

Growth of Literature on Aerodynamic Research: A Scientometrics Study

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Abstract - The study deals with scientometric study on the Growth of Literature on Aerodynamic Research. The required data was collected from SCOPUS database for the period 2006 - 2015. It can be seen that nearly 41628 bibliographic records of contribution in field of Aerodynamic cover the period of 10 years. The researcher applied the search strings “(KEY (Aerodynamics) AND PUBYEAR > 2005 AND PUBYEAR < 2016)” that has used for the data extraction from the database downloaded the records based on the above strings. A total of 41628 records were downloaded and analyzed by using the Excel software with application as per the objectives of the study. This research study explores the growth rate and relative growth level during the study period. The study aims to analyze the thrust areas of research concentration on Aerodynamic research. It is analytical in nature with the suitable statistical tools applications in strengthening the empirical validity. The study based on Scopus bibliographic database has been used and searched using the word “Aerodynamic” for the period 2006-2016 and extracted 41628 records with full bibliographical details such as Title, Authors, Source, Year, Country, Subject, Language and so on.

Keywords: Aerodynamic, SCOPUS database, Scientometric, Growth, Literature, CAGR

I. INTRODUCTION

Scientometrics is used to quantify scientific activities. Generally quantification of scientific activities is measurable by producing statistics on scientific publications indexed in indicator databases such as SCOPUS, Web of Science. Scientometric data can be useful to measure research collaborations among scientific environments and to monitor the evolution of special scientific subject and fields. Also decision and policy –makers are going to be interested in scientometric indicators. The major sub-fields of Aerospace are: Aerospace Engineering, Aerospace Medicine, Computer Simulation, Space flight, Aerospace applications, Mathematical models, Space research, Aircraft, Spacecraft, Optimization, Algorithms, Satellites, Aerospace vehicles, Aviation, Remote sensing, Computer Software, Aerodynamic, Computer Networks and Robotics. Being that "gas dynamics" applies to the study of the motion of all gases, and is not limited to air. Aerodynamics (Wikipedia, 2017)¹ derived from Greek word (air) and (dynamics), the study of the motion of air, particularly its interaction with a solid object, such as an airplane wing. Aerodynamics is a sub-field of fluid dynamics and gas dynamics, and many aspects of aerodynamics theory are common to these fields. The

term aerodynamics is often used synonymously with gas dynamics, the difference. In this study the literature published specially in the Aerodynamic fields, and covered in SCOPUS database has been analyzed.

II. OBJECTIVES

The major objectives are framed with the exclusive notion of the present study as mentioned below

1. To examine the growth of research productivity of Aerodynamic during 2006- 2015
2. To identify the Document type of publications
3. To find out the Journal distribution of publications in Aerodynamic
4. To study the subject-wise breakup of publications
5. To identify country-wise distribution of publications and
6. To assess the form of communication and language wise research concentration of Aerodynamic.

III. METHODOLOGY

The research design is analytical that adopt detailed analysis of secondary data using a range of scientometric tools, techniques and formula along with standard statistical techniques. The required data was collected from the SCOPUS database. Scopus is the largest abstract and citation databases of research publication and quality web resources. Scopus provides superior support of any literature research process. The data is updated regularly. The database also helps the research and find innovative tools that give an at –a – glance overview of search results. A total of 41628 records were analyzed by using the Excel software with application as per the objectives of the study.

A. Compound Annual Growth Rate (CAGR)

According to Choi *et al.*, (2011)², Growth rate is being measured with Compound Growth Rate (CAGR). The mathematical formula of CAGR is as follows

$$CAGR = \left| \frac{\left(\frac{\text{Ending Value}}{\text{Beginning Value}} \right)^{\frac{1}{n-1}}}{-1} \right|$$

IV. REVIEW OF LITERATURE

Scientometrics can be defined as the “quantitative study of science, communication in science, and science policy”

(Hess, 1997)³. Scientometrics is the science of measuring and analyzing science. In practice, Scientometrics studies has been done using bibliometric methods (Wikipedia, 2014)⁴. Pritchard (1969)⁵ defined Bibliometrics as “the application of mathematical and statistical methods to books and other media of communication”, while Nalimov and Mulchenko (1969)⁶ defined Scientometrics as “the application of those quantitative methods which are dealing with the analysis of science viewed as an information process”.

Gupta and Adarsh Bala (2010)⁷ analyzed Indian Science and Technology publications of 1996-2010. This study conducted on the basis of Scopus database and examined several quantitative measures including India's global publication share, rank and growth rate, its publication share in various subjects in terms of national and global context. The study found that India contributed 538609 papers in science and technology during 1996 to 2010 with an annual average growth rate of 9.32 per cent. The study found that top 100 most productive Indian organisations contributed 54.92 per cent share (295827 papers). The study shows that among the India's contribution to global research output in broad 20 subjects during 1996-2010, the largest publications share (5.49 per cent) comes from veterinary science.

Van Raan (1997)⁸ argued that the core research activities of scientometrics fall in four interrelated areas: science and technology indicators, information systems on science and technology, the interaction between science and technology, and cognitive as well as socio-organisational structures in science and technology. He emphasizes that an essential condition for the healthy development of the field is a careful balance between application and basic work, in which the applied side is the driving force. In other words: scientometrics is primarily a field of applied science. This means that the interaction with 'users' is at least as important as the interaction with colleague-scientists. He states that this situation is so stimulating, it strengthens methodology and it activates basic work. He considers the idea of Scientometrics lacking theoretical content or being otherwise in a 'crisis-like' situation as groundless. Scientometrics is in a typical developmental stage in which the creativity of its individual researchers and the 'climate' and facilities of their institutional environments determine the progress in the field and, particularly, its relation with other disciplines.

The study carried out by Bagalkoti (2013)⁹ on Scientometric analysis of Indian science publication output as reflected in Scopus Database found that 7,01,900 papers received 36,65,095 citations during the period 1997-2011. India was ranked 10th among the 50 productive countries of the world in Science and Technology. The study shows that global publications share of India during 1997-2011 was 2.73%, which has increased from 1.93 in 1997 to 4.00 in 2011 and India has published 1,59,110 (22.29%) international collaborative papers. As per the study Physical sciences subjects together contributed the highest publications share (57.59%), followed by Life Sciences (26.91%), and Medicine (15.51%). The study found that Indian Institute of Science contributed the highest publications, i.e.,

26161 articles with 14.41% to total output and among universities, the largest number of papers 11685 (4.81%) is published by Jadavapur University, followed by Banaras Hindu University 11680 (4.80%).

Biswas, S K. and Akhtaruzzaman, M (2012)¹⁰, have found that, a detail Scientometric analysis of medical research performance of Bangladesh and its comparison with other countries is very important to obtain a clear picture and to take necessary measures to upgrade our research performance. At the same time it is also very important to evaluate the research performance of major medical research institutes of the country and to compare their performance among themselves and similar institutes of other countries.

According to Rasolabadi, M., *et al.*, (2015)¹¹, the aim of this study was to analyze Iran's research performance on diabetes in national and international context. This Scientometric analysis is based on the Iranian publication data in diabetes research retrieved from the Scopus citation database till the end of 2014. The study found that Iran's cumulative publication output in diabetes research consisted of 4425 papers from 1968 to 2014, with an average number of 96.2 papers per year and an annual average growth rate of 25.5 per cent. Iran ranked 25th place with 4425 papers among top 25 countries with a global share of 0.72 per cent. Average of Iran's publication output was 6.19 citations per paper.

V. DATA ANALYSIS

A. Year Wise Publications

The year wise distribution of aerodynamic research publications is given in Table I.

TABLE I YEAR WISE PUBLICATIONS

| S.No | Year | No. of Publications | % | CAGR |
|------|-------|---------------------|-------|--------|
| 1 | 2006 | 3164 | 7.6 | |
| 2 | 2007 | 2908 | 6.98 | -8.09 |
| 3 | 2008 | 4316 | 10.37 | 48.42 |
| 4 | 2009 | 4883 | 11.73 | 13.14 |
| 5 | 2010 | 5099 | 12.24 | 4.42 |
| 6 | 2011 | 4181 | 10.04 | -18.00 |
| 7 | 2012 | 4359 | 10.47 | 4.26 |
| 8 | 2013 | 4131 | 9.93 | -5.23 |
| 9 | 2014 | 4064 | 9.77 | -1.62 |
| 10 | 2015 | 4523 | 10.87 | 11.29 |
| | Total | 41628 | 100 | |

The Table I and Figure.1 shows that a total of 41628 research publications in Aerodynamic during 2006 – 2015 were published with an average 4162 papers per year.

The maximum number of publications is in 2010 with 5099 papers. Regarding Compound annual growth rate (CAGR), Maximum CAGR observed in 2008 and negative growth observed in 2007, 2011, 2013 and 2014.

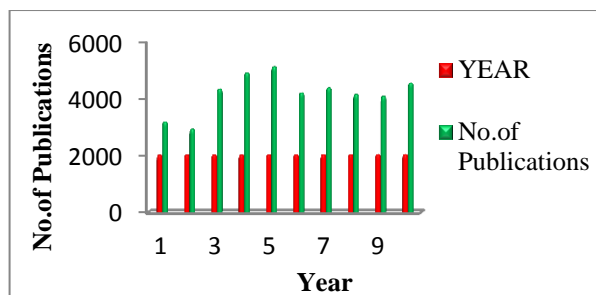


Fig. 1 Year Wise Distribution of Publications

B. Prolific Countries

There are 41628 contributions available in SCOPUS database. The country wise production of papers in Aerodynamic is shown in Table II.

TABLE II PROLIFIC COUNTRY WITH NO. OF PAPERS

| S. No. | Country | No. of Publications | % of 41628 |
|--------|--------------------|---------------------|------------|
| 1 | United States | 11551 | 27.75 |
| 2 | China | 11129 | 26.73 |
| 3 | United Kingdom | 2683 | 6.45 |
| 4 | Germany | 2538 | 6.09 |
| 5 | Japan | 2474 | 5.94 |
| 6 | France | 1901 | 4.57 |
| 7 | Italy | 1513 | 3.63 |
| 8 | Canada | 1373 | 3.29 |
| 9 | Russian Federation | 1127 | 2.71 |
| 10 | South Korea | 1090 | 2.69 |
| 11 | India | 1005 | 2.41 |
| 12 | Australia | 968 | 2.33 |
| 13 | Netherlands | 765 | 1.84 |
| 14 | Spain | 683 | 1.64 |
| 15 | Sweden | 544 | 1.31 |
| 16 | Iran | 543 | 1.3 |
| 17 | Brazil | 463 | 1.11 |
| 18 | Taiwan | 431 | 1.04 |
| 19 | Switzerland | 422 | 0.99 |
| 20 | Belgium | 412 | 0.98 |
| 20 | Turkey | 287 | 0.68 |
| 21 | Israel | 285 | 0.68 |
| 22 | Denmark | 281 | 0.67 |
| 23 | Poland | 233 | 0.56 |
| 24 | Hong Kong | 220 | 0.53 |
| 25 | Greece | 3997 | 9.6 |
| | Total | 48918 | 117.52 |

It is seen from Table II that collaborative research has been carried out in the research area Aerodynamic beyond the territory. Most of the contributions are collaborative research i.e. 7290 contributions seem to be the joint contributions of two or more countries. Developing countries contributing are China (11129), United Kingdom (2683), Germany (2538) and Japan (2474)

positioned in top five Prolific Countries in Aerodynamic research. Table II also shows that India has Eleventh position in this study.

C. Document Type

There are different Bibliographic forms such as Conference paper, Article, Review, Article in Press, Conference Review, Book Chapter, Short Survey, Letter, Note and Editorial forms. The distribution of research production in these forms is Table III.

TABLE III DOCUMENT TYPE

| S.No. | Document Type | No. of Publications | % |
|-------|-------------------|---------------------|-------|
| 1 | Conference paper | 20732 | 49.8 |
| 2 | Article | 20339 | 48.84 |
| 3 | Review | 313 | 0.77 |
| 4 | Article in Press | 117 | 0.28 |
| 5 | Conference Review | 70 | 0.17 |
| 6 | Book Chapter | 28 | 0.07 |
| 7 | Short Survey | 23 | 0.06 |
| 8 | Letter | 3 | 0.01 |
| 9 | Note | 2 | 0 |
| 10 | Editorial | 1 | 0 |
| | Total | 41628 | 100 |

The research productions have been contributed in 10 forms of bibliographical formats and Conference paper and Articles occupy most of the publications. They occupy 98.64% of the worldwide publications.

D. Language Wise Distributions

Language wise distribution of publications in Aerodynamic is shown in Fig 2.

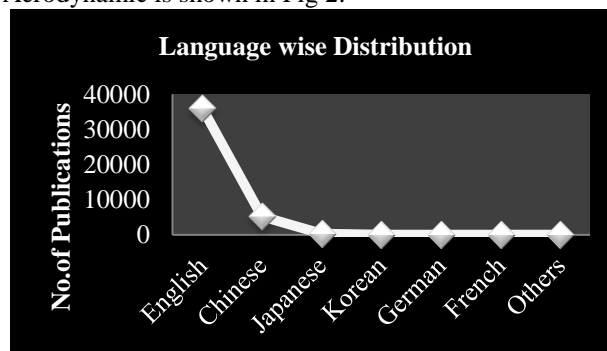


Fig. 2 Language wise Distribution

The majority of documents (86.55 %) published in English Language (Fig. 4) which is followed by Chinese (5161 papers), Japanese (295 papers) and Korean (44 papers).

E. Source Title Wise Distributions

Table IV indicates that the top 25 journals are used for publishing the research papers. Maximum (1231) papers are published in Proceedings of the ASME Turbo Expo (1231) followed by Journal of Aircraft with 651 publications.

TABLE IV SOURCE TITLE WISE DISTRIBUTIONS

| S.No. | Source Title | No. of Publications | % |
|-------|---|---------------------|--------|
| 1 | Proceedings of the ASME Turbo Expo | 1231 | 2.95 |
| 2 | Journal of Aircraft | 651 | 1.56 |
| 3 | AIAA Journal | 563 | 1.35 |
| 4 | Applied Mechanics And Materials | 525 | 1.26 |
| 5 | Collection of Technical Papers AIAA ASME ASCE AHS ASC Structures Structural Dynamics and Materials Conference | 507 | 1.22 |
| 6 | Hangkong Dongli Xuebao Journal of Aerospace Power | 483 | 1.16 |
| 7 | 27th Congress of the International Council of the Aeronautical Sciences 2010 ICAS 2010 | 475 | 1.98 |
| 8 | Collection of Technical Papers AIAA Applied Aerodynamics Conference | 404 | 0.97 |
| 9 | Hangkong Xuebao Acta Aeronautica Et Astronautica Sinica | 394 | 0.95 |
| 10 | Advanced Materials Research | 390 | 0.94 |
| 11 | 28th Congress of the International Council of the Aeronautical Sciences 2012 ICAS 2012 | 378 | 0.91 |
| 12 | Proceedings of SPIE the International Society for Optical Engineering | 348 | 0.84 |
| 13 | Journal of Wind Engineering and Industrial Aerodynamics | 343 | 0.82 |
| 14 | SAE Technical Papers | 342 | 0.82 |
| 15 | Journal of Fluid Mechanics | 338 | 0.81 |
| 16 | Kongqi Donglixue Xuebao Acta Aerodynamica Sinica | 325 | 0.78 |
| 17 | ICAS Secretariat 26th Congress of International Council of the Aeronautical Sciences 2008 ICAS 2008 | 316 | 0.76 |
| 18 | ICAS Secretariat 25th Congress of the International Council of the Aeronautical Sciences 2006 | 289 | 0.69 |
| 19 | ISSCAA2010 3rd International Symposium on Systems and Control in Aeronautics and Astronautics | 284 | 0.68 |
| 20 | Collection of Technical papers 44th AIAA Aerospace Sciences Meeting | 277 | 0.67 |
| 21 | Annual Forum Proceedings AHS International | 265 | 0.64 |
| 22 | Journal of Turbo machinery | 249 | 0.59 |
| 23 | Tuijin Jishu Journal of Propulsion Technology | 245 | 0.59 |
| 24 | Aerospace Science and Technology | 242 | 0.58 |
| 25 | Others | 31764 | 76.3 |
| | Total | 41628 | 100.82 |

F. Prolific Affiliations

Affiliations wise distribution of research publications in Aerodynamic is shown in Table V. Table V shows that Beihang University (1228), Northwestern Polytechnic University (1218), Nanjing University of Aeronautics and Astronautics (798), Harbin Institute of Technology(723) and Deutsches Zentrum fur Luft- Und Raumfahrt (714) are the top five Prolific Affiliations in present study.

It also indicates that Indian Institute of Technology, Kanpur (99 papers) has 107th place as well as Indian Institute of Technology, Madras occupied in 160th position with 66 papers.

G. Source Wise Distributions

Research publications in Aerodynamic were contributed from five different source type and the same presented in Figure 3.

Figure 3 explains that Journals got the first rank with 21840 publications followed by Conference Proceedings (18239) and Book Series with 1308 papers.

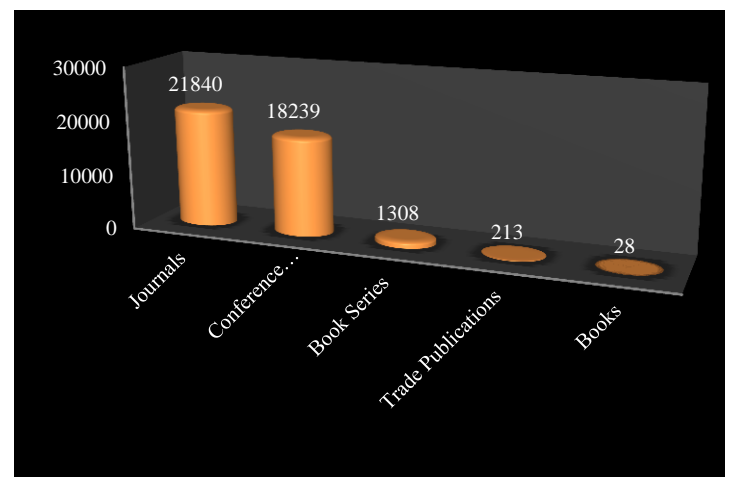


Fig. 3 Source Type

TABLE V AFFILIATIONS WISE DISTRIBUTIONS

| S.No. | Affiliation | No. of Publications | % |
|----------------|---|---------------------|--------|
| 1 | Beihang University | 1228 | 2.95 |
| 2 | Northwestern Polytechnical University | 1218 | 2.93 |
| 3 | Nanjing University of Aeronautics and Astronautics | 798 | 1.92 |
| 4 | Harbin Institute of Technology | 723 | 1.74 |
| 5 | Deutsches Zentrum für Luft- Und Raumfahrt | 714 | 1.72 |
| 6 | NASA Langley Research Center | 668 | 1.60 |
| 7 | Wright-Patterson AFB | 515 | 1.24 |
| 8 | Tongji University | 458 | 1.10 |
| 9 | Japan Aerospace Exploration Agency | 417 | 1.00 |
| 10 | China Aerodynamics Research and Development Center | 405 | 0.97 |
| 11 | NASA Ames Research Center | 383 | 0.92 |
| 12 | Delft University of Technology | 383 | 0.92 |
| 13 | National University of Defense Technology | 377 | 0.91 |
| 14 | Tsinghua University | 377 | 0.91 |
| 15 | Georgia Institute of Technology | 351 | 0.84 |
| 16 | Boeing Corporation | 324 | 0.78 |
| 17 | Virginia Polytechnic Institute and State University | 323 | 0.78 |
| 18 | Xi'an Jiaotong University | 313 | 0.75 |
| 19 | University Michigan Ann Arbor | 312 | 0.75 |
| 20 | Politecnico di Milano | 284 | 0.68 |
| 107 | Indian Institute of Technology, Kanpur | 99 | 0.24 |
| 160 | Indian Institute of Technology, Madras | 69 | 0.17 |
| 21-106 108-159 | Others | 30889 | 74.20 |
| Total | | 41628 | 100.00 |

TABLE VI MOST PREFERRED KEYWORDS

| S.No. | Keyword | No. of Publication | % of 41628 |
|-------|------------------------------|--------------------|------------|
| 1 | Aerodynamics | 32253 | 77.48 |
| 2 | Computational Fluid Dynamics | 6144 | 14.76 |
| 3 | Wind Tunnels | 4530 | 10.88 |
| 4 | Computer Simulation | 4476 | 10.75 |
| 5 | Reynolds Number | 3496 | 8.39 |
| 6 | Mach Number | 3434 | 8.25 |
| 7 | Supersonic Aerodynamics | 2890 | 6.94 |
| 8 | Optimization | 2725 | 6.55 |
| 9 | Airfoils | 2632 | 6.32 |
| 10 | Navier Stokes Equations | 2588 | 6.21 |
| 11 | Design | 2574 | 6.18 |
| 12 | Flutter (aerodynamics) | 2568 | 6.17 |
| 13 | Vortex Flow | 2438 | 5.86 |
| 14 | Hypersonic Aerodynamics | 2381 | 5.72 |
| 15 | Aircraft | 2308 | 5.54 |
| 16 | Fluid Dynamics | 2101 | 5.05 |
| 17 | Boundary Layers | 2062 | 4.95 |
| 18 | Turbomachine Blades | 2039 | 4.89 |
| 19 | Aeroelasticity | 1980 | 4.76 |
| 20 | Mathematical Models | 1975 | 4.74 |
| 21 | Wind Turbines | 1912 | 4.59 |
| 22 | Drag | 1813 | 4.36 |
| 23 | Gas Dynamics | 1795 | 4.31 |
| 24 | Numerical Simulation | 1717 | 4.12 |
| 25 | Aerospace Engineering | 1688 | 4.05 |

VI. CONCLUSION

The present study is to highlight the status and development of research trends in Aerodynamics. They are,

1. Maximum (5099) research publication published in 2010 and Minimum (2908) research publications are reported in 2007.
2. United States published Maximum with 11551 publications followed by China (11129) publications.
3. Maximum number of papers presented in Conference (49.8%) followed by Articles (48.84%).
4. Maximum (1231) papers are published in Proceedings of the ASME Turbo Expo (1231) followed by Journal of Aircraft with 651 publications as in source title in Aerodynamic research.
5. Regarding Affiliations, Beihang University (1228) is the top Prolific Affiliations in this study. In India, Indian Institute of Technology, Kanpur (99 papers) has 107th place as well as Indian Institute of Technology, Madras occupies in 160th position with 66 papers.
6. This quantitative analysis are helping tool to analysis and strengthen the research areas in Aerodynamic field.

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