results

The documents were obtained from the WoS database, of the 801 documents, 99.0% of the publications are in English, 0.5% in Spanish, 0.2% in Portuguese, 0.1% in French and 0.1% in German.

3.1. Annual publication performance

Figure one shows the trend in the number of publications on diagnostic failure studies in ICM in the countries selected in 2007 and 2017, the country with the highest number of publications and the highest H- index is the People's Republic of China, which shows a sustained increase in the period under analysis.

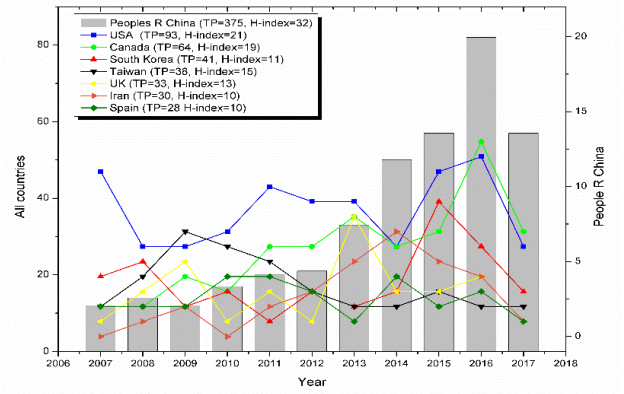

Fig 1. The annual trend for the 10 countries with the highest number of publications

This analysis allows, knowing the research production in a country, presenting the global distribution of publications related to the study topic. Table one, identifying 60 countries that contribute to the different indicators, the first 10 countries that contribute to the bibliometric indices, People's Republic of China 374, United States 104 Articles, Canada 64 Articles, South Korea 41 Articles, Taiwan 38 Articles, United Kingdom 33 Articles , Iran 30 Articles, Spain 28 Articles, France 24 Articles and finally Australia with 22 Articles.

Although the People's Republic of China is the country with the largest number of publications, these works have not been referenced in the origin locality. The country that has the greatest reference in its own locality corresponds to

Canada with a score of 2,406 citations during the years 2007 to 2017, while the United States retains second place in research production reflected in high-impact articles and local references.

Table 1. Contribution from countries ranked according to Total Local Quotations (TCLS) and TLCS/Publications score records

#	Country	Recs	Country	TLCS	Country	TLCS/ Recs
1	Peoples R China	374	Peoples R China	558	Canada	2.406
2	USA	104	USA	237	USA	2.279
3	Canada	64	Canada	154	Taiwan	1.854
4	South korea	41	Taiwan	76	France	1.576
5	Taiwan	38	South korea	59	UK	1.567
6	UK	33	France	52	South korea	1.553
7	Iran	30	UK	47	Peoples R China	1.492
8	Spain	28	Spain	41	Spain	1.464
9	France	24	Iran	35	Iran	1.458
10	Australia	22	Australia	31	Australia	1.409

Likewise, Figure two and Table two show the impact factor of the publications of the countries according to the WoS database where the People's Republic of China has 46.8% of the world publications obtained the highest Impact factor.

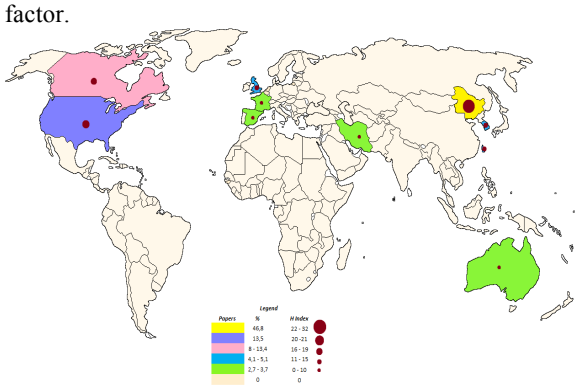

Fig 2. Impact Factor of the countries contributing to the diagnostic research of failures in ICM

Table 2. Research Characteristics of the 10 contributing countries in the field of Failure Diagnosis in ICM

Country	Recs (%)	H_index GCS - LCS
Peoples R China	375 (46.8)	32(9)
USA	93 (13.5)	21(8)
Canada	64 (8.0)	19(7)
South Korea	41 (5.1)	11(4)
Taiwán	38 (4.7)	15(5)
UK	33 (4.1)	13(4)
Irán	30 (3.7)	10(3)
Spain	28 (3.5)	10(5)
France	24 (3.0)	11(4)
Australia	22 (2.7)	7(3)

3.2. Journals in which it has been publishing

Of the 801 publications analyzed, 244 were in journals, among the 15 journals with the highest number of publications, Industrial & Engineering chemistry research stands out with 20%, as shown in Table three. It is also the most cited locally, and in relation to TCL /Publications, it corresponds to Aiche journal shown in Figure three.

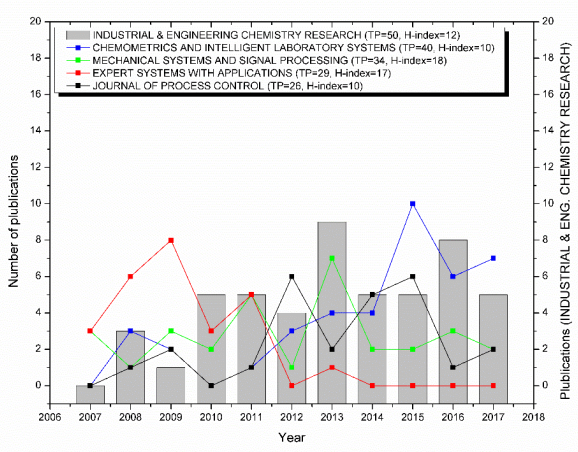

Fig 3. Journals with the largest number of publications

The journals that occupy the top three positions in the largest number of publications and citations are from the United States; these are Industrial & Engineering chemistry research AIChE Journal, Industrial & Engineering Chemistry Research, Mechanical systems and signal processing and Expert systems with applications.

Table 3. Top 15 in publications according to the different journals

#	Journals	Rcs	Rcs / Tjournals	Journals	TLCS	Journals	TLCS/Journals
1	INDUSTRIAL & ENGINEERING CHEMISTRY RESEARCH	50	20%	INDUSTRIAL & ENGINEERING CHEMISTRY RESEARCH	108	AICHE Journal	4.636
2	CHEMOMETRICS RESEARCH	40	16%	CHEMOMETRICS RESEARCH	106	EXPERT SYSTEMS WITH APPLICATIONS	4.077
3	CHEMOMETRICS AND INTELLIGENT LABORATORY SYSTEM			EXPERT SYSTEMS WITH APPLICATIONS	78		3.846
4	MECHANICAL SYSTEMS AND SIGNAL PROCESSING	31	13%	JOURNAL OF PROCESS CONTROL	77	Computer	3.154
5	EXPERT SYSTEMS WITH APPLICATIONS	26	11%	CHEMOMETRICS AND INTELLIGENT LABORATORY SYSTEM	65	ENEGY AND BUILDING	3
6	JOURNAL OF PROCESS CONTROL	26	11%	MECHANICAL SYSTEMS AND SIGNAL PROCESSING	51	JOURNAL OF PROCESS CONTROL	2.278
7	MATHEMATICAL PROBLEMS IN ENGINEERING	20	8%	AICHE JOURNAL	50	IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS	2.16
8	CONTROL ENGINEERING PRACTICE	19	8%	COMPUTERS &CHEMICAL ENGINEERING	41	Industrial & Engineering Chemistry Research	2.097
9	IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS	18	7%	IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS	41	MECHANICAL SYSTEMS AND SIGNAL PROCESSING	1.925
10	NEUROCOMPUTING	18	7%	ENEGY AND BUILDING	35	CHEMOMETRICS AND INTELLIGENT	1.842
11	JOURNAL OF VIBROENGINEERING	14	6%	CONTROL ENGINEERING PRACTICE	26	CONTROL ENGINEERING PRACTICE	1.444
12	COMPUTERS &CHEMICAL ENGINEERING	13	5%	NEUROCOMPUTING	8	NEUROCOMPUTING	0.615
13	Industrial & Engineering Chemistry Research	13	5%	JOURNAL OF ENGINEERING	2	journ	0.167
14	CHEMOMETRICS AND INTEL	13	5%	JOURNAL OF VIBROENGINEERING	2	SHOCK AND VIBRATION	0.154
15	MECHANICAL SYSTEMS AND SIGNAL PROCESSING	12	5%	SHOCK AND VIBRATION	0	JOURNAL OF VIBROENGINEERING	0.143

3.3. Authors - Articles

The authors with the greatest impact were of Western origin, identified by the Total Citation Local Score TLCS indicator or local citations as shown in Table four, the author with the greatest number of publications was Yan XF, and the most cited was Zhang YW, with 66 citations. The second and third are Yu J and Wu JD, with 55 and 38 citations respectively.

The articles with the highest citation have been shown in Table five, which highlights the so-called "Fault detection using the k-nearest neighbor rule for semiconductor manufacturing processes" with 24 citations in IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS Journals, which has 18 publications, corresponding to 7% of the total failure investigations of ICM.

Table 4. First 10 authors according to the TLC

Authors	Recs	TLCS	% Research	Authors	TCLS
Yan XF	15	37	1.9%	Zhang YW	66
Zhao CH	14	33	1.7%	Yu J	55
Li Y	12	4	1.5%	Wu JD	38
Zhang YW	12	66	1.5%	Yan XF	37
Wu JD	11	38	1.4%	Zhao CH	33
Gao FR	10	29	1.2%	Gao FR	29
Jiang QC	10	28	1.2%	Jiang QC	28
Khorasani K	10	15	1.2%	Chen HX	20
Yu J	10	55	1.2%	Khorasani K	15
Chen HX	9	20	1.1%	Li Y	4

Table 5. Most Cited ICM Fault Diagnostic Articles

Papers (Author)	Journals(Date)	Recs	Annual citations
Fault detection using the k-nearest neighbor rule for semiconductor manufacturing processes (He QP, Wang J)	IEEE transactions on semiconductor manufacturing. (2007 NOV)	24	2
Analysis and generalization of fault diagnosis methods for process monitoring (Alcala CF, Qin SJ)	Abstract and applied analysis(2014.APR)	23	2.88
Generalized Reconstruction-Based Contributions for Output-Relevant Fault Diagnosis With Application to the Tennessee Eastman Process (Li G, Alcala CF, Qin SJ, Zhou DH)	Journal of process control. (2011 MAR)	19	2.38
Application of nonlinear feature extraction and support vector machines for fault diagnosis of induction motors (Widodo A, Yang BS)	Expert systems with applications. (2007 JUL)	16	1.33
Decentralized Fault Diagnosis of Large-Scale Processes Using Multiblock Kernel Partial Least Squares (Zhang YW, Zhou H, Qin SJ, Chai TY)	IEEE transactions on industrial informatics (2010 FEB)	16	1.78
Fault detection and diagnosis in process data using one-class support vector machines (Mahadevan S, Shah SL)	Journal of process control. (2009 DEC)	15	1.5
A nonlinear kernel Gaussian mixture model based inferential monitoring approach for fault detection and diagnosis of chemical processes (Yu J)	Chemical engineering science. (2012 JAN)	15	2.14
Improved Nonlinear Fault Detection Technique and Statistical Analysis (Zhang YW, Qin SJ)	Aiche journal. (2008 DEC)	14	1.27
Fault detection and isolation with robust principal component analysis (Therriault Y, Mourot G, Ragot J, Moquin D)	International journal of applied mathematics and computer science. (2008 DEC)	14	1.27
A study on the number of principal components and sensitivity of fault detection using PCA (Tamura M, Tsujita S)	Computers & chemical engineering. (2007 SEP7)	13	1.08

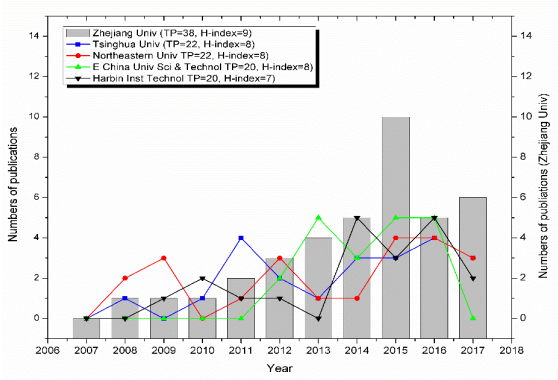

Fig 4. Institutions with the greatest contribution

3.4. Contribution of institutions

Figure four shows, the five most productive institutions in research on the detection and diagnosis of failures in MCI between 2007 and 2017. The Zhejiang Univ institution is the most productive, with 38 articles on the subject, headed by author Wang CJ, Zhao YH at the Journals Chemical Engineering,

These institutions belong to the eastern state; the annual projection of publications has been sustained, implying greater quantities of publications in high impact journals.

4. . Conclusions

With the research and industrial development related to ICM maintenance, it is essential to evaluate the availability of information provided by the different technologies and specialized databases, which provide a mapping of the development situation of the different evaluation methods that contribute to the construction of an integrated maintenance plan for generation engines in the different companies. Because of this, the subject matter has been

studied from the perspective of the systematic review of studies in publications that have a high level of impact during 2007 and 2017. On the subject matter of the study (diagnosis of failures in MCI-driven power generation units). This was possible thanks to the evaluation of the different scientometric indicators, where it was reflected that most of the studies related to the detection of failures in MCI are generated in the People's Republic of China with oriental authors highlighting Yang XF with more publications and with the most cited Zhang Yw.

With this information, one would expect that the journals with the greatest impact would be oriental, since it is still the country with the largest training institutions in the subject, such as Zhejiang University, but the journals with the greatest impact belong to the United States with the magazines Industrial & Engineering chemistry research, AIChE Journal, Industrial & Engineering Chemistry Research, Mechanical systems and signal processing, and Expert systems with applications. Which indicate that developing countries are the main exponents and most involved in this type of research. Is expected that the results will be useful to provide references for future studies, works, and publications related to the detection of failures in ICM.

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