|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **UČNI NAČRT PREDMETA / COURSE SYLLABUS** | | | | | | | | | | | | | | | | | |
| **Predmet:** | | | Elektromotorski pogoni | | | | | | | | | | | | | | |
| **Course title:** | | | Electrical Drives | | | | | | | | | | | | | | |
|  | | | | |  | | | | | | | |  | |  | | |
| **Študijski program in stopnja**  **Study programme and level** | | | | | **Študijska smer**  **Study field** | | | | | | | | **Letnik**  **Academic year** | | **Semester**  **Semester** | | |
| Podiplomski magistrski študijski program druge stopnje Elektrotehnika | | | | | Mehatronika, Elektroenergetika | | | | | | | | 1 | | 2 | | |
| 2nd cycle masters study programme in Electrical Engineering | | | | | Mechatronics, Electrical Power Engineering | | | | | | | | 1 | | 2 | | |
|  | | | | | | | | | | | | | | | | | |
| **Vrsta predmeta / Course type** | | | | | | | | | | | | Obvezni-strokovni / Compulsory professional | | | | | |
|  | | | | | | | | | | | |  | | | | | |
| **Univerzitetna koda predmeta / University course code:** | | | | | | | | | | | | 64221 | | | | | |
|  | | | | | | | | | | | | | | | | | |
| **Predavanja**  **Lectures** | **Seminar**  **Seminar** | | | **Vaje**  **Tutorial** | | | **Klinične vaje**  **work** | | | | **Druge oblike študija** | | | **Samost. delo**  **Individ. work** | |  | **ECTS** |
| **45** |  | | | **30** | | |  | | | |  | | | **75** | |  | **6** |
|  | | | | | | | | | | | | | | | | | |
| **Nosilec predmeta / Lecturer:** | | | | | Rastko Fišer | | | | | | | | | | | | |
|  | | | | | | | | | | | | | | | | | |
| **Jeziki /**  **Languages:** | | **Predavanja / Lectures:** | | | | **slovenski / Slovenian** | | | | | | | | | | | |
| **Vaje / Tutorial:** | | | | **slovenski / Slovenian** | | | | | | | | | | | |
| **Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:** | | | | | | | | |  | **Prerequisits:** | | | | | | | |
| Vpis v letnik. | | | | | | | | |  | Enrolment in the year of the course. | | | | | | | |
| **Vsebina:** | | | | | | | |  | | **Content (Syllabus outline):** | | | | | | | |
| Osnovne komponente elektromotorskih pogonov. Kratek zgodovinski pregled razvoja področja, trenutno stanje in trendi razvoja. Stacionarna in dinamična stanja elektromotorskih pogonov. Obratovalne karakteristike električnih motorjev in delovnih strojev. Vztrajnostni momenti v pogonskem sistemu, osnovna pogonska enačba, dinamični vrtilni moment. Mehanski prehodni pojavi, statična stabilnost pogonskega sistema. Izvedbe, priključevanje, označevanje in hlajenje električnih motorjev.  Enosmerni, asinhronski in sinhronski motorji v pogonski tehniki - značilnosti izvedb, načini napajanja, stacionarne in dinamične pogonske karakteristike, parametri s katerimi vplivamo na spremembe obratovalnih karakteristik. Nastavljanje vrtilne hitrosti. Problematika in izvedbe zagona in zaviranja.    Izbira pogonskih motorjev, segrevanje in ohlajanje. Normirane vrste obratovanja električnih strojev. Metode za določanje moči pogonskih motorjev. Kompenzacija jalove energije izmeničnih električnih motorjev.  Moderne izvedbe energijsko varčnih električnih motorjev in problematika njihove vgradnje v pogonske sisteme - tehnični in ekonomski vidik. Principi načrtovanja elektromotorskih pogonov z visokim izkoristkom in zanesljivostjo obratovanja. Standardna zaščita elektromotorskih pogonov. | | | | | | | |  | | Components of electrical drives. Past, present and future trends in drive systems. Stationary and transient states of electrical drives. Characteristics of electric motors, typical load torques. Moments of inertia of complex drive systems, accelerating torque. Electrical and mechanical transients, stability problem of drive system. Types of electric motors, their supplying, connection, selecting and cooling.  Electric motors in drive systems:  DC (commutator and brushless) machines. Induction (slip ring, squirrel cage, solid rotor) machines. Synchronous (field winding, permanent magnet, reluctance) machines. Principles of operation, speed-torque characteristics and possibilities of their modifications. Starting and breaking dynamics, classical and modern principles of speed and motion control. 4Q operation.  Methods for selecting the drive types. Sizing and dimensioning electric motors. Thermal conditions, cooling principles, standard and user defined duty types. Reactive power compensation.  Energy efficient motors and drive systems – technical and economical aspects, principles of energy savings. Electrical drives with increased reliability and fault tolerant operation. Standard protection of drive systems. | | | | | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Temeljni literatura in viri / Readings:** | | | | | |
| 1. R. Fišer, Interno študijsko gradivo v pisni in elektronski obliki (Internal study material).  2. J. Weidauer, R. Messer, Electrical Drives – Principles, Planning, Applications, Solutions,  Publicis Publishing, Siemens, 2014  3. A. Hughes, B. Drury, Electric Motors and Drives – Fundamentals, Types, Applications, 4th Ed.,  Newness, Elsevier, 2013.  4. B. Drury, The Control Techniques Drives and Controls Handbook, 2nd Ed., IET, 2009.  5. A. Emadi, Energy-Efficient Electric Motors, Marcel Dekker, 2005.  6. T. Wildi, Electrical Machines, Drives, and Power Systems, Pearson, Prentice Hall, 2006. | | | | | |
| **Cilji in kompetence:** | |  | | **Objectives and competences:** | |
| Osvojiti znanja in postopke za načrtovanje, dimenzioniranje in prilagajanje električnih pogonskih motorjev delovnim strojem v industrijskih in transportnih sistemih. | |  | | Student will be provided with the knowledge and procedures for design and maintenance of grid supplied and controlled electrical drives in industrial and traction systems. | |
| **Predvideni študijski rezultati:** | | |  | **Intended learning outcomes:** | |
| Študent bo spoznal enostavne in zahtevnejše električne pogonske sisteme, njihove gradnike in osvojil njihov princip delovanja. Seznanil se bo s sklopom električni motor-mehansko breme, razumel bo odvisnost obratovalnih karakteristik pogonskih motorjev od vhodnih prarametrov, s katerimi krmilimo in reguliramo delovanje sistema. | | |  | Student will get knowledge about basic and advanced electrical drives, their elements and principles of operation. He will be acquainted with the relations between electric motor and driven machine. He will understand dependence of current and torque characteristics on several input controllable parameters. | |
|  | | |  |  | |
| **Metode poučevanja in učenja:** | | |  | **Learning and teaching methods:** | |
| Predavanja, laboratorijske vaje s predhodnimi pripravami. | | |  | Lectures, practical laboratory hands-on excercises with preliminary instructions. | |
| **Načini ocenjevanja:** | Delež (v %) /  Weight (in %) | | | | **Assessment:** |
| Način: laboratorijske vaje, pisni izpit, ustni izpit.  Ocene od 1 do vključno 5 so negativne, ocene od vključno 6 do 10 so pozitivne.  Pozitivna ocena laboratorijskih vaj je pogoj za pristop k izpitu.  Prispevki k oceni:   * laboratorijske vaje * pisni izpit * ustni izpit | 25%  50%  25% | | | | Type: laboratory exercises, written exam, oral exam.  Negative grades: from 1 to 5, positive grades: from 6 to 10.  Positive evaluation of laboratory exercises is a prerequisite for the exam.  Contributions to the final grade:   * laboratory exercises * written exam * oral examination |
| **Reference nosilca / Lecturer's references:** | | | | | |
| 1. GAŠPARIN, Lovrenc, **FIŠER, Rastko**. Cogging torque sensitivity to permanent magnet tolerance combinations. *Archives of electical engineering*, 2013, vol. 62, no. 3, str. 449-461. 2. **FIŠER, Rastko**, LAVRIČ, Henrik, BUGEZA, Miroslav, MAKUC, Danilo. Computations of magnetic field anomalies in synchronous generator due to rotor excitaton coil faults. *IEEE transactions on magnetics*, May 2013, vol. 49, no. 5, str. 2303-2306. 3. DROBNIČ, Klemen, NEMEC, Mitja, **FIŠER, Rastko**, AMBROŽIČ, Vanja. Simplified detection of broken rotor bars in induction motors controlled in field reference frame. *Control engineering practice*, [Print ed.], Aug. 2012, vol. 20, no. 8, str. 761-769. 4. GAŠPARIN, Lovrenc, ČERNIGOJ, Andrej, **FIŠER, Rastko**. Additional cogging torque components due to asymmetry in stator back iron of PM synchronous motors. *Compel*, 2011, vol. 30, no. 3, str. 894-905. 5. NEMEC, Mitja, DROBNIČ, Klemen, NEDELJKOVIĆ, David, **FIŠER, Rastko**, AMBROŽIČ, Vanja. Detection of broken bars in induction motor through the analysis of supply voltage modulation. *IEEE transactions on industrial electronics*, [Print ed.], Aug. 2010, vol. 57, no. 8, str. 2879-2888. | | | | | |