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A scientometric study of heat transfer journal literature from 1900 to 2017

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ABSTRACT

The present study conducts a scientometric study of the journal literature of heat transfer from 1900 to 2017 based on the database of Web of Science, 2018. A total of 120,628 items resulted from topic search using “heat transfer” as the search term. The results of this work reveal that the literature on heat transfer grows exponentially with an annual growth rate of about 9.71% for the last century the first two decades of this century through the emergence of new subjects, identified through word cloud of authors' keywords. The document types, countries and languages, journal distribution, number of authors, institution productivity and paper citations are analyzed. Highly productive journals and authors and highly cited papers are identified. The results reveal that USA and China are the two most productive countries contributing 17.4% and 14.3%, respectively. About 90% of papers are published with co-authors and 73% of the paper was published with two to four authors. The author distribution follows the trend of Lotka's law, with 61.3% of the authors published only one paper, and 15.9% of the authors published two papers. *International Journal of Heat and Mass Transfer* is the most productive journal contributing 9.4% of the publications. Most highly cited papers are identified and found to be consist with the emergence of new subjects in heat transfer.

1. Introduction

Heat transfer is the transport process of thermal energy from high intensity region to low intensity region due to a spatial difference [1]. Heat transfer is very common in nature as well as in industrial processes and is of fundamental importance for many science and engineering studies. Conduction, convection and radiation are the three basic modes of heat transfer and it usually deals with the transport of energy, momentum and mass. Therefore, heat transfer, fluid mechanics and mass transport are all important subjects in the broad area of heat transfer.

As a reflection, the heat transfer literature must also grow dramatically. The background information reveals in the increasing importance of heat transfer and the literature survey by the author indicates the lack of scientometric study on such area. This study aims to investigate the characteristics of heat transfer literature from 1900 to 2017 and its implication using the scientometric techniques, which is a statistical method of bibliography counting to evaluate and quantify the growth of literature for a particular subject of scientific field.

The objectives of this study are: (1) to explore the growth of heat transfer literature published; (2) to determine the core journals that contain a substantial portion of journal literature on heat transfer; (3) to find the productivity distribution of institutions on this subject; (4) to identify major contributing countries that published heat transfer

articles most; (5) to find the dispersion of kinds of language and document types of the literature on heat transfer; (6) to reveal the characteristics of citation for the heat transfer literature; (7) to investigate the subject evolution in the heat transfer field.

2. Methodology

For the present work, the database of Web of Science (WoS), a product of the Clarivate Analytics [2] is employed to retrieve bibliographic data of literature on heat transfer from 1900 to 2017 for this study. Although other databases such as Applied Science and Technology ABS, Compendex, EngIndex/FS, are also available for scientometric analysis, WoS is adopted because it is recognized as the leading English-language supplier of services providing access to the published information in the multidiscipline fields of science and technology. Moreover, it is one of the major databases that offer a comprehensive citation data of the published literature.

The Web of Science database currently contains approximately 7000 world leading scholarly science and technical journals covering > 250 disciplines from 1900 to date [2]. For the present study the time span of the WoS available is from 1900 to 2017. Generally, each record in the WoS database contains an English-language title and descriptive abstract together with full bibliographic information. The bibliographic

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information includes the journal or other publication title, the authors' name and affiliation, document type, the language of the original document, etc. Documents indexed included books and monographs, conferences, symposia, meetings, journal articles, reports, theses and dissertations.

In this study, the search command topic = ("heat transfer") is used in the topic field to retrieve most of the papers which embodied this key word in the field of article Title, Abstract, Author Keyword, and KeyWords Plus. Each relevant record was then downloaded to a compact disc. Care has been exercised to examine the data collected to assure their identity. Subsequently, the data were analyzed by Visual Fox Pro and Excel. By employing scientometric techniques, especially literature growth model, Bradford's law and citation counting, the results of this study are analyzed and discussed.

3. Results

3.1. The growth of heat transfer literature published

As indicated earlier, the WoS database, from 1900 to 2017, is available during the course of this study. For this time span, the WoS contains 120,628 items on heat transfer, which are mainly journal literature (105,351 out of 120,628). Fig. 1 illustrates growth of the number of journal literature on heat transfer published cumulating number yearly.

Before 1960, the number of WoS papers on heat transfer published each year was no > 100. The year from 1961 to 1990 was the period of significant publication on heat transfer based on the WoS, as the number of articles published on heat transfer grew steadily and the number of articles published in 1990 reached about 660. A jump in growth of the heat transfer literature appeared in 1991 with the total number of 1528 articles, which is nearly 900 more than that of 1990. The reason for this pump in publication in 1991 needs a further study. The literature on heat transfer published after 1991 presents steadily growth again and reached 2211 in 2000, 4740 in 2010, and 10,689 in 2017. Indeed, the literature on heat transfer grows exponentially for the study period as demonstrated in Fig. 1, which illustrates that the cumulative literature on heat transfer may be fitted relatively well by an exponential function as $y = 2.80e^{0.0971(x-1902)}$, where y is the cumulative literature on heat transfer collected in WoS and x stands for the year. The annual growth rate is around 9.71%. This suggests that heat transfer is a subject with a relatively large growth rate even though it has been developed for more than one century. The figure also demonstrates that the growing curve showing no sign of saturation. This suggests the heat transfer is still an important area with large growth rate.

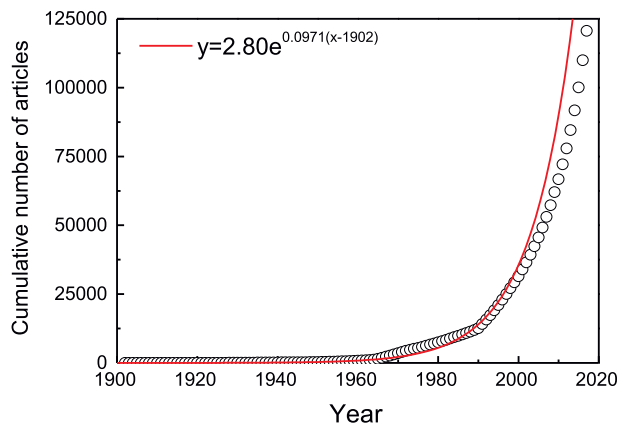


Fig. 1. Journal literature growth of heat transfer literature, 1900–2017.

3.2. Word cloud analysis of author keywords

It is also interesting to examine the evolution of research areas in heat transfer, especially after 1990. Fig. 2 illustrates the evolution of "word cloud" based on the keywords given by the authors. In the figure, the bigger the word, the more frequent it appears. The figure indicates that in early 1990's traditional subjects such as forced convection and natural convection are the predominant areas of heat transfer study. In the second half of 1990's forced convection and natural convection remain the top two-studied subjects, while boiling begins to play an important role. At the beginning of this century, mass transfer becomes the most-studies subject and natural convection, convection, modeling, and numerical simulation also play important roles. For the second half of 2000's, natural convection and numerical simulation remains the foremost subjects with mass transfer. For the first half of 2010's, nanofluid begins to play the leading role with natural convection and numerical simulation. In recent years, nanofluid, natural convection and numerical simulation continue to attract much attention. Nanofluid with its innovative technique for enhancing heat transfer seems to have replaced the traditional forced and natural convection studies becoming the principal subject of heat transfer study. Numerical simulation seems to be the well-adopted approach for heat transfer research. It is the emergence of these new research subjects, which support the continuous growth of heat transfer publications.

1990–1994	1995–1999
2000–2004	2005–2009
2010–2014	2015–2017

3.3. Some scientometric characteristics of heat transfer literature

3.3.1. Document type

Table 1 illustrates the distribution of document type in heat transfer literature. As common in many subjects, the single most prevalent form of publication is the research article, which contributes 87.3% of the total literature. The second largest form of heat transfer publication is proceedings paper, which covers 7.2%, significantly lower than that for research articles. Other minor documents include review, note, meeting abstract, letter, editorial material, book review, etc. Most of document type on heat transfer that collected in the WoS is in the form of journal articles. This reflects the collection policy of the WoS. The major source materials for the WoS database are scientific and technical journals and some conference publications published throughout the world over a wide range of languages.

3.3.2. Language

As one might expect, English is the predominant language of documents on heat transfer. As shown in Table 2, English language documents constitute 97% of the total. There are only 3% non-English-language documents. This may be due to the fact that English is the official language for most international scholarly communication. In addition to English, the heat transfer literature is also published in 24 different languages, based on the collection in WoS, as also shown in Table 2. Among them German and Japanese are the second and third largest contributing languages.

3.3.3. Country and institution productivity

Table 3 illustrates the distribution of 11 most productive countries contributing at least 4000 heat transfer literature. The table is ranked by the number of documents each country publishing heat transfer literature. It can be seen that the biggest contributor, the United States has published 32,079 (17.4%) documents and is followed closely by the China, which contributes 26,380 (14.3%) articles. The India comes

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