

TEKA

AN INTERNATIONAL QUARTERLY JOURNAL
ON MOTORIZATION, VEHICLE OPERATION,
ENERGY EFFICIENCY AND MECHANICAL ENGINEERING

Editor-in-Chief

Prof. Eugeniusz Krasowski, Polish Academy of Sciences in Lublin, Poland

Assistant Editor

Prof. Andrzej Kusz, Polish Academy of Sciences in Lublin, Poland

Associate Editors

1. MOTORIZATION AND VEHICLE OPERATION

Prof. Kazimierz Lejda, Rzeszów University of Technology, Poland

2. MECHANICAL ENGINEERING

Prof. Andrzej Mruk, Krakow University of Technology, Poland

3. ENERGY EFFICIENCY

Prof. Witold Niemiec, Rzeszów University of Technology, Poland
Prof. Stepan Kovalyshyn, Lviv National Agrarian University in Dublany, Ukraine

4. MATHEMATICAL, STATISTICS

Dr hab. Andrzej Kornacki, University of Life Sciences in Lublin, Poland

Editorial Board

Prof. Dariusz Andrejko, University of Life Sciences in Lublin, Poland
Prof. Valery Adamchuk, National Scientific Centre Institute of Mechanization and Electrification of Agriculture, Kiev, Ukraine
Prof. Andrzej Baliński, Foundry Research Institute in Krakow, Poland
Prof. Vitaliy Bojarchuk, Lviv National Agrarian University in Dublany, Ukraine
Prof. Volodymyr Bulgakow, National University of Life and Environmental Sciences in Kiev, Ukraine
Prof. Dariusz Dziki, University of Life Sciences in Lublin, Poland
Prof. Stepan Epoyan, Kharkiv National University of Civil Engineering and Architecture, Ukraine
Doc. Ing. PhD. Pavol Findura, Slovak University of Agriculture in Nitra, Slovak Republic
Prof. Jan Gliński, Polish Academy of Sciences in Lublin, Poland
Prof. Jerzy Grudziński, University of Life Sciences in Lublin, Poland
Prof. Janusz Grzelka, Częstochowa University of Technology, Poland
Prof. L.P.B.M. Janssen, University of Groningen, Holland
Doc. Vladimir Kobzev, Kharkiv National University of Radio Electronics, Ukraine
Prof. Serhey Kostiukewich, Agrarian Technology, Minsk, Bielarus
Prof. Józef Kowalczyk, University of Life Sciences in Lublin, Poland
Prof. Volodymyr Kravchuk, State Scientific Organization „L. Pogorilyy Ukrainian Scientific Research Institute of Forecasting and Testing of Machinery and Technologies for Agricultural Production”
Prof. Petro Kulikov, Kiev National University of Construction and Architecture, Ukraine
Prof. Elżbieta Kusińska, University of Life Sciences in Lublin, Poland
Prof. Serhii Kvasha, National University of Life and Environmental Sciences in Kiev, Ukraine
Prof. Andrzej Marczyk, University of Life Sciences in Lublin, Poland
Prof. Mykola Medykowskij, Lviv Polytechnic National University, Ukraine
Dr hab. Sławomir Mikrut, University of Agriculture in Krakow, Poland
Prof. Leszek Mościcki, University of Life Sciences in Lublin, Poland
Prof. Janusz Mysłowski, Koszalin University of Technology, Poland
Prof. Jaromir Mysłowski, West Pomeranian University of Technology in Szczecin, Poland
Prof. Stanislav Nikolajenko, National University of Life and Environmental Sciences in Kiev, Ukraine
Prof. Gennadij Oborski, Odessa Polytechnic National University, Ukraine
Prof. Marian Panasiewicz, University of Life Sciences in Lublin, Poland
Prof. Sergiy Pastushenko, Petro Mohyla Black Sea State University, Mykolayiv, Ukraine
Doc. Iwan Rohowski, National University of Life and Environmental Sciences in Kiev, Ukraine
Prof. Ondrej Savec, Czech University of Life Sciences Prague, Czech Republic
Prof. Vjacheslav Shebanin, Mykolayiv National Agrarian University, Ukraine
Prof. Povilas A. Sirvydas, Agrarian University in Kaunas, Lithuania
Prof. Volodymyr Snitynskiy, Lviv National Agrarian University in Dublany, Ukraine
Prof. Henryk Sobczuk, Polish Academy of Sciences in Lublin, Poland
Prof. Stanisław Sosnowski, University of Engineering and Economics in Rzeszów, Poland
Prof. Ludvikas Spokas, Agrarian University in Kaunas, Lithuania
Dr hab. Anna Stankiewicz, University of Life Sciences in Lublin, Poland
Prof. Andrzej Stępniewski, University of Life Sciences in Lublin, Poland
Prof. Agnieszka Sujak, University of Life Sciences in Lublin, Poland
Prof. Mykhailo Sukach, Kiev National University of Construction and Architecture, Ukraine
Prof. Aleksandr Sydoruk, National Scientific Centre Institute of Mechanization and Electrification of Agriculture, Kiev, Ukraine
Prof. Wojciech Tanaś, University of Life Sciences in Lublin, Poland
Prof. Georgiy F. Tayanowski, University of Agriculture in Minsk, Bielarus
Prof. Andrey Tevyashev, Kharkov National University of Radio Electronics, Ukraine
Prof. Dainis Viesturs, Latvia University of Agriculture, Latvia
Prof. Dmytro Voytiuk, National University of Life and Environmental Science of Kiev, Ukraine
Prof. Janusz Wojdański, Warsaw University of Life, Poland
Prof. Anatolij Yakovenko, National Agrarian University in Odessa, Ukraine
Prof. Tadeusz Złoto, Częstochowa University of Technology, Poland

Polish Academy of Sciences
University of Engineering and Economics in Rzeszów
University of Life Sciences in Lublin

TEKA

COMMISSION OF MOTORIZATION AND ENERGETICS IN AGRICULTURE

AN INTERNATIONAL QUARTERLY JOURNAL
ON MOTORIZATION, VEHICLE OPERATION,
ENERGY EFFICIENCY AND MECHANICAL ENGINEERING

Vol. 17, No 3

LUBLIN–RZESZÓW 2017

Linguistic consultant: Ivan Rogovskii
Typeset: Ivan Rogovskii, Adam Niezbecki
Cover design: Hanna Krasowska-Kołodziej

All the articles are available on the webpage:
<http://www.pan-ol.lublin.pl/wydawnictwa/Teka-Motrol.html>

All the scientific articles received positive evaluations by independent reviewers

ISSN 1641-7739

© Copyright by Polish Academy of Sciences 2017
© Copyright by University of Engineering and Economics in Rzeszów 2017
© Copyright by University of Life Sciences in Lublin 2017
in co-operation with National University of Life and Environmental Science of Ukraine in Kiev 2017

Editorial Office address

Polish Academy of Sciences Branch in Lublin
Pałac Czartoryskich, Plac Litewski 2, 20-080 Lublin, Poland
e-mail: eugeniusz.krasowski@up.lublin.pl

Publishing Office address

National University of Life and Environmental Science of Ukraine
Geroyiv Oborony Str., 15, Kyiv, Ukraine, 03041
e-mail: irogovskii@gmail.com

Printing

AgroMediaGroup, Novokonstantinovska Str. 4a, 04-080 Kiev, Ukraine
phone: +38 044 246 2735

Edition 150+16 vol.