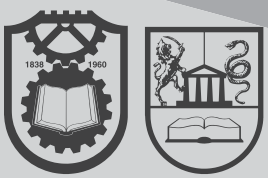

Faculty of Engineering
University of Kragujevac

IRMES
KRAGUJEVAC 2019

9th International Scientific Conference - IRMES 2019
Research and Development of Mechanical Elements and Systems

BOOK OF ABSTRACTS

05. – 07. SEPTEMBER 2019

Department for
Mechanical Constructions and Mechanization

UNIVERSITY OF KRAGUJEVAC

FACULTY OF ENGINEERING

DEPARTMENT OF MECHANICAL CONSTRUCTIONS AND MECHANIZATION

IRMES KRAGUJEVAC 2019

9TH INTERNATIONAL SCIENTIFIC CONFERENCE - IRMES 2019

RESEARCH AND DEVELOPMENT OF MECHANICAL ELEMENTS AND SYSTEMS

BOOK OF ABSTRACTS

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FOREWORD

The 9th International Scientific Conference - IRMES 2019 - Research and Development of Mechanical Elements and Systems is organized by the Department for Mechanical Constructions and Mechanization of the Faculty of Engineering at the University of Kragujevac and the Association for Design, Elements and Constructions – ADEKO.

On the previous eight IRMES Conferences (the first in 1995, the last in 2017), around a thousand papers have been presented, and there were over a thousand participants from all over the world. A long and successful tradition is a stable basis for organizing this and future IRMES Conferences.

The mission of IRMES Conferences is to serve the global community by improving, spreading and applying new engineering knowledge, with the goal of being used as a source of the newest and most relevant information for mechanical engineers and experts in related fields – on a local, regional and global level.

Specific goals, themes and fields of the IRMES 2019 Conference are defined in cooperation with the ADEKO association, and in accordance with current topics and problems. Thematic units of the conference are: Mechanical Elements and Systems (modeling and simulation, loading and stress conditions, tribology, noise and vibrations, maintenance and monitoring, safety, quality, reliability), Power and Motion Transmission Systems (development of new concepts, modeling and simulations, noise and vibrations, testing, safety, quality, reliability), Product Development Process (technology transfer, creativity and innovations, development and design, Innovative product development, smart systems, industry 4.0, knowledge economy) and New Technologies and Materials (CAD/ CAM/ CAE technology, intelligent production systems, robotics and mechatronics, rapid prototyping, new materials).

We have ensured a wide international participation, in order to have as many high quality research papers as possible and in order to increase the significance and influence of IRMES Conferences on a global level. Of a total of over 180 submitted papers, authors of over 60% of the papers are from over 30 different foreign countries.

All submitted papers have undergone the process of international review, and of the submitted papers 140 were accepted which met the high set criteria. We would like to thank the reviewers on their hard work and dedication, which have increased the quality of the IRMES 2019 Conference.

This Book of Abstracts features extended abstracts of those papers, while the complete papers will be, according to authors' preferences be published through IOP Publishing Service in "IOP Conference Series: Materials Science and Engineering", or in one of six eminent journals.

Keynote lectures for the IRMES 2019 Conference will be held by prominent professors: Marco Ceccarelli - President of IFToMM, professor of Mechanics of Machines at the University of Rome Tor Vergata, Italy, Radoslav Martinović - retired professor at the University of Montenegro, Vojislav Miltenović - Chief of the Smart office 1 of the Innovation Center of the University in Nis (ICUN), and Milosav Ognjanović - professor emeritus at the University of Belgrade, Faculty of Mechanical Engineering. He is a full member of Academy for Engineering Sciences of Serbia – AESS and works for EDePro – Engine Design and Production.

Included in the IRMES 2019 Conference is also the Honorary Committee, which is made up of the most respected and experienced professors and researchers from the field of machine elements and design, with the goal of achieving continuity and a high quality of IRMES conferences to come.

Using good experiences from the previous IRMES 2017 conference, a student section will be organized again this year. Our goal is to spark interest in, and include, a large number of students, young and creative people, to work in the field of elements and design and to suggest new ideas and specific solutions, and to, through their participation in the conference, gain new experiences.

A large support for the organization of the Conference was provided by our sponsors. Aside from material help, it is important that a large number of companies understands and supports the importance of research and connecting results to practical application. We would like to thank or sponsors on their support.

The IRMES 2019 Conference will also include a number of other manifestations in order to ensure a high quality of exchanging knowledge and experiences, as well as a pleasant stay in Kragujevac in September of 2019.

We would like to thank all authors, committee members, reviewers, sponsors and others who have helped this Conference and attributed to its quality and importance.

To all participants we wish successful involvement in the IRMES 2019 Conference and a pleasant stay in Kragujevac.

Chairman of the Organizing Committee of IRMES 2019

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The IRMES Programme Committee is a constant body which decides on important matters for future IRMES conferences, such as: the organizer, time and place of conferences, themes, etc. The committee is made up of representatives from ADEKO member institutions and organizers of previous IRMES conferences.

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The honorary committee for IRMES 2019 is made up of members which have through their work and/or authority contributed to the development of machine elements and systems, as well as creating and maintaining IRMES conferences. Honorary committee members are from the ranks of distinguished academic citizens and experts specializing in relevant fields to the conference theme. The idea behind forming the Honorary committee as a permanent IRMES conference body is to show much deserved respect and appreciation to deserving researchers, and to have them actively and formally be included in the organization and workings of IRMES conferences.

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PRODUCT DEVELOPMENT PROCESS (technology transfer, creativity and innovations, development and design, Innovative product development, smart systems, industry 4.0, knowledge economy)

RESEARCH AND DEVELOPMENT IN FIELD OF VECIHLES AND TRANSPORT

IRMES KRAGUJEVAC 2019

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APPLICATION OF THE MULTI-CRITERIA DECISION MAKING IN THE SELECTION OF MATERIALS OF COMPOSITE SHAFTS

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Key words: multi-criteria decision making, shaft, material, composite

Thanks to the outstanding combination of construction and special features such as high resistance and stiffness, increased wear resistance to fatigue, higher values of critical speeds, lower mass, long lifetime, and so on, today a growing number of shafts, especially in the automotive industry, are made of composite materials. The optimal values of these parameters can be obtained by selecting the appropriate material.
The selection of materials in the process of product design requires efficient decision-making. In this sense, the use of multi-criteria decision making (MCDM) was used as an adequate tool and support for making optimum decisions.
For the construction of shafts most commonly used general structural steels, tempering steels or cementing steels, depending on the required strength, durability, cost of production, etc. In recent years, due to its good characteristics, composite materials increasingly replace steel in shaft production. The most commonly used shafts are carbon or glass fibers in combination with epoxy or polyester resins or hybrid constructions obtained by combining these fibers. Also, the laminates obtained by the combination of a metal matrix-composite are suitable for high resistance, load and specific stiffness.
When choosing metal materials for shaft production, more criteria must be considered (required load capacity, stiffness, stability, ...). When it comes to composite materials, the problem becomes even more complicated. In order to include as many criteria as possible when deciding on material selection, the multi-criteria decision making process (MCDM) is recommended.
In this case, four different materials (steel, carbon fibers/epoxy resin, fiberglass/epoxy resin, aramid fibers/epoxy resin, respectively) for the production of shafts were analysed the influence of six characteristic values (Young's Modulus E_1 and E_2, Shear Modulus G_{12}, density ρ, max. deflection f, max bending stress σ, respectively) that have the role of criteria in the MCDM process. The values of the x_{ij} are given and in this way the Matrix of the decision is formed. Linear data normalization was made on the basis of the equation from literature

depending on whether the maximization or minimization type is the criterion. On bases on SAW (Simple Additive Weighting Method) which is one of the most well-known and widely used methods, it takes into account the weight coefficients of the criteria. It is necessary to join the weight factor assigned directly by the decision maker or obtained by applying some of the known methods for determining the weight coefficients of the criteria. For each of the considered alternatives, the aggregate characteristic, or the value of the sum of multiplication of relative weight factors and normalized performance values, is calculated according to all criteria. Quotient an alternative with the highest value is the best of the offered solutions, where W_j` represents the normalized value of the weight coefficient W_j:

$$A^* = \left\{ A_i \left| \max_i \sum_{j=1}^{n} W_j' r_{ij} \right. \right\} \qquad W_j' = \frac{W_j}{\sum_{j=1}^{n} W_j}$$

As the final result of the analysis, using the expression above, the values of the aggregate characteristics for the three variants of the weight coefficients of the performances - criteria were obtained. In Table 1 and Figure 1 it is noted that for the values of the first variant of weight coefficients, the carbon fiber composite and the epoxy resin are best chosen.

Table 1. Collective characteristics for different values of weight coefficients

	S	C	F	A
A_{i1}	0.493151	0.722192	0.475890	0.46
A_{i2}	0.666667	0.511668	0.315006	0.24
A_{i3}	0.64	0.637972	0.420144	0.333189

For the second group of weight coefficients, steel was shown as the most favorable material, while in the third case, these two materials were practically identical. The remaining two materials received less or lesser grades in all three variants.

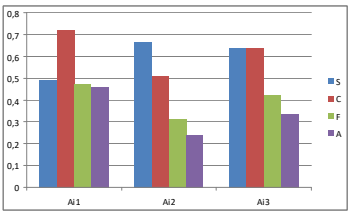

Figure 1. Diagram showing aggregate characteristics for three variants of weight coefficients of preformance - criteria

Based on the analysis presented for the four materials considered and the evaluations of the six selected characteristics, it can be concluded that the steel and carbon fiber composites with epoxy resins are the best estimate of the potential solution.

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