HABILITATION THESIS

CONTRIBUTIONS TO THE STRUCTURAL, KINEMATIC, AND DYNAMIC ANALYSIS OF MECHANICAL SYSTEMS

- Abstract -

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Abstract

The habilitation thesis entitled "Contributions to the Structural, Kinematic, and Dynamic Analysis of Mechanical Systems" presents the most important scientific and professional achievements of the author, assoc. prof. dr. eng. Călin-Octavian Micloşină, subsequent to obtaining the doctoral degree.

The habilitation thesis is structured in two main parts, the first part containing the scientific and professional achievements, and the second, the evolution and career development plan, followed by a part of conclusions, bibliography, and the list of publications relevant to the scientific research reported in the thesis.

Part I comprises four chapters, containing excerpts from the author's postdoctoral research project completion report, and from author's scientific papers and books published after obtaining the doctoral degree, as well as a synthesis of the didactic, scientific, and academic achievements. For 3D modeling, and for structural, kinematic, and dynamic analyses, SolidWorks software environment was used.

In the first chapter, the runner blade operating mechanism of a Kaplan turbine is analyzed from a structural, kinematic and dynamic point of view. Based on the kinematical scheme, the number of degrees of mobility of the mechanism is calculated and the 3D model is accomplished.

The simulation of the mechanism operation is carried out, by using a law of motion defined on the basis of the measurements made in the hydropower plant, determining the forces acting on the links of the mechanism and studying the influence of friction on the action force.

Next, the structural analysis of some components is carried out, by using the finite element method, as follows: analysis of the outer bearing bush, of the fork head bolt, and of the pin lever in static regime, wear analysis of fork head and bolt as a result of contact in operation, and analysis of the outer bearing bush in dynamic regime (with variable loads imported from a motion study into a finite element analysis file).

The second chapter presents the structural, kinematic, and dynamic analysis of some types of guiding devices mechanisms of robots with parallel and hybrid topology, respectively a parallel topology mechanism with three degrees of mobility, one with six degrees of mobility, and one hybrid topology mechanism with 12 degrees of mobility.

Starting from the kinematical scheme, the 3D model of the guiding device mechanism with the structure $FP_3 + 3 \cdot \underline{R}RS + MP_3$, the simulation of operation, kinematic and dynamic analysis, as well as structural analysis of the mechanism lower level links in dynamic regime are accomplished.

Based on the kinematical scheme of another type of a parallel topology guiding device mechanism, having the structure $FP_3+6 \cdot S\underline{T}S+MP_3$, the 3D model is obtained and the workspace for different link lengths is determined. On the mobile platform of the 3D model, the 3D models of a human operator and of a chair are attached, obtaining the assembly of a flight or driving simulator. For this 3D model of the *parallel topology robot - chair - human operator* assembly, the operation simulation and the kinematic and dynamic analyses are accomplished.

Next, starting from the kinematical scheme of a hybrid topology guiding device mechanism having the structure $FP_3+6 \cdot S\underline{T}S+MP_6^{I}+6 \cdot S\underline{T}S+MP_3^{II}$, the 3D model, the operation simulation, and the kinematic analysis are performed.

Chapter three presents a manner of determining the frictional forces that occur during the operation of some types of kinematical joints of mechanical systems, based on numerical simulations.

The cases of frictional forces that occur between plane surfaces, in revolute kinematical joints, and in spherical kinematical joints are studied. The results of the simulations are then compared with the results obtained from analytical calculations.

Chapter four presents the synthesis of the author's didactic, scientific and academic achievements.

The main didactic achievements are presented as follows:

- Author:
  - 2 university courses published: "Bazele proiectării asistate de calculator" - Basics of Computer-Aided Design (2018), "Acţionări hidraulice şi pneumatice" - Hydraulic and Pneumatic Drives (2022);
  - 1 laboratory handbook: "Roboţi industriali " - Industrial Robots (2013);
- Construction / modernization of 7 laboratory experimental stands, of which 6 after the doctoral degree was awarded, used for the disciplines Hydraulic and Pneumatic Drives, Robotics, Industrial Robotics, Industrial Robots;
- Coordination of 71 successfully defended graduation works, of which 39 diploma projects and 32 master’s dissertations.

The scientific and professional activity is reflected in the following main results and positions/roles:

- Author: 2 scientific books / specialized monographs: "Roboţi industriali şi linii flexibile" - Industrial Robots and Flexible Lines" (2009), "Roboţi cu topologie paralelă" - Robots with parallel topology (2024);
- Main author / co-author of 128 scientific papers published in specialized journals and in national / international symposia or conferences proceedings;
- Project director in 1 national grant, partner activities implementation expert in 1 national grant and theme responsible within 2 research contracts with national economic environment beneficiary;
- Member of the implementation/research team in 12 grants and in the research team in 9 research contracts with beneficiaries from the national economic environment;

The most important scientific papers are indexed in the following databases and author profiles:

WOS - Author identifier: B-9867-2013 SCOPUS - Author ID: 36666987600
ORCID - 0000-0002-7520-4564 Google Scholar - link

The academic activity is supported by the following main positions/roles:

- Member of the editorial boards of the scientific journals "Robotics & Management" (editor-in-chief since 2012, general secretary between 1999-2012) and "International Journal of Computer and Electrical Engineering" (editor in 2010);
- Member of the scientific committees of the following conferences: MTM & ROBOTICS 2020, Timisoara; SYROM & ROBOTICS 2022, Iasi; MTM & ROBOTICS 2024, Iasi; TEHNOMUS, Suceava, 2017, 2019, 2021, 2023, 2025; CIES, Reşiţa, 2018; DEMI 2021, Banja Luka; ICEES, Reşiţa, 2022;
- Member of the competition committees for associate professor positions at the Politehnica University Timisoara (2) and at the "Aurel Vlaicu" University of Arad (2)
- Member of doctoral students supervisory committees in the field of Mechanical Engineering at Babeş-Bolyai University of Cluj-Napoca, Technical University of Cluj-Napoca and Politehnica University Timisoara;
- Member of the ARACIS National Register of Evaluators (RNE-ARACIS), with expertise in Mechanical Engineering, since 2024.

The topics of interest addressed in the teaching and research activity - computer-aided design and analysis, hydraulic and pneumatic drives, industrial robots, and the structural, kinematic, and dynamic analysis of mechanical systems - fall within the field of Mechanical Engineering.

Part II includes the author's evolution and career development plan.

The educational and professional career path of Dr. Eng. Călin-Octavian Micloșină is outlined, beginning with the academic position of university tutor and continuing through the successive ranks of university assistant, university lecturer, and associate professor.

The career development plan presents the objectives pursued in the professional career - didactic, scientific and academic, as well as the future research directions considered.

The development of the scientific career pursues the following main objectives:

- continuing the research directions pursued so far in the field of *Mechanical Engineering*:
  - structural, kinematic, and dynamic analysis of runner blade operating mechanism of Kaplan turbines;
  - structural, kinematic, and dynamic analysis of the mechanisms within the guiding devices of robots with different types of topologies (serial, parallel, hybrid);
  - study of frictional forces and reactions occurring during the operation of mechanical systems;
  - lifetime estimations of mechanical system components;
- pursuing new research directions, such as:
  - the study of mechanical system structures with components obtained by 3D printing, having different infill types, aiming for low mass and high mechanical resistance;
  - predictive maintenance of mechatronic systems, particularly industrial robots.

Part III contains the final conclusions regarding the achievements presented in the thesis, with the indication of the future research directions in the topics addressed.

The bibliography includes the references used for writing the thesis, mostly works by the author.

The professional achievements, as well as the research directions and objectives proposed in the career development plan fall within the field of *Mechanical Engineering*.