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Progress in Gasification Research: A Bibliometric Study

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Abstract

Biomass Gasification as alternative to substitute electric energy generation by consuming fossil fuel have been studied widely conducted worldwide in order to evaluate the feasibility of economics and environmental. Aiming to move forward in the research of the topic, a bibliometric analysis is presented in this paper, studying the characteristics of the gasification-related publications and its impact among scientific community by citation parameters between 2007–2018. Bibliometrics using HistCite by data processing from Web of Science on 2 Feb. 2018 index that China and USA are publishers and high-impact research world powers in this line. Results obtained in this article also show valuable information for researchers in considering information of gasification-related characteristics and citation for statistical purposes.

Keywords: Gasification, bibliometric analysis, Web of science, research results.

INTRODUCTION

Due to population growth, world energy demand has increased exponentially in recent years. This leads to a faster exhaustion of fossil fuels and is also associated with some environmental effects, such as CO2 which is the main greenhouse gas (GHG) and SOx and NOx in acid rain [1]. For these reasons, it is urgent to investigate how to substitute these traditional fuels with clean energy from renewable resources such as biomass and hydrogen, which have been widely accepted in the scientific community as sources to increase energy sustainability and reduce GHG emissions [2].

Generally, the conversion of biomass to energy or combustible substances can be carried out in a biological or thermochemical manner. In biological processes, biomass is transformed into biogas and a residual is digested by the action of microorganisms [3]. On the other hand, the thermochemical conversion of biomass, currently with abundant reserves, transforms the raw material into biofuels, gases and other chemicals through the application of heat and pressure. Thermochemical conversion methods can be classified into combustion, pyrolysis, gasification and liquefaction. Among these methods, gasification is considered an alternative with one of the highest potentials for the production of clean raw materials for energy generation and for its lower emission of pollutants [4, 5].

Gasification is one of the most important thermochemical processes as it increases the overall efficiency of plants as the gas produced can be used for electrical power generation, for example in gas engines and turbines and fuel cells[6]. Gasification is defined as the conversion of biomass by heating into a partial oxygen atmosphere, which produces a mixture of combustible substances composed of CO, H2 and CH4 and non-fuels such as CO2 and N2[5].

The quality of the product depends on the calorific value of the gas mixture and its tar content. A synthetic gas with high calorific value and low tar content means better product qualities. The production of the gas mixture depends on the type of biomass, the type of gasifier and the gasifying agent [7]. The characterization of biomass should consider particle size, density, elemental analysis (C, H, O, N), fixed assay, volatile matter and ash and moisture content [8]. According to the equipment used for solid-liquid contact, gasification is divided into three types: fixed bed or moving bed, fluidized bed and entrained flow;

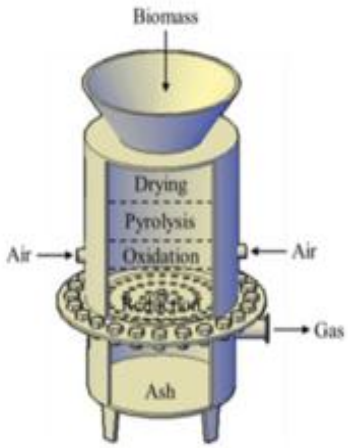

Figure 1. Downstream gasifier [14].

And process performance must take into account: the temperature at which gasification is carried out, the gasifying agent and the particle size of the feed material [9]. The process can be carried out using different gasifying agents, such as: air, oxygen, and oxygen enriched air and water vapor [10]. However, using air the gas produced is low calorific value and if pure oxygen is used as an agent it will contribute to raising the cost of the whole process [11].

The first phase of gasification where volatile components are released and carbonization is formed is called pyrolysis. After this the carbonization reacts with the gasifying agent to form carbon monoxide, carbon dioxide, hydrogen and methane [12]. Regarding increasing hydrogen production in the gasifier, the use of water vapor as a gasifier has been widely accepted, as it gives the highest yields [13]. Di Blasi was the first to propose a complex network of reaction equations that were classified to

construct the gasification process in stages: Drying, Pyrolysis, Combustion and Reduction [15] with a schematic for a downstream gasifier presented in Fig. 1.

This document presents a bibliometric study pertinent to the urgency of the search for new alternatives that replace energy demand with a less harmful effect on the environment, such as traditional fuels, considering the progress made in research on thermochemical conversion of biomass, more specifically those related to gasification published between 2007 and 2018.

METHODOLOGY

Bibliometric analysis

Bibliometric analysis is a systematic approach in which scientific publications can be quantified and analyzed in order to identify a particular research phenomenon. The application of bibliometric analysis has been extended from the point of publication and information science to measuring scientific progress in various fields [16]. Mathematical and statistical tools are applied in bibliometric analysis to investigate data distribution, variant patterns and quantitative management of the information studied, to analyze its structure, characteristics as well as the patterns that define science and technology [17].

Data

The Institute for Scientific Information (ISI) Web of Science (WoS) is widely used as a source of scientific publications. [18]. as an accepted database in different scientific fields, WoS is considered a significant source of data for bibliometric analysis [19]. "Gasification" "Gasification studies" were the searches selected in the search section "topic" to search for related studies published in the period 2007-2018 in the aforementioned database. Data analysis was performed based on the February 2, 2018 search.

HistCite

HistCite is a software used for bibliometric analysis and visualization of information. It was developed by Eugene Garfield, founder of the ISI and inventor of tools such as Current Contents and Science Citation Index (SCI). HistCite is a system to help identify significant publications (the most cited) from research in the WoS database. Histcite processes the data and sorts them into tables according to Author, year and number of citations [20]. In this study HistCite was used to visualize the influence on the area of authors, countries and institutes.

RESULTS AND DISCUSSIONS

Languages in which it is most published

Of the 4606 publications processed in the aforementioned database, approximately 63.72% were in English, followed by Unknown (34.89%), Polish (0.65%), German (0.22%), Spanish (0.17%), Japanese (0.09%), Chinese (0.07%), Czech (0.07%), Portuguese (0.07%), Italian (0.02%), Korean (0.02%) and Turkish (0.02%), since English is a widely accepted language by the scientific community. Table 1 shows the data obtained by the software. The Total Local Citation Score (TLCS) indicator represents the total local quantity of publications in which a given item is cited in other articles, thus measuring its importance in the matter.

Table 1. Language with most publications..

Language	PT	TLCS
English	2,935	9,809
Unknown	1,607	9,422
Polish	30	32
German	10	4
Spanish	8	0
Japanese	4	0
Chinese	3	5
Czech	3	4
Portuguese	3	0
Italian	1	0
Korean	1	0
Turkish	1	0
Total	4,606	

PT: Total publications
TLCS: Total Local Citation Score

Countries that publish the most

The country that publishes the most is the Unknown with 35.9% of articles published, followed by China (17.3%), USA (6.7%), Japan (4.2%), Canada (4.1%) and Germany (3.0%). The other countries (with less than 3% each) were not represented in Table 2 in order to better visualize those already mentioned, which account for 70.2% of the total publications. Unknown is a record that has a high local citation value, while globally has not been popularly quoted. This may be due to the lack of classification of the corresponding information into a significant number of WoS data. The rest of the data follows the direct behavior of the publications by country and their local and global citation index.

Table 2. Countries with most publications

Pais	PT	TLCS	TGCS
Unknown	1,639	9,435	107
China	813	2.537	8,789
USA	313	1,169	6,000
Japan	196	819	3,071
Canada	192	887	2,872
Germany	141	378	1,421

PT (%): Percentage of total publications
TGCS: Total Global Citation Score

Most cited journals

The Energy & Fuels Journal has the most gasification publications with 15.4%, slightly higher than Fuel (15.3%) and higher than the International Journal of Hydrogen Energy (11.2%). However, the latter two have more impact on the matter, as shown in Table 3 with a higher value of articles cited of 2 695 and 2 317 respectively. The rest of the statistics present a direct list of their publications with respect to their impact on research.

Number of publications during 2007-2018

The research and publication of articles on Gasification as a process for the production of energy from synthesis gas has increased over the period studied. Until February 2, 2018, the number of articles published increased with respect to the average value of 383.83 articles (per year) and since 2007 it has been growing until it remained above this value since 2011. This is because the average is directly affected by the low value of the current year, as can be seen in Fig. 2 which shows a much smaller number of published scientific articles for 2018 than 383.83. As for the impact of the articles published, the year that shows the greatest effectiveness in this index was 2013, which by the way was one of the years of greater publication of the subject. Citations also peaked in 2010, but internationally, although the number of documents published in that year was no higher than the average number of publications for the entire period 2007-2018.

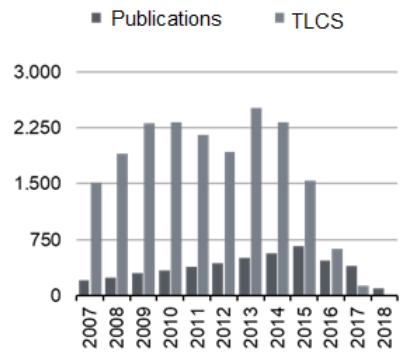

Figure 2. Publications in the period 2007-2018

Contribution from Institutions/Universities

The research centers as universities and institutions that have contributed most to the study of gasification in the period 2007-2018 are represented in Table 4. The Unknown record reached its highest value with a total of 1,635 publications (35.5%), although as mentioned above, this may be due to a mass of data that HistCite did not classify from the information provided by WoS. It is then considered to take the five (5) records after this one, all corresponding to Chinese Institutions and Universities, in order of Chinese Academy of Science (2.56%), East China University of Science and Technology (1.35%), Harbin Institute of Technology (1.26%), Xi An Jiao Tong University (1.13%), Huazhong University of Science and Technology (0.96%).

With regard to the impact of published articles, madly speaking, Xi An Juan Tong University with 377, has a higher citation rate, even with fewer published articles than other records; it is followed by the East China University of Science and Technology (356), Chinese Academy of Science (317), Harbin Institute of Technology (242) and Huazhong University of Science and Technology (192).

The published articles and Impact of these from Chinese Institutions and Universities are in perfect coherence with Table 2 where the statistics by country of these parameters are represented.

Table 4. Impact results top 5 institutions.

Inst/Univ	PT	TLCS
Unknown	1635	9423
Chinese Academy of Science	118	317
East China University of Science and Technology	62	356
Harbin Institute of Technology	58	242
Xi An Jiao Tong University	52	377
Huazhong University of Science and Technology	44	192

Individual records

The author who has published the most on the subject is Williams P.T. with a record 50 articles and has been referenced in 355 locally and 945 internationally.

The most frequently cited article is that of Torres W. and collaborators hot gas removal of tars, ammonia and hydrogen sulfide from Biomass Gasification gas, in the Journal Catalysis reviews-science and engineering, published in 2007. The article has been referenced a total of 43 times.

CONCLUSIONS

This article is a bibliometric study on the scientific progress of Biomass Gasification as an alternative energy source, covering

the period 2007-2018. The compilation of data from the publications made at this time was obtained by the Web of Science database and displayed in HistCite for analysis. It should be noted that there are a significant number of statistics that HistCite was unable to classify from the metadata provided by Web of Science.

Statistics show that the language of 63.72% of the publications is English, which consolidates that it is widely accepted in the scientific community. The country that has published the most publications on the subject during this period is China, with a total of 813 publications, 2,537 and 8,789 times its articles were used as references for other local and international research, respectively. However, it should be noted that although the USA has made fewer publications (313), the impact of these was considerably significant (1,169 and 6,000).

Biomass Gasification research has increased in popularity over the years, with an annual number of publications rising from 202 in 2007 to an average of 383.83 by 2018, with a total number of 4,606. Distributed in several scientific journals of high worldwide impact with Energy & Fuels and Fuels leading the publications with more than 430 total articles, although speaking of the impact of them, this second Journal is more popular in the scientific community, with 2,695 articles that have referenced some of its 433.

China has had great diffusion of its research on the subject since the main research centers in the world are represented by this country, having as first exponent the Chinese Academy of Science with 118 published articles and more than 300 references of these. This is in line with the results of the countries that are most representative in this scientific field.

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