

Journal

of Achievements in Materials
and Manufacturing Engineering



Published monthly as the organ of the World Academy of Materials and Manufacturing Engineering

Editor-in-Chief Prof. Leszek A. Dobrzański

Volume 70 • Issue 1 • May 2015





Editor-in-Chief

Prof. Leszek A. Dobrzański – Gliwice, Poland

Editorial Council

Deputies Editor-in-Chief

Prof. Emin Bayraktar – St-Ouen, France
Prof. Tsanka Dikova – Varna, Bulgaria
Prof. Anna Dobrzańska-Danikiewicz – Gliwice, Poland
Prof. Yong Taek Im – Daejeon, South Korea
Prof. Lothar Kroll – Chemnitz, Germany
Prof. Cemal Meran – Denizli, Turkey
Prof. Jerzy Pacyna – Cracow, Poland
Prof. Maria Helena Robert – Campinas, Brazil
Prof. George Totten – Portland, USA
Prof. Jose Roberto Vargas Garcia – Mexico-City, Mexico
Prof. Kanaka Durga Vara Prasad Yarlagadda – Brisbane, Australia

Production Editor

Ms Marzena Kraszewska, MA, – Poland

Associated Editors

Technical Editor

Dr Małgorzata Dziekońska

Text Editors

Dr Eugeniusz Hajduczek
Ms Justyna Hajduczek-Jarka, MSc

Thematic Area Editors

Prof. Marcin Adamiak
Prof. Klaudiusz Gołombek
Prof. Janusz Mazurkiewicz
Prof. Marek Roszak
Dr Wojciech Borek
Dr Zbigniew Brytan

Statistical Editor

Prof. Jarosław Żmudzki

Language Editor

Prof. Piotr Malara

Editorial Assistance

Dr Paweł Jarka
Dr Ludwina Żukowska
Ms Barbara Nieradka, MSc
Ms Magdalena Zorychta, MSc

Reading Direct Editors

Dr Marek Sroka
Mr Adam Jagiello, MSc

Editorial Key Reviewers Committee

Prof. Sadek Absi Alfaro – Brasilia, Brazil
Prof. Gilmar Batalha – Sao Paulo, Brazil
Prof. Michal Besterci – Kosice, Slovakia
Prof. Silvio Brunatto - Curitiba, Brazil
Prof. Andrzej Buchacz – Gliwice, Poland
Prof. Tara Chandra – Wollongong, Australia
Prof. Dhanesh Chandra – Reno, USA
Prof. Antonio Cuhna – Guimaraes, Portugal
Prof. Elena David – Rm. Valcea, Romania
Prof. Janusz Dobrzański – Gliwice, Poland
Prof. Marek Dollar – Oxford, Ohio, USA
Prof. Georgiy Drapak – Khmelnytsky, Ukraine
Prof. Sabahudin Ekinović – Zenica, Bosnia and Herzegovina
Prof. Renato Esposito – Naples, Italy
Prof. Spilios Fassois – Patras, Greece
Prof. Janez Grum – Ljubljana, Slovenia
Prof. Toshio Haga – Osaka, Japan
Prof. Abdel Magid Hamouda – Doha, Qatar
Prof. Stuart Hampshire – Limerick, Ireland
Prof. Marek Hetmańczyk – Katowice, Poland
Prof. Hong Hocheng – Hsinchu, Taiwan
Prof. Werner Hufenbach – Dresden, Germany
Prof. David Hui – New Orleans, USA
Prof. Leopold Jeziorski – Czestochowa, Poland
Prof. Jerzy Jędrzejewski – Wrocław, Poland
Prof. Ivars Knets – Riga, Latvia
Prof. Janez Kopač – Ljubljana, Slovenia
Prof. Borut Kosec – Ljubljana, Slovenia
Prof. Antonin Kriz - Plzen, Czech Republic
Prof. Piotr Kula – Lodz, Poland
Prof. Karl Kuzman – Ljubljana, Slovenia
Prof. Klaudiusz Lenik – Lublin, Poland
Prof. Bogusław Major – Cracow, Poland
Prof. Stanisław Mitura – Koszalin, Poland
Prof. Andrew Nee – Singapore, Singapore
Prof. Jerzy Nowacki – Szczecin, Poland
Prof. Jose Luis Ocaña Moreno – Madrid, Spain

Prof. Abraham Ogwu – Paisley, United Kingdom
 Prof. Peter Palček – Zilina, Slovak Republic
 Prof. Fusheng Pan – Chongqing, China
 Prof. Roumen Petrov – Zwijnaarde, Belgium
 Prof. Mario Rosso – Turin, Italy
 Prof. Stanislav Rusz – Ostrava, Czech Republic
 Prof. Yuriy Shalapko – Khmelnytsky, Ukraine
 Prof. Božo Smoljan – Rijeka, Croatia
 Prof. Jerry Sokolowski – Windsor, Ontario, Canada
 Prof. Mirko Soković – Ljubljana, Slovenia
 Prof. Zinoviy Stotsko – Lviv, Ukraine
 Prof. Shamsuddin Sulaiman – Serdang, Malaysia
 Prof. Michał Szota - Czestochowa, Poland
 Prof. Ming-Jen Tan – Singapore, Singapore
 Prof. Eva Tillova – Zilina, Slovak Republic
 Prof. Miklos Tisza – Miskolc, Hungary
 Prof. Bekir Sam Yilbas – Dhahran, Saudi Arabia
 Prof. Andrzej Wojciechowski – Warsaw, Poland
 Prof. Emilia Wołowicz-Korecka – Lodz, Poland
 Prof. Dagou Zeze – Durham, United Kingdom
 Prof. Jie Zhou – Delf, the Netherlands
 Prof. Marian Żenkiewicz – Bydgoszcz, Poland

Patronage



World Academy of Materials and Manufacturing Engineering



Polish Academy of Sciences, Committee of Materials Science, Section of Metallic Materials



International Federation of Heat Treatment and Surface Engineering



Association of Computational Materials Science and Surface Engineering

Financial support

In 2015 the publication of the Journal is financially supported by the Ministry of Science and Higher Education in Poland.

Journal Registration

The Journal is registered by the Civil Department of the District Court in Gliwice, Poland at number 279.

Abstracting services

This Journal is sent to individual receivers from ca. 50 countries of the world and is delivered to the National Libraries and Universities and also to other scientific institutions in ca. 50 countries of the world. The electronic system of Reading Direct allows to access to the electronic version of that journal on-line, in the promotional period free of charge. This Journal is included in the reference list of the Polish Ministry of Science and Higher Education (9 points). The Journal is cited by Abstracting Services such as:



The procedure of its registration in the databases of Scopus, Compendex, CiteSeer, GetCited, Web of science, Engineering Village, Public Knowledge Project, Edith Cowan University's Institutional Repository, Journals Online and Inspec has begun.

Publisher



International OCSCO World Press
 ul. Zygmunta Starego 6/30
 44-100 Gliwice, Poland

e-mail: info@archivesmse.org

Bank account:

Stowarzyszenie Komputerowej Nauki o Materiałach i Inżynierii Powierzchni

Bank name: ING Bank Śląski

Bank address: ul. Zwycięstwa 28, 44-100 Gliwice, Poland

Account number/IBAN CODE:

PL7610501298100002300809767

Swift code: INGBPLPW

Gliwice – Campinas – Portland – Madrid – Daejeon – Brisbane – Cairo

© 2015 International OCSCO World Press. All rights reserved.

∞ The paper used for this journal meets the requirements of acid-free paper.
 Printed in Poland.



This journal is a part of Reading Direct, the free of charge alerting service which sends tables of contents by e-mail for this journal and in the promotion period also the full texts of papers. You can register to Reading Direct at

<http://www.journalamme.org>