

## Nikolaos M. Vaxevanidis

Professor  
School of Pedagogical and  
Technological Education (ASPETE), Athens  
Greece

## Aleksandar Vencel

Professor  
University of Belgrade  
Faculty of Mechanical Engineering, Belgrade  
Serbia  
South Ural State University, Chelyabinsk  
Russia

## Emilia Assenova

Society of Bulgarian Tribologists, Sofia  
Bulgaria

## Mara Kandeve

Professor  
Technical University of Sofia  
Faculty of Industrial Technology, Sofia  
Bulgaria  
South Ural State University, Chelyabinsk  
Russia

## Pandora Psyllaki

Associate Professor  
University of West Attica  
Laboratory of Tribology, Athens  
Greece

# Scientific Literature on Thermal Spray Coatings from Southeastern Europe: A Ten Years Bibliometric Analysis

*One of the tools used within the effort of developing new quantitative scientometric tools, reliable to be used for ranking academic/research unities is the bibliometric analysis of the scientific production from discrete geographical regions on a certain scientific topic. These analyses apply the so-called bibliometric methods. In the present work, the research output of all countries in Southeastern Europe (SEE) on the scientific topic of thermal spray coatings is presented by using bibliometric indices such as the total number of publications and citations as well as the h-index and the average number of citations per publication. Analysis spans the last ten years and the required scientific data in order to calculate the bibliometric indices were retrieved using the Scopus<sup>®</sup> scientific database.*

**Keywords:** thermal spray coatings, Southeastern Europe, bibliometric indices, scientific publications, Scopus database.

## 1. INTRODUCTION

Bibliometrics is the research methodology which helps to analyze current trends in the literature regarding a particular area and provides guidelines and motivations for future research work. It basically provides a general outline and overall structure of the research area [1] whilst an accurate definition of bibliometric study has been given by Broadus [2].

Bibliometrics as a research area has received tremendous attention from the scientific fraternity in recent times. Bibliometrics is now identified as an efficient technique to build a general outline of a certain scientific research field. There has been a rapid development in the field of bibliometrics in recent times attributing to social developments significantly gaining from the advancement of the internet and computers. Bibliometrics therefore gives a “total” view of scientific activity. It basically is a part of library and information science, but it has been extensively used in numerous other research areas [3,4]. In addition, bibliometrics constitute now a tool which may be easily scaled from micro (faculty member or individual researcher) to macro (world) level [5]. Typically, bibliometric studies can be classified into subject specific, see for example [1,6-8], journal specific, see for example [3,9,10] and/or geographical district specific, see for example [11-14]. A combined, subject and district specific type is also commonly found, see for example [15-21].

From an overview of the relative scientific literature it can be concluded that, in recent years there has been a noticeable number of articles focusing on the scientific production from discrete geographical regions on a certain scientific topic. As far as the countries of Southeastern Europe (SEE)\* are concerned bibliometric studies of scientific disciplines are rather limited [16,21].

This work presents the research output of the countries in SEE on the scientific topic of thermal spray coatings by examining bibliometric indices like the total number of publications and citations, *h*-index and the average number of citations per publication. Analysis spans the last ten years and the required scientific data in order to compute the bibliometric indices were retrieved from Scopus<sup>®</sup>. This study is a follow-up on a similar work concerning the scientific field of tribology [16]. Note that the fundamentals and the current status of plasma spray techniques are not discussed here; see for an overview [22].

Evaluation of the scientific research, performed by Higher Education Institutions (HEIs), is currently obligatory in several SEE countries adhering to the European initiatives for a European Higher Education Area (Bologna process and Bergen report) [23,24].

## 2. BIBLIOMETRIC INDICES

Selecting the suitable bibliometric indices is essential for the reliable presentation, as well as, the evaluation of

---

Received: November 2018, Accepted: March 2019  
Correspondence to: Dr Nikolaos M. Vaxevanidis  
School of Pedagogical and Technological Education  
(ASPETE), ASPETE Campus, GR 14121, Athens, Greece  
E-mail: vaxev@aspete.gr  
**doi:10.5937/fmet1903649V**

© Faculty of Mechanical Engineering, Belgrade. All rights reserved

---

\* According to EU and to World Bank sources the countries of Southeastern Europe (SEE) are geographically, as follows: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Montenegro, North Macedonia, Romania, Serbia, Slovenia and Turkey (partially)

research by bibliometrics. It has been argued that "...at all level of evaluation no indicator should be taken in isolation. A series of indicators representing the different facets of scientific activity should be employed..." [25]. The indices selected in this work refer to four research elements: productivity; impact; efficiency; and hybrid (productivity + impact). The same philosophy was adopted in some recent contributions [14,21,24]. Under this viewpoint, the following bibliometric indices were initially monitored:

#### Productivity

- P: Total number of publications (on country level) in the given time-period.
- $P_y$ : Total number of publications (on country level) during a year.
- $P_{av}$ : Average number of publications per year (on country level) in the given time-period.

#### Impact

- C: Total number of citations excluding self-citations (on country level) in the given time-period.
- $C_s$ : Total number of citations with self-citations (on country level) in the given time-period.

#### Efficiency

- $c_{av}$ : Average number of citations per publication (on country level), excluding self-citations (C/P).
- $c_{avs}$ : Average number of citations per publication (on country level), including self-citations ( $C_s/P$ ).

#### Hybrid (productivity + impact)

- $h$ -index (on country level), excluding self-citations, i.e. considering P and C of a country as the outcome of a sole researcher.
- $h_s$ -index ( $h$ -index on country level), taking into account self-citations).

Indices P and  $P_y$  may be considered as a metric for the scientific magnitude of a country. However, scientific magnitude differs from scientific strength as it is mentioned elsewhere [26]. Another standard indicator is the total number of citations (C) received by these P publications in the examined period.

The average number of citations per publication is calculated on the basis of the total number of publications (P) and citations within the given time-period. This measure, corresponding to citations per publication, is deployed as an indicator of efficiency [14] or as an impact index [26]. This measure may be computed either by excluding or by including self-citations to assess the effect of self-citations on the publication profile of national research.

The  $h$ -index was introduced in 2005 by Hirsch [27], combining the measure of quantity and impact of the scientific output of a researcher in a single index. According to Hirsch, "a scientist has index  $h$  if  $h$  of his or her  $N_p$  papers have at least  $h$  citations each and the other ( $N_p - h$ ) papers have  $\leq h$  citations each". The scientific community has accepted this indicator, as shown by the vast number of publications on the topic and its adoption by *Nature* and *Science* [14]. Detailed analysis of the  $h$ -

index and the  $h$ -type indices for evaluating scientific research performance is given elsewhere [25].

A crucial problem arisen after monitoring measures such as P and/or  $c_{av}$  is how to characterize a certain number of publications or citations per publication as low or high. On the basis of experience and the already published relevant research articles it is believed that the most appropriate method is the field-based normalization [28].

### 3. METHODOLOGY

Web of Science (WoS), which is a part of Clarivate Analytics® (<https://clarivate.com>) is considered the dominant of multidisciplinary citation indexes. Nevertheless, since 2004 two other alternatives are also available: Scopus® (<http://www.scopus.com>) and Google Scholar® (<http://scholar.google.com>). The former has been developed by Elsevier and comes with its own registration policy whilst the latter provides free access. The comparison between these two important databases falls outside of this work's main objectives, since it has already been addressed elsewhere [29].

To enable the robust calculation of the bibliometric indices by collecting scientific data per each country, the Scopus® research data base was considered. Its selection was based on previous suggestions [14,16,20], as well as, preliminary case studies referring to the current scientific topic studied in this work. Scopus® involves certain characteristics allowing for the enhanced service, when it comes to educational and academic needs, engineering literature research and bibliometric analysis. In addition Scopus® provides almost 100 % "engineering" coverage.

Combined searching criteria are presented in the following scheme that includes not only the keywords proposed, but also the hierarchical order in which they should be inserted in the searching machine:

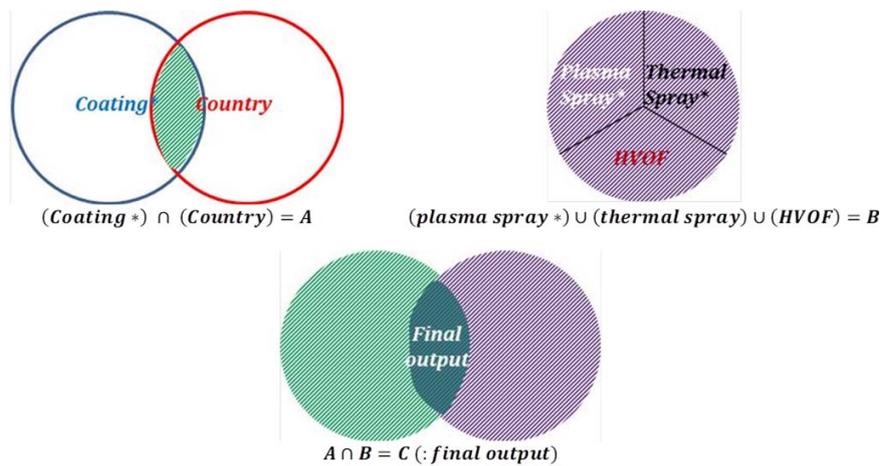
$$[(\text{coating}^*)^1 \text{ AND } (\text{country})^2] \text{ AND } [(\text{plasma spray}^*)^1 \text{ OR } (\text{thermal spray}^*)^1 \text{ OR } (\text{HVOF})^1]$$

where term: 1 refer to the classification "Article title, Abstract, Keywords" and 2 refer to the classification "Affiliation".

The asterisk at the end of some terms is used to overcome the underestimation resulting in by the use of different but equivalent terms, mainly concerning their suffix, i.e. "coating" or "coatings", "plasma spray" or "plasma spraying" or "plasma sprayed".

Trying to describe mathematically the above scheme, the first bracketed term corresponds to the intersection between two main sets (coating\*, country), whilst the second one to the union of three subsets concerning the technique applied (thermal spray\*, plasma spray\*, HVOF); the final result would be the intersection between the above two (Fig. 1).

As an example, a snapshot of terms used for the bibliometric search on the scientific productivity in Greece on the specific topic is shown in Figure 2. Note that each country search was conducted twice by: (i) taking into account the complete research profile of each country with no time limit and (ii) considering only the documents and corresponding references for



**Figure 1. Mathematical expression of the performed bibliometric search on the productivity of scientific research per country, on the topic of thermal spraying coatings**

Documents Authors Affiliations Advanced

---

Search  
coating\* x Article title, Abstract, Keywords ▾ +

E.g., "Cognitive architectures" AND robots

AND ▾

Search  
Greece x Affiliation ▾ - +

AND ▾

Search  
"plasma spray\*" x Article title, Abstract, Keywords ▾ - +

OR ▾

Search  
"thermal spray\*" x Article title, Abstract, Keywords ▾ - +

OR ▾

Search  
HVOF x Article title, Abstract, Keywords ▾ - +

**Figure 2. Keywords entered during the present bibliometric study**

the last decade (period 2008 – 2017) to make comparisons using the same time basis. In this case, the index “10” is added to the symbol of each bibliometric index, indicating its correspondence to the last ten years. For comparison purposes search with no time limit was expanded to include some Mediterranean and nearby countries (Table 1).

The keywords selection used in this approach is actually the result of an optimization, based on a number of trials. The main question to be answered is focused on the number of articles in referred scientific journals per country, on the specific topic of coatings deposited by thermal spray/-ing (general term) or any of the two most widely used techniques: (a) plasma spraying, in order to obtain, mainly, oxide coatings and (b) HVOF for carbide ones; both types of coatings find applications on the protection of metallic parts against wear, thus the relevant keywords have been considered to be proper attributes to represent the thermal spray coating concept in scientific contributions. Even though one may imagine another approach, the proposed one is definitely a reference point. All data presented in this work were collected from 11<sup>th</sup> to 13<sup>th</sup> December 2018 and involved scientific work published until the end of 2017.

## 4. RESULTS AND DISCUSSION

### 4.1 Trends in publication

Twenty six (26) searches were performed in total; each search was run twice. There was no refinement of the results besides some evident irrelevant entries. Search results obtained are given in Table 1 and Table 2 for indices with no time limit and for last decade’s indices, respectively.

Table 1 gives the “timeless whole picture” of scientific production from the SEE geographical region about thermal spray coating. The following discussion refers to last decade’s bibliometric data (Table 2), so as to comment on the basis of a determined time-window. Note also, that for the internationally co-authored publications the “whole counting” method was applied, i.e. every country gets full credit for internationally co-authored papers.

Comparison of the sum of publication totals of the first column with the world total indicate the fact that these countries account for only 3.6 % of the literature on thermal spray coatings published worldwide (Table 2). Turkey has the largest publication output of the SEE countries, i.e., 39.3 % of total articles, followed by

**Table 1. Overall bibliometric indices with no time limit**

Country	Number of articles	Number of citations		<i>h</i> -index		Year of 1 <sup>st</sup> publication
	P	C <sub>s</sub>	C	<i>h</i> <sub>s</sub>	<i>h</i>	
Albania	0	0	0	0	0	–
Bosnia and Herzegovina	0	0	0	0	0	–
Bulgaria	25	159	123	6	6	1991
Croatia	8	47	37	4	4	1996
FYROM	0	0	0	0	0	–
Greece	105	1021	808	19	17	1994
Montenegro	0	0	0	0	0	–
Romania	139	412	308	10	10	1997
Serbia	22	213	185	9	9	2007
Slovenia	14	132	104	6	5	1991
Turkey	243	3068	2585	34	30	1993
For comparison						
Austria	93	1539	1273	22	20	1989
Egypt	63	679	593	17	16	1991
France	1295	23116	n/a	63	n/a	1982
Italy	569	10010	8437	52	47	1976
Spain	487	9202	7703	48	44	1986
Israel	38	896	767	16	16	1980
Word total	20933	n/a	n/a	n/a	n/a	1966

n/a – not available

**Table 2. Overall bibliometric indices for the last decade (2008 – 2017)**

Country	Number of articles	Number of citations		<i>h</i> -index		Number of citations per article	
	P <sub>10</sub>	C <sub>s10</sub>	C <sub>10</sub>	<i>h</i> <sub>s10</sub>	<i>h</i> <sub>10</sub>	<i>c</i> <sub>avs10</sub>	<i>c</i> <sub>av10</sub>
Bulgaria	7	27	15	3	1	3.86	2.14
Croatia	7	44	34	4	4	6.29	4.86
Greece	51	599	499	15	14	11.75	9.78
Romania	109	363	265	10	9	3.33	2.43
Serbia	20	210	185	9	9	10.50	9.25
Slovenia	11	127	100	6	5	11.55	9.09
Turkey	133	1211	1071	19	18	9.11	8.05
Word total	9510	n/a	n/a	n/a	n/a	n/a	n/a

n/a – not available

Romania (32.2 %), Greece (15.1 %) and Serbia (5.9 %). These four countries contribute more than 92 % of the total SEE production on the topic.

The variation of paper with year for countries of SEE is presented in Figure 3. The graphs in this figure reveal no monotonic trend, decrease or increase whilst, the annual total of articles ranges from 26 (2008) to 39 (2009) with an average value of 33.8.

Besides the number of publications P, the total number of citations C, which a scientific body of P articles has received, is usually used as a criterion of the impact of the research under consideration [16]. From Table 2 it is clear that Turkey holds the highest C<sub>s10</sub> and C<sub>10</sub> followed in descending order by Greece, Romania and Serbia. These countries account for 93 % approximately of all citations received.

The average number of citations per publication on a country level is considered as an index of the scientific

research efficiency. Greece holds the highest index (*c*<sub>av10</sub> = 9.78), followed by Serbia (*c*<sub>av10</sub> = 9.25), Slovenia (*c*<sub>av10</sub> = 9.09) and Turkey (*c*<sub>av10</sub> = 8.05). Thus, it is evident that only these four countries are above the average value of 6.41 calculated for the whole region.

The *h*-index as it was originally introduced [27] combined in a single, synthetic, indicator a metric for quantity and impact of a researcher's scientific output. In spite of being originally designed to evaluate individual scholars, *h*-index may also be implemented to other units of analysis, like research teams, university departments, scientific facilities, journals and countries [24,30,31]. During present research *h*-index was estimated on country level, by considering P and C values of a country as the output of a sole researcher; results obtained are tabulated in Table 2. According to Table 2 Turkey holds the highest *h*<sub>s10</sub> and *h*<sub>10</sub> followed in descending order by Greece, Romania, and Serbia.

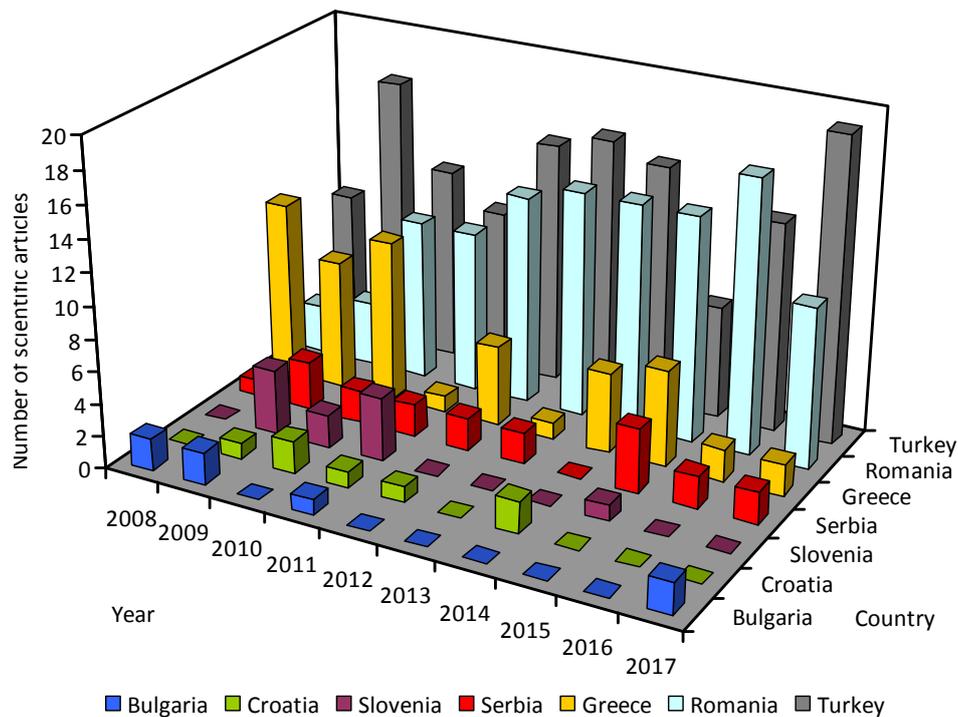


Figure 3. Annual variation of papers (P<sub>j</sub>) from SEE countries published from 2008 to 2017

Table 3. The most prolific authors on the topic of thermal spray coatings in SEE for the last decade (2008 – 2017)

Country	Author	P <sub>10</sub>	Affiliation
Bulgaria	E. Assenova	3	Society of Bulgarian Tribologists, Sofia
	M. Kandeveva	3	Technical University of Sofia, Faculty of Industrial Technology, Sofia
Greece	M. Vardavoulias	15	PyroGenesis S.A., Lavrio
	G. Stergioudis	12	Aristotle University of Thessaloniki, Department of Physics, Thessaloniki
	G. Vourlias	12	Aristotle University of Thessaloniki, Department of Physics, Thessaloniki
Romania	C. Munteanu	22	Universitatea Alexandru Ioan Cuza, Faculty of Mechanical Engineering, Iasi
	V.A. Șerban	17	Universitatea Politehnica din Timisoara, Timisoara
	I. Hulka	14	Universitatea Politehnica din Timisoara, Timisoara
Serbia	A. Vencel	9	University of Belgrade, Faculty of Mechanical Engineering, Belgrade
	M.R. Mrdak	6	Research and Development Center, Belgrade
	M.N. Vilotijević	5	Institut za nuklearne nauke Vinca, Belgrade
Slovenia	D. Lisjak	8	Jozef Stefan Institute, Ljubljana
	M. Drofënik	4	Jozef Stefan Institute, Ljubljana
Turkey	A.C. Karaoglanli	12	Bartın University, Department of Metallurgy and Material Engineering, Nevsehir
	F. Ustel	11	Sakarya Üniversitesi, Department of Metallurgy and Material Engineering, Sakarya
	A. Turk	10	Celal Bayar Üniversitesi, Department of Materials Engineering, Manisa

A comparison of the results discussed above with similar results concerning other geographical regions, e.g. Scandinavia or EU countries would be of great interest; nevertheless such a comparison is not feasible yet since relative data are not available. Research profiles for a number of countries including Greece and Turkey are discussed elsewhere [26]; the scientific size (publications) and the scientific strength (standardized citations per publication) of EU-27 member states are presented there as well. It should be mentioned that no international data is available to reliably compare outputs in terms of publications to inputs in terms of number of researchers. Instead, publication output is usually compared to the size of the population in the different countries – although differences in population do not necessarily reflect differences in research efforts [32].

Some of the noticeable differences among countries in terms of publication output are shown in Tables 1 and 2 whilst they may be attributed to differences in country size and investments in research. For a better insight to research production and impact, a correlation between bibliometric indices to social-economic indices such as population, number of engineering departments in universities, gross domestic product (GDP) and gross domestic expenditure on R&D (GERD) should be conducted. In general, a gross positive relationship between the economic potential of a country and its scientific production is displayed [33]. On the other hand, most of the SEE countries are far from reaching the investment levels of scientifically developed countries in terms of GERD and efforts must be directed towards the increase of this indicator.

**Table 4. The most cited articles on the topic of thermal spray coatings for each SEE country**

Country	Authors and article	C <sub>s</sub>
Bulgaria	Skulev H., Malinov S., Sha W., Basheer P.A.M., <i>Microstructural and mechanical properties of nickel-base plasma sprayed coatings on steel and cast iron substrates</i> , Surface and Coatings Technology, 197, 2-3, 2005, 177-184	21
	Skulev H., Malinov S., Basheer P.A.M., Sha W., <i>Modifications of phases, microstructure and hardness of Ni-based alloy plasma coatings due to thermal treatment</i> , Surface and Coatings Technology, 185, 1, 2004, 18-29	21
	Iordanova I., Forcey K.S., Gergov B., Bojinov V., <i>Characterization of flame-sprayed and plasma-sprayed pure metallic and alloyed coatings</i> , Surface and Coatings Technology, 72, 1-2, 1995, 23-29	21
Croatia	Simunovic K., Saric T., Simunovic G., <i>Different approaches to the investigation and testing of the Ni-based self-fluxing alloy coatings – A review. Part 1: General facts, wear and corrosion investigations</i> , Tribology Transactions, 57, 6, 2014, 955-979	13
	Jakovljević S., Hendrix W., Havermans D., Meneve J., <i>Characterisation of ZrO<sub>2</sub> layers deposited on Al<sub>2</sub>O<sub>3</sub> coating</i> , Wear, 266, 3-4, 2009, 417-423	7
	Simunovic K., Saric T., Simunovic G., <i>Different approaches to the investigation and testing of the Ni-based self-fluxing alloy coatings – A review. Part 2: Microstructure, adhesive strength, cracking behavior, and residual stresses investigations</i> , Tribology Transactions, 57, 6, 2014, 980-1000	6
Greece	Pantelis D.I., Psyllaki P., Alexopoulos N., <i>Tribological behaviour of plasma-sprayed Al<sub>2</sub>O<sub>3</sub> coatings under severe wear conditions</i> , Wear, 237, 2, 2000, 197-204	60
	Yugeswaran S., Yoganand C.P., Kobayashi A., Paraskevopoulos K.M., Subramanian B., <i>Mechanical properties, electrochemical corrosion and in-vitro bioactivity of yttria stabilized zirconia reinforced hydroxyapatite coatings prepared by gas tunnel type plasma spraying</i> , Journal of the Mechanical Behavior of Biomedical Materials, 9, 2012, 22-33	47
	Psyllaki P.P., Jeandin M., Pantelis D.I., <i>Microstructure and wear mechanisms of thermal-sprayed alumina coatings</i> , Materials Letters, 47, 1-2, 2001, 77-82	38
Romania	Marginean G., Utu D., <i>Cyclic oxidation behaviour of different treated CoNiCrAlY coatings</i> , Applied Surface Science, 258, 20, 2012, 8307-8311	29
	Ruset C., Grigore E., Maier H., Neu R., Greuner H., Mayer M., Matthews G., <i>Development of W coatings for fusion applications</i> , Fusion Engineering and Design, 86, 9-11, 2011, 1677-1680	26
	Bogya E.S., Károly Z., Barabás R., <i>Atmospheric plasma sprayed silica-hydroxyapatite coatings on magnesium alloy substrates</i> , Ceramics International, 41, 4, 2015, 6005-6012	25
Serbia	Vencel A., Arostegui S., Favaro G., Zivic F., Mrdak M., Mitrović S., Popovic V., <i>Evaluation of adhesion/cohesion bond strength of the thick plasma spray coatings by scratch testing on coatings cross-sections</i> , Tribology International, 44, 11, 2011, 1281-1288	49
	Vilotijević M., Marković P., Zec S., Marinković S., Jokanović V., <i>Hydroxyapatite coatings prepared by a high power laminar plasma jet</i> , Journal of Materials Processing Technology, 211, 6, 2011, 996-1004	17
	Vencel A., Manić N., Popovic V., Mrdak M., <i>Possibility of the abrasive wear resistance determination with scratch tester</i> , Tribology Letters, 37, 3, 2010, 591-604	17
Slovenia	Bégard M., Bobzin K., Bolelli G., Hujanen A., Lintunen P., Lisjak D., Gyergyek S., Lusvarghi L., Pasquale M., Richardt K., Schläfer T., Varis T., <i>Thermal spraying of Co,Ti-substituted Ba-hexaferrite coatings for electromagnetic wave absorption applications</i> , Surface and Coatings Technology, 203, 20-21, 2009, 3312-3319	27
	Lisjak D., Bobzin K., Richardt K., Bégard M., Bolelli G., Lusvarghi L., Hujanen A., Lintunen P., Pasquale M., Olivetti E., Drogenik M., Schläfer T., <i>Preparation of barium hexaferrite coatings using atmospheric plasma spraying</i> , Journal of the European Ceramic Society, 29, 11, 2009, 2333-2341	22
	Bobzin K., Bolelli G., Bruehl M., Hujanen A., Lintunen P., Lisjak D., Gyergyek S., Lusvarghi L., <i>Characterisation of plasma-sprayed SrFe<sub>12</sub>O<sub>19</sub> coatings for electromagnetic wave absorption</i> , Journal of the European Ceramic Society, 31, 8, 2011, 1439-1449	19
Turkey	Sarikaya O., <i>Effect of some parameters on microstructure and hardness of alumina coatings prepared by the air plasma spraying process</i> , Surface and Coatings Technology, 190, 2-3, 2005, 388-393	104
	Hazar H., <i>Effects of biodiesel on a low heat loss diesel engine</i> , Renewable Energy, 34, 6, 2009, 1533-1537	92
	Yılmaz R., Kurt A.O., Demir A., Tatlı Z., <i>Effects of TiO<sub>2</sub> on the mechanical properties of the Al<sub>2</sub>O<sub>3</sub>-TiO<sub>2</sub> plasma sprayed coating</i> , Journal of the European Ceramic Society, 27, 2-3, 2007, 1319-1323	82

#### 4.2 Authorship characteristics

As evident in Table 2, the present analysis lies on an overall output of almost 340 papers published in journals indexed by Scopus®, during the period 2008–2017. These are papers that include at least one author listing an affiliation in one of the SEE countries. While counting

the papers it is observed that, in average, more than 80 % of the total number of papers comes from universities. This suggests that thermal spray coatings research in SEE countries is performed mainly in universities and public research institutions associated to higher education organizations; private research centers and industry seem to have marginal contribution and participation.

Moreover, as it is expected for a multi-disciplinary scientific topic such as thermal spraying, the vast majority of published articles have been co-authored.

In Table 3, the most prolific authors in the field in each of SEE counties are presented. A threshold of  $P_{10} \geq 3$  resulted in a number of 16 scientists from 6 different countries. Note that  $P_{10}$  values in Table 3 refer to thermal spray coatings papers only; the overall output of an author might be even greater.

In Table 4 the most cited articles on the topic in each of SEE counties are presented. Three articles at maximum from each country were included provided that the article received at least 5 citations.

Another essential aspect to be investigated is the “journal preference”. Scientists' selection of journals for publication has always been an important attribute of their publication activity. In thermal spray coatings, as in most other fields such as engineering and/or materials science, hundreds of journals of different levels of readership are available in Scopus®. These journals have been ranked according to their readership and scientific influence levels as measured by their IPP (impact per publication) [1] and SJR (SCImago Journal Rank) indicators. It is worth of mentioning that SJR indicator based on Scopus® is a free journal metric and provides an alternative to the impact factor (IF) which is based on data from the Science Citation Index [34].

**Table 5. The most preferred journals for publication on thermal spraying by scholars from SEE countries for the last decade (2008 – 2017)**

Country (P <sub>10</sub> )	Journal	No. of articles
Bulgaria (7)	IOP Conference Series: Materials Science and Engineering	2
Croatia (7)	Tribology Transactions	2
Greece (51)	Surface and Coatings Technology	8
	Journal of Alloys and Compounds	4
	Tribology in Industry	3
Romania (109)	Metalurgia International	11
	IOP Conference Series: Materials Science and Engineering	10
	Advanced Materials Research	7
Serbia (20)	Tribology in Industry	2
	Hemijska industrija	2
Slovenia (11)	International Journal of Hydrogen Energy	2
	Journal of the American Ceramic Society	2
	Surface and Coatings Technology	2
	Journal of Thermal Spray Technology	2
Turkey (133)	Surface and Coatings Technology	13
	Acta Physica Polonica A	7
	Ceramics International	5
	Materiali in tehnologije (Materials and Technology)	5
	Materials & Design	5

Table 5 presents information about the most preferred journals for publication by scholars from SEE countries. Three journals, at maximum, for each country

were included, provided that more than one article was published in the journal. Different patterns of preference are identified from different countries; in some cases preference is strongly influenced by the nationality of the editing company of a journal.

### 4.3 International scientific collaboration

It has been shown that there is an increasing international scientific collaboration in many disciplines [13,26]. Furthermore, the growing share of internationally co-authored papers involves an increasing number of countries. Table 6 refers to international collaboration within the SEE counties. For each country the three countries with the highest number of common papers are presented. The percentage of international publications is for all countries quite high; yet, no other considerable “internal” collaboration among the SEE countries is identified.

**Table 6. Collaborations of SEE countries with other countries in the topic of thermal spray coatings**

Country (P <sub>10</sub> )	Collaboration country (P <sub>10</sub> )		
Bulgaria (7)	Switzerland (2)	Poland (1)	Serbia (1)
Croatia (7)	Belgium (1)	Slovakia (1)	
Greece (51)	Belgium (4)	Italy (4)	UK (4)
Romania (109)	Germany (17)	Finland (7)	France (6)
Serbia (20)	8 countries with 1 common paper with each		
Slovenia (11)	Finland (8)	Italy (8)	Germany (7)
Turkey (133)	Japan (6)	Germany (5)	Iran (4)

The share of internationally collaborative publications in the overall scientific output of a country can be considered as first indication of the extent to which researchers in a country cooperate with colleagues outside their own country. This indicator can be seen as a measure of the international orientation of a country. On the other hand the complementary percentage, i.e. the share of non-internationally collaborative publications, is an indicator of the size of a country's own scientific basis and of its “scientific independence” [26].

### 4.4 General remarks and limitations

Bibliometric indicators are increasingly being used as a tool for research performance monitoring and/or evaluation. Bibliometric methods are quantitative by nature, but are used to make pronouncements about qualitative features [5,14]. The authors are aware of the fact that the use of bibliometric techniques to assess the publication efforts of scholars is far from not being controversial. They know that there is a burgeoning debate about the convenience of the use of citation indicators; the limitations and undesirable effects of the citation system are described elsewhere [35]. Moreover, they wish to emphasize the fact that publication-related activities is only one output in the knowledge transfer process of Higher Education Institutions (HEIs) [36]. However, they do believe that, in spite of the inherent limitations of bibliometrics, the viability of the adopted method for monitoring the scientific performance is quite effective, especially when limited resources are available.

## 5. CONCLUSIONS

In this study, bibliometric indices were used for describing the scientific activity on the topic of thermal spray coatings in the 11 Southeastern Europe countries during the last decade. Based on the authors' knowledge, this is the first article to analyze the quantity and quality of thermal spray-related research from this region. The research output is presented by using indices such as the total number of publications and citations, as well as, the *h*-index and the average number of citations per publication.

The total number of publications found in Scopus® between 2008 and 2017 is 338. Turkey has the largest publication output, i.e. 39.3 %, followed by Romania (32.2 %), Greece (15.1 %) and Serbia (5.9 %).

For the efficiency and the research impact, as these parameters are dictated by the average number of citations per publication on country level, Greece possesses the highest index ( $c_{av10} = 9.78$ ) followed by Serbia ( $c_{av10} = 9.25$ ), Slovenia ( $c_{av10} = 9.09$ ) and Turkey ( $c_{av10} = 8.05$ ). Only these four countries are above the average value of 6.5 calculated for the whole region.

## ACKNOWLEDGMENT

Nikolaos M. Vaxevanidis acknowledges the funding program "Strengthening research of ASPETE faculty members", supported by the "Special Account for Research of ASPETE", Greece. Aleksandar Vencl acknowledges the projects TR 34028 and TR 35021, supported by the Republic of Serbia, Ministry of Education, Science and Technological Development. Mara Kandeva acknowledges the project ДН 07/28-15.12.2016, funded by the National Science Fund at the Ministry of Education and Science, Bulgaria. Collaboration through the CEEPUS network CIII-BG-0703 is also acknowledged.

## REFERENCES

- [1] Muhuri, P.K., Shukla, A.K. and Abraham, A.: Industry 4.0: A bibliometric analysis and detailed overview, *Engineering Applications of Artificial Intelligence*, Vol. 78, pp. 218-235, 2019.
- [2] Broadus, R.N.: Toward a definition of "Bibliometrics", *Scientometrics*, Vol. 12, No. 5-6, pp. 373-379, 1987.
- [3] Janmajaya, M., Shukla, A.K., Abraham, A. and Muhuri, P.K.: A scientometric study of neurocomputing publications (1992-2018): An aerial overview of intrinsic structure, *Publications*, Vol. 6, No. 3, Paper 32, 2018.
- [4] Merigó, J.M., Rocafort, A. and Aznar-Alarcón, J.P.: Bibliometric overview of business & economics research, *Journal of Business Economics and Management*, Vol. 17, No. 3, pp. 397-413, 2016.
- [5] Wallin, J.A.: Bibliometric methods: Pitfalls and possibilities, *Basic & Clinical Pharmacology & Toxicology*, Vol. 97, No. 5, pp. 261-275, 2005.
- [6] Karanatsiou, D., Li, Y., Arvanitou, E.-M., Misirlis, N. and Wong, W.E.: A bibliometric assessment of software engineering scholars and institutions (2010-2017), *Journal of Systems and Software*, Vol. 147, pp. 246-261, 2019.
- [7] Kostoff, R.N., Stump, J.A., Johnson, D., Murday, J.S., Lau, C.G.Y. and Tolles, W.M.: The structure and infrastructure of the global nanotechnology literature, *Journal of Nanoparticle Research*, Vol. 8, No. 3-4, pp. 301-321, 2006.
- [8] Elango, B. and Ho, Y.-S.: Top-cited articles in the field of tribology: A bibliometric analysis, *COLLNET Journal of Scientometrics and Information Management*, Vol. 12, No. 2, pp. 289-307, 2018.
- [9] Cobo, M.J., Martínez, M.A., Gutiérrez-Salcedo, M., Fujita, H. and Herrera-Viedma, E.: 25 years at knowledge-based systems: A bibliometric analysis, *Knowledge-Based Systems*, Vol. 80, pp. 3-13, 2015.
- [10] Muhuri, P.K., Shukla, A.K., Janmajaya, M. and Basu, A.: Applied soft computing: A bibliometric analysis of the publications and citations during (2004-2016), *Applied Soft Computing*, Vol. 69, pp. 381-392, 2018.
- [11] Teodorescu, D. and Andrei, T.: The growth of international collaboration in East European scholarly communities: A bibliometric analysis of journal articles published between 1989 and 2009, *Scientometrics*, Vol. 89, No. 2, pp. 711-722, 2011.
- [12] Ivanović, D., Fu, H.-Z. and Ho, Y.-S.: Publications from Serbia in the Science Citation Index Expanded: A bibliometric analysis, *Scientometrics*, Vol. 105, No. 1, pp. 145-160, 2015.
- [13] Glänzel, W.: Science in Scandinavia: A bibliometric approach, *Scientometrics*, Vol. 48, No. 2, pp. 121-150, 2000.
- [14] Vaxevanidis, N.M., Despotidi, H., Prokopiou, H. and Koutsomichalis, A.: On the evaluation of the quality of research in Greek HEIs using bibliometric indices, *International Journal for Quality Research*, Vol. 5, No. 4, pp. 247-254, 2011.
- [15] Pavković, M. and Protić, J.: An analysis of scientific publications from Serbia: The case of computer science, in: *Proceedings of ISSI 2015 Istanbul: 15<sup>th</sup> International Society of Scientometrics and Informetrics Conference*, 29.06-03.07.2015, Istanbul (Turkey), pp. 423-424.
- [16] Vaxevanidis, N.M., Vencl, A. and Psyllaki, P.: Research on tribology in Southeastern Europe: A bibliometric study, *FME Transactions*, Vol. 43, No. 3, pp. 259-268, 2015.
- [17] Ševkušić, M. and Uskoković, D.: State of the art in nanoscience and nanotechnology in Serbia: A preliminary bibliometric analysis, *Tehnika*, Vol. 64, No. 5, pp. 1-15, 2009, (in Serbian).
- [18] Franceschini, F. and Maisano, D.: Publication and patent analysis of European researchers in the field of production technology and manufacturing systems, *Scientometrics*, Vol. 93, No. 1, pp. 89-100, 2012.
- [19] Kazakis, N.A.: Bibliometric evaluation of the research performance of the Greek civil engineering departments in national and European

- context, *Scientometrics*, Vol. 101, No. 1, pp. 505-525, 2014.
- [20] Kazakis, N.A., Diamantidis, A.D., Fragidis, L.L. and Lazarides, M.K.: Evaluating the research performance of the Greek medical schools using bibliometrics, *Scientometrics*, Vol. 98, No. 2, pp. 1367-1384, 2014.
- [21] Vaxevanidis, N.M., Psyllaki, P., Asteris, P.G., Chatzarakis, G.E., Prokopiou, H. and Krivokapić, Z.: Research on quality management in Southeastern Europe: A bibliometric study, in: *Proceedings of the 10<sup>th</sup> International Conference ICQME 2016*, 28-30.09.2016, Petrovac (Montenegro), pp. 77-88.
- [22] Pawlowski, L.: *The Science and Engineering of Thermal Spray Coatings*, John Wiley & Sons, Chichester, 2008.
- [23] Vaxevanidis, N.M.: Quality assurance in Greek HEIs: Convergence or divergence with European models? in: Davim, J.P. (Ed.): *Mechanical Engineering Education*, ISTE, London, pp. 1-60, 2012.
- [24] Vaxevanidis, N.M., Despotidi, H., Asteris, P.G. and Typas, G.: Evaluation of research in a Greek pedagogical and technological higher education institution, in: *Proceedings of the 7<sup>th</sup> International Working Conference "Total Quality Management – Advanced and Intelligent Approaches"*, 04-07.06.2013, Belgrade (Serbia), pp. 473-479.
- [25] Martin, B.R.: The use of multiple indicators in the assessment of basic research, *Scientometrics*, Vol. 36, No. 3, pp. 343-362, 1996.
- [26] Van Raan, A.F.J., Van Leeuwen, T.N. and Calero-Medina, C.: Performance of European Science: Research networks and profiles of EU countries in a global perspective, in: Delanghe, H., Muldur, U. and Soete, L. (Eds.): *European Science and Technology Policy*, Edward Elgar Publishing, Cheltenham, pp. 256-290, 2009.
- [27] Hirsch, J.E.: An index to quantify an individual's scientific research output, *Proceedings of the National Academy of Sciences of the United States of America*, Vol. 102, No. 46, pp. 16569-16572, 2005.
- [28] Panaretos, J. and Malesios, C.: Assessing scientific research performance and impact with single indices, *Scientometrics*, Vol. 81, No. 3, pp. 635-670, 2009.
- [29] Harzing, A.-W. and Alakangas, S.: Google Scholar, Scopus and the Web of Science: A longitudinal and cross-disciplinary comparison, *Scientometrics*, Vol. 106, No. 2, pp. 787-804, 2016.
- [30] Csajbók, E., Berhidi, A., Vasas, L. and Schubert, A.: Hirsch-index for countries based on essential science indicators data, *Scientometrics*, Vol. 73, No. 1, pp. 91-117, 2007.
- [31] Schneider, J.W. (Ed.): *Bibliometric Research Performance Indicators for the Nordic Countries*, NordForsk, Oslo, 2010.
- [32] Dos Santos Rubem, A.P., De Moura, A.L. and Soares De Mello, J.C.C.B.: Comparative analysis of some individual bibliometric indices when applied to groups of researchers, *Scientometrics*, Vol. 102, No. 1, pp. 1019-1035, 2015.
- [33] Alfaraz, P.H. and Calviño, A.M.: Bibliometric study on food science and technology: Scientific production in Iberian-American countries (1991-2000), *Scientometrics*, Vol. 61, No. 1, pp. 89-102, 2004.
- [34] González-Pereira, B., Guerrero-Bote, V.P. and Moya-Anegón, F.: A new approach to the metric of journals' scientific prestige: The SJR indicator, *Journal of Informetrics*, Vol. 4, No. 3, pp. 379-391, 2010.
- [35] Rodríguez-Ruiz, Ó.: The citation indexes and the quantification of knowledge, *Journal of Educational Administration*, Vol. 47, No. 2, pp. 250-266, 2009.
- [36] Schmoch, U. and Schubert, T.: When and how to use bibliometrics as a screening tool for research performance, *Science and Public Policy*, Vol. 36, No. 10, pp. 753-762, 2009.

---

**НАУЧНА ЛИТЕРАТУРА ИЗ ЈУГОИСТОЧНЕ  
ЕВРОПЕ У ОБЛАСТИ ПРЕВЛАКА НАНЕТИХ  
ТЕРМИЧКИ ПРОЦЕСОМ РАСПРШИВАЊА:  
ДЕСЕТОГОДИШЊА БИБЛИОМЕТРИЈСКА  
АНАЛИЗА**

**Николаос М. Ваксеванидис, Александар Венцл,  
Емилија Асенова, Мара Кандева,  
Пандора Псилаки**

Библиометријске анализе научно-истраживачког рада у одређеној научној области, у оквиру дефинисаног географског региона, представљају један од начина за квантитативно поређење и рангирање академских и/или истраживачких институција. У овим анализама се примењују тзв. библиометријске методе, а у овом раду су приказани резултати научно-истраживачког рада у земљама југоисточне Европе, у области превлака нанетих термички процесом распршивања. Резултати су приказани помоћу следећих библиометријских параметара: укупан број публикација и цитата, *h*-индекс и просечан број цитата по публикацији. Разматране су публикације објављене у последњих десет година, а подаци потребни за израчунавање библиометријских параметара су добијени коришћењем Скопус (Scopus<sup>®</sup>) цитатне базе података.