Renewable and Sustainable Energy Reviews 59 (2016) 206–224

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

A scientific approach with bibliometric analysis related to brick and tile drying: A review

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ARTICLE INFO

Article history:
Received 8 April 2015
Received in revised form
30 December 2015
Accepted 31 December 2015

Keywords:
Drying
Porous media
Brick/tile drying
Bibliometric analysis

ABSTRACT

Extensive analyses of technological developments and technology foresight studies have been vital to help prepare possible scientific scenarios for the future. The primary purpose of this type of foresight study is to utilise methods and attempt to assess development trends in science and technology. This paper presents an approach to find out the various trends in scientific studies in the field of drying brick/tile that are occurring in the world. All documents used in this study were obtained from the Scopus database. To shed light on drying trends, both bibliometric and network analyses were conducted in this research. For the bibliometric analysis, the Scopus database was systematically searched to obtain a dataset in relation to the drying of brick/tile. The year range covered from 1980 to 2015. On the other hand, the patent data used in the study were taken from the Espacenet international patent database. The same keywords coupled with bibliometric analysis were used to find the relevant patent data. Some parameters were considered, such as the number of documents, authorship and ownership, patterns of international collaborations, address, and number of times cited. The collaboration networks with co-citation analysis for authors were also analysed in this study. Significant growth is observed in scientific production particularly in the period from 2000–2015. The countries that became evident as most productive on a scientific basis are the United States, Germany and China.

Contents

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http://dx.doi.org/10.1016/j.rser.2015.12.357
1364-0321/

1. Introduction

The term “drying” is commonly used to describe the process of thermally removing moisture from a solid product. It is often one of the most complex operations in a manufacturing process. The difficulties in theoretical analysis of the phenomena of simultaneous transport of heat, mass, and momentum constitute the main reason of underestimated process [1].

The efficient use of energy in the drying process and reduction in cost are immensely profitable for the industry. Therefore, recently, a considerable literature has grown up around the theme of drying in both industrial and academic contexts. Drying is inherently a cross and multidisciplinary field which has a very broad application area, such as food, agriculture and chemical industries, textile, building materials, and other applications. It requires optimal understanding of transport phenomenon and adequate knowledge of material science because the priority is not only to conserve energy but also to obtain better product quality during drying [2].

Developments in drying are driven in many ways, such as by [3]:

- presenting a new experimental approach for characterisation and quality control of desired dried product
- strengthening the technological aspects of existing equipment and putting emphasis on more effective design
- supporting an active collaboration among researchers from different disciplines
- using modern methods supported by computer tools and software which make transitions possible from the molecular pore to particles

Products must meet some specific requirements after the drying process such as being free flowing or dust free, specified particle size distribution, solubility or active component preservation. Hence, the selection of the right drying process and dryer design has an undeniable importance on the quality, size, shape and moisture content of final product and cost price [4].

Due to the above mentioned importance, drying has been an important part of research since the 1980s. Most of the studies generally have focused on two components; “drying theory” which deals with the analysis of the transport phenomenon and “drying equipment” which aims to design, manufacture and optimise dryers based on drying theory [5]. Professor Arun S. Mujumdar is one of the leading researchers popularly known as “Drying Guru” who led to the increasing interest in this subject with over 575 journal publications, 9 e-books, 3 authored books, 60+ edited books, and 120+ book chapters [6]. The latest book by Professor Mujumdar is a comprehensive source called “Modern Drying Technology” which has provided a significant contribution to the researchers.

A considerable amount of literature has been published in the field of drying process. In particular, scientific and technological research institutions in many countries have been trying to constitute a road map with the reports published in certain periods for researchers and global companies that work on drying systems. In contrast to these studies, there is much less information about the drying of porous medium, especially related to brick/tile drying. Therefore, this is the first study that aims to make an original contribution to the literature and fill in the gap in the relevant area by using bibliometric analysis technique on brick/tile drying. Indeed, the bibliometric analysis offers a big potential and promotes their use for better understanding of this type of reviews.

2. Basic drying theory

The most common, important and expensive step of industrial applications is the drying process. For instance, this process is used in the following fields: agricultural and chemical industry, food preservation, drying of building materials, etc. Basically, the drying phenomenon can be defined as simultaneous heat, mass and momentum transfer resulting in the removal of water from the products to reduce the moisture content (Fig. 1).

The drying process takes place in two basic mechanisms; the migration of moisture from the interior of a product to the surface, and the evaporation of moisture from the heated surface to the surrounding air. These transport mechanisms of moisture are closely related to several external factors such as temperature, the type and nature of the exposed surface, humidity, pressure and the flow velocity [7–9]. Investigations on drying phenomenon due to its complexity, are still a major area of interest for many researchers around the world. The central motivation in most of these research projects is to determine the effects of external factors on the drying process, since the understanding of the drying process in detail is necessary for the process design with scientific principles, preserving the quality of the product and energy optimisation [10–13].

Despite the increase in the number of studies and technological developments, drying process is an exclusive area to be studied in detail and extensively by researchers. Continued efforts are needed to make drying process more understandable on the grounds that non-linear physical phenomenon and to simplify dryer design, control and product quality. The integration of the knowledge of basic thermodynamics and transport phenomenon into the description of phase equilibria and drying kinetics is among the current challenges for the research [14,15].

A number of researchers have presented review articles on the topic of drying in the past decades. Hall [16] published an article to present the list of literature on drying and related topics from the period 1982–2006. These articles including the word “review”, were prime sources of these listings. In the same vein, several attempts have been made to highlight the current state and future trends related to drying [17–21]. A great development has been made in computer software and hardware over the past 30 years, which obviously broaden the application of computers to drying technologies. Since then, calculations have become feasible with one, two, or three independent state variables (i.e., temperature, moisture content) in one, two, and three dimensions thanks to developments in computer technology along with the advantages of applied mathematics in engineering applications [22]. Numerous studies have attempted to explain the computational modelling and software that can be used in the drying process [23–34].