

Faculty of Engineering  
University of Kragujevac



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

# BOOK OF ABSTRACTS

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Department for  
Mechanical Constructions and Mechanization

UNIVERSITY OF  
Kragujevac



FACULTY OF ENGINEERING



DEPARTMENT OF  
MECHANICAL  
CONSTRUCTIONS AND  
MECHANIZATION



9TH INTERNATIONAL SCIENTIFIC CONFERENCE - IRMES 2019

RESEARCH AND DEVELOPMENT OF MECHANICAL ELEMENTS AND  
SYSTEMS

# BOOK OF ABSTRACTS

Editor: Nenad Marjanović

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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 our 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.

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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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## **LIFE CYCLE ASSESSMENT OF THE CAR TIRE WITH ECO-INDICATOR 99 METHODOLOGY**

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The concept of the product life cycle (PLC) was introduced in the fifties of the last century in scientific researches. The existence of the biological life cycle is implemented on the products. Namely, the PLC represents one cycle or the process from birth to death. The product life cycle is an important phenomenon because it describes all the phases through which it passes. In each phase, the product is interdependent with the society, economy and environment, and it encounters a number of limitations.

From the point of view of the environment, the current economic model is based on the transformation of resources into ready to use products and their disposal. This economic model, ie the product life cycle is not eco-friendly.

The previously mentioned fact can be proved by certain analyzes, such as life-cycle assessment (LCA). The LCA is a technique to evaluate environmental impacts related to all the phases of a product's life cycle. This assessment takes into account numerous activities: from extraction the raw material and its production, manufacturing of a product, product use, end-of-life disposal and all of the transportation activities that happen between all mentioned phases.

Today the automotive industry is a driving force for the development of national economics so the number of a vehicle increases expeditiously. As an integral part of the vehicle, tires are generated annually in large amounts all over the world. The growth of the car tires production affects the environment and also the growth of non-degradable waste which has a large energetic potential but which currently is not fully used.

The aim of this study is to evaluate the environmental impact of car tire during its whole life cycle. That analysis can be achieved throughout its service life, from the acquisition of the raw materials through to the recycling of the worn tire, because the tire constantly interacts with the environment. Approaches to effectively reducing the negative environmental impact can be demonstrated only on the basis of detailed knowledge of this interaction.

This is why a life cycle assessment quantifies the material and energy flows in the different stages of a tire's life cycle (life cycle inventory analysis) and describes the interaction with

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the environment (impact assessment and interpretation). In this study, the environmental impact is evaluated by using methodology Eco Indicator (EI) 99, which is one of the most widely used impact assessment methods in LCA. The EI was developed to connect the life cycle inventory results with procedures for determining weight coefficients, with the aim of presenting LCA results at all levels.

In this paper, EI 99 methodology is done for a single tire with an average service life of 50,000.00 km over a four-year period. The car tire is assumed to weight approximately 6.5 kg.

The main phases of the life-cycle tires that are analyzed in this research:

*Phase 1.* Production of raw material: the feedstock for tires is manufactured from mineral, fossil, and reused resources.

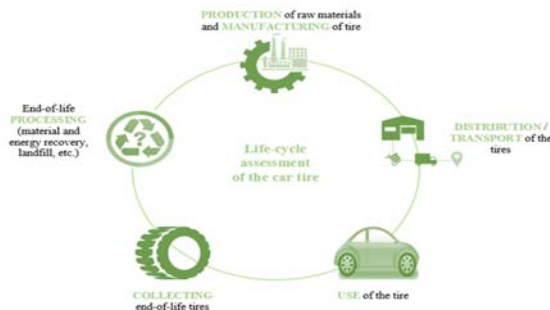
*Phase 2.* Production/manufacture of the tire: includes the production of the structural parts of the tire and its packaging.

*Phase 3.* Distribution/transport of the tire: involves all activities that are undertaken in the transport, storage and distribution sector.

*Phase 4.* Use of the tire: includes using process scenarios and processes such as maintenance, repair, cleaning of the tires, etc.

*Phase 5.* End-of-life tires: includes activities that are associated with collecting the worn tire and its disposal.

*Phase 6.* End-of-life processing: involves all activities that are established on waste management and treatment.



**Figure 1.** Life-cycle of the car tire

In this research, the above-mentioned phases are analyzed expect phase 5. and 6. Due to insufficient data, the EI was not calculated for the disposal phase but it is known that the car tire has a big negative impact on the environment in this phase.

According to the calculation which is done in software Microsoft Excel, it is concluded that the biggest environmental impact and expenses have the “production” phase.

Based on the obtained results, can be summarized that the way of production of the car tire is necessary to be changed and improved. One of the solutions for that is implementing the circular model of production, ie using the worn tires in the production process.

Life-cycle assessment is very important because based on values which are obtained from analysis, it is possible to identify activities in life-cycle phases that can be improved and on that way it is possible to reduce the negative impact of the tire on the environment.