COURSE DESCRIPTION CARD - SYLLABUS

Course name

MAGNETIC FIELD CONTROLLED FLUID TRANSDUCERS, ANALYSIS AND APPLICATIONS

Course

Proposed by Discipline
Automation, electronics, electrical engineering and space technologies

Type of studies
Doctoral School

Form of study
full-time

Year/Semester
II/4

Course offered in
English

Requirements
elective

Number of hours

Lecture	Tutorials	Projects/seminars
8		

Number of credit points

2

Lecturers

Responsible for the course/lecturer:

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Responsible for the course/lecturer:

Prerequisites

Knowledge: the student has knowledge about methods describing systems with electromagnetic field and knowledge about numerical methods for solving partial differential equations in electromagnetism.

Skills: the student is able to describe electromagnetic field and to form numerical, finite difference schemes for electromagnetic field equations.

Social competencies: the student is aware that in conducting research he/she must abide by the code of ethics for electric al engineering and information engineering.

Course objective

Acquiring knowledge about: fluids of rheological properties controlled by means of magnetic field; principle of operation and applications of transducers with magnetic fluids; analysis of coupled phenomena problems in electromechanical transducers with magnetorheological fluids.

Course-related learning outcomes

Knowledge

A PhD student who graduated from doctoral school knows and understands:

1) the views and opinions presented in the literature on electrical engineering and on numerical method and models used in the analysis and designing the devices with magnetic fluids, [P8S_WG/SzD_W01]

2) advanced knowledge about development trends in the area of modern electromechanical transducers and can elaborate the numerical methods of coupled field analysis in those devices. [P8S_WG/SzD_W03]

Skills

A PhD student who graduated from doctoral school can:

1) able to properly match numerical methods for the problem of coupled field analysis in the systems that are studied in the PhD thesis, [P8S_UW/SzD_U02]

2) make use, in advanced way, of commercial as well as in house developed tools for solving advanced coupled phenomena problems and to critically evaluate the results of research in the field of magnetic fluids applications, [P8S_UK/SzD_U04]

3) able to present a paper at technical/scientific conference in his/her native language and in at least one foreign language, in the area of computer methods of analysis of transducers with magnetic fluids. [P8S_UK/SzD_U08]

Social competences

A PhD student who graduated from doctoral school is ready to:

1) able to popularize, in accessible way, scientific and technical achievements in electrical engineering and information engineering. [P8S_KK/SzD_K03]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

PQF code	Methods for verification of learning outcomes	Assessment criteria
W01, W03,	Written/oral exam graded on the basis of a points system (0-100 points)	3: 50,1 -70,0 points 4: 70,1 -90,0 points 5: 90,1 -100 points
U02, U04, U08	Continuous assessment during the lecture based on discussion and solving the stated problems	evaluation of activities

K03	Continuous assessment during the lecture based on discussion and solving the stated problems	evaluation of activities

Programme content

Magnetic fluids types and applications (ferro-fluids, magnetorheological fluids and suspensions). Vibration dampers, brakes and clutches with MRF. Methods of analysis of coupled field problems in magnetic fluids transducers.

Course topics

Newtonian and non-Newtonian fluids, rheological properties, Bingham model, magnetic field phenomena and it source in context of technical applications in transducers with magnetic fluids. Ferro-fluids vs. magnetorheological fluids properties and applications. Lumped parameter vs. field models of magnetic fluid transducers. Coupled, transient field model of systems with magnetorheological fluids employed for torque or force transmission.

Teaching methods

Lecture: multimedia presentation including illustrations and examples

Bibliography

Basic

[1] Z. Piech i W. Szelag, „Elevator brake with magneto-rheological fluid", US8631917B2, 21 styczeń 2014 Dostęp: 3 październik 2024. [Online]. Dostępne na: https://patents.google.com/patent/US8631917B2/ko

[2] W. Szelag, C. Jedryczka, A. Myszkowski, i R. M. Wojciechowski, „Coupled Field Analysis of Phenomena in Hybrid Excited Magnetorheological Fluid Brake", *Sensors*, t. 23, nr 1, Art. nr 1, sty. 2023, doi: 10.3390/s23010358.

[3] J. d. Carlson, D. m. Catanzarite, i K. a. St. Clair, „Commercial magneto-rheological fluid devices", Int. J. Mod. Phys. B, t. 10, nr 23n24, s. 2857–2865, paź. 1996, doi: 10.1142/S0217979296001306.

[4] J.-Y. Park, J.-S. Oh, i Y.-C. Kim, „Design and Control of Multi-Plate MR Clutch Featuring Friction and Magnetic Field Control Modes", Sensors, t. 22, nr 5, Art. nr 5, sty. 2022, doi: 10.3390/s22051757.

[5] W. East, J. Turcotte, J.-S. Plante, i G. Julio, „Experimental assessment of a linear actuator driven by magnetorheological clutches for automotive active suspensions", Journal of Intelligent Material Systems and Structures, t. 32, nr 9, s. 955–970, maj 2021, doi: 10.1177/1045389X21991237.

[6] J. D. Carlson i M. R. Jolly, „MR fluid, foam and elastomer devices", Mechatronics, t. 10, nr 4, s. 555–569, cze. 2000, doi: 10.1016/S0957-4158(99)00064-1.

[7] Y. Sato i S. Umebara, „Power-Saving Magnetization for Magnetorheological Fluid Control Using a Combination of Permanent Magnet and Electromagnet", IEEE Transactions on Magnetics, t. 48, nr 11, s. 3521–3524, lis. 2012, doi: 10.1109/TMAG.2012.2207093.

[8] M. R. Jolly, J. W. Bender, i J. D. Carlson, „Properties and Applications of Commercial Magnetorheological Fluids", Journal of Intelligent Material Systems and Structures, t. 10, nr 1, s. 5–13, sty. 1999, doi: 10.1177/1045389X9901000102.

[9] G. Hu, L. Wu, i L. Li, „Torque Characteristics Analysis of a Magnetorheological Brake with Double Brake Disc", Actuators, t. 10, nr 2, Art. nr 2, luty 2021, doi: 10.3390/act10020023.

Additional

[1] Rosensweig, R.E. Ferrohydrodynamics; Courier Corporation: Washington, DC, USA, 2013; ISBN 978-0-486-78300-0.

[2] Zienkiewicz, O.C. The Finite Element Method for Fluid Dynamics, 6th ed.; Elsevier: Amsterdam, The Netherlands, 2005.

[3] Transport Phenomena, R.B.; Bird, W.E.; Stewart, E.N. Lightfoot, John Wiley and Sons, Inc., New York (1960). 780 Pages. AIChE J. 1961, 7, 5J–6J.

[4] Nouar, C.; Frigaard, I.A. Nonlinear Stability of Poiseuille Flow of a Bingham Fluid: Theoretical Results and Comparison with

[5] Phenomenological Criteria. J. Non-Newton. Fluid Mech. 2001, 100, 127–149.

Breakdown of average student's workload

	Hours	ECTS
Total workload	50	2,0
Classes requiring direct contact with the teacher	8	0,0
Doctoral student's own work (literature studies, preparation for tutorials, project preparation) [1]	42	2,0

[1] delete or add other activities as appropriate