AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Module name: Materials in electrical applications

Academic year: 2019/2020 Code: NIMN-1-712-s ECTS credits: 4

Faculty of: Non-Ferrous Metals

Field of study: Inżynieria Metali Nieżelaznych Specialty: —

Study level: First-cycle studies Form and type of study: Full-time studies

Lecture language: English Profile of education: Academic (A) Semester: 7

Course homepage: —

Responsible teacher: dr hab. inż, prof. AGH Smyrak Beata (smyrak@agh.edu.pl)

Module summary

The student has knowledge of materials (metals, plastics, ceramics, composites) used for electrical purposes and he knows the trends in the development of materials used in electrical applications i.e. modern nad superconducting materials (graphene, carbon nanotubes, conducting polymers).

Description of learning outcomes for module

MLO code	Student after module completion has the knowledge/ knows how to/is able to	Connections with FLO	Method of learning outcomes verification (form of completion)
Social competence: is able to			
M_K001	The student is able to organize a work environment allowing for the acquisition of knowledge about the properties of materials	IMN1A_K01	Participation in a discussion, Case study
Skills: he can			
M_U001	The student is able to design the properties of materials used in conductive elements, bearing and insulation elements	IMN1A_U02, IMN1A_U03	Project
M_U002	The student is able to independently plan the program and methodology of a study allowing for the assessment of the operational properties of materials used in the field of electrical engineering	IMN1A_U06, IMN1A_U08	Execution of a project, Participation in a discussion, Project, Activity during classes
Knowledge: he knows and understands			

M_W001	The student has an elementary knowledge of the materials used in the field of electrical power engineering	IMN1A_W01, IMN1A_W02	Test
M_W002	The student knows of the principles of selection of materials in applications from the field of electrical power engineering and the trends in the development of materials used in electrical applications	IMN1A_W03, IMN1A_W01, IMN1A_W02	Test

Number of hours for each form of classes

	Form of classes										
Suma	Lectures	Auditorium classes	Laboratory classes	Project classes	Conversation seminar	Seminar classes	Practical classes	Fieldwork classes	Workshops	Prace kontrolne i przejściowe	Lektorat
45	15	0	0	30	0	0	0	0	0	0	0

FLO matrix in relation to forms of classes

MLO code	Student after module completion has the knowledge/ knows how to/is able to	Form of classes										
		Lectures	Auditorium classes	Laboratory classes	Project classes	Conversation seminar	Seminar classes	Practical classes	Fieldwork classes	Workshops	Prace kontrolne i przejściowe	Lektorat
Social competence: is able to												
M_K001	The student is able to organize a work environment allowing for the acquisition of knowledge about the properties of materials	+	-	-	+	-	-	-	-	-	-	-
Skills: he can												
M_U001	The student is able to design the properties of materials used in conductive elements, bearing and insulation elements	-	-	-	+	-	-	-	-	-	-	-
M_U002	The student is able to independently plan the program and methodology of a study allowing for the assessment of the operational properties of materials used in the field of electrical engineering	-	-	-	+	-	-	-	-	-	-	-
Knowledge: he knows and understands												
M_W001	The student has an elementary knowledge of the materials used in the field of electrical power engineering	+	-	-	-	-	-	-	-	-	-	-

M_W002	The student knows of the principles of selection of materials in applications from the field of electrical power engineering and the trends in the development of materials used in electrical applications	+	-	-	-	-	-	-	-	-	-	-

Student workload (ECTS credits balance)

Student activity form	Student workload
Udział w zajęciach dydaktycznych/praktyka	45 h
Preparation for classes	10 h
przygotowanie projektu, prezentacji, pracy pisemnej, sprawozdania	10 h
Realization of independently performed tasks	30 h
Examination or Final test	2 h
Contact hours	5 h
Summary student workload	102 h
Module ECTS credits	4 ECTS

Additional information

Module content

Lectures

1. Introduction:
Characteristics of electrical power systems, structure of the system components, discussion of the working conditions of the components of electrical power systems, detailed characteristics of the system components (cables, wires, connection elements, insulators, covers, etc.).
2. Characteristics of the property requirements for materials used in electrical power engineering:
Classification of conductive, bearing and insulation materials. Identification of the properties of materials used in electrical power engineering. Analysis of the requirements of physical, electrical, mechanical and operational properties (heat resistance, rheological resistance, fatigue resistance) of materials. Domestic and international standardization. Methods of testing material properties.
3. Materials used for conductive elements in electrical power engineering:
Characteristics of the properties of copper and copper alloys used for cables and wires and for the elements of accessories of overhead lines. Characteristics of the properties of aluminum and aluminum alloys used in high, medium and low voltage cables and wires and in the accessories of overhead power lines. Non-conventional conductive materials. Trends in the development of conductive materials. Standardization.
4. Materials used for the bearing elements in electrical power engineering:
Characteristics of the materials used for the bearing cores of bimaterial electrical wires. Discussion of the properties of materials used for the bearing elements in

electrical power systems from the point of view of the requirements of national and international standards.
5. Materials used for the insulation elements in electrical power engineering systems: Characteristics of the insulating materials used for the insulation coating in power cables and wires (polyvinyl chloride, polyethylene, cross-linked polyethylene, cable paper, rubber insulation, saturants, oils, thermoplastics). Characteristics of the properties of materials used for insulators in electrical power systems (electrotechnical porcelain, lime-silicate glass, borosilicate glass, quartz glass). Characteristics of the property requirements of materials used in cable accessories (cable joints, connector heads). Materials used for the insulation of power transformers (oils, mineral oils, synthetic oils). Analysis of the property requirements of insulating materials in accordance with national and international standardization.
6. Economic analysis of the materials used in electrical power engineering in relation to the world economy.
7. Factor analysis of the costs of materials used for the components of electrical power systems. Historical analysis of the prices of materials. Discussion of the market of manufacturers of conductive, bearing and insulating materials used in electrical power engineering.

Project classes

The main purpose of design exercises is to study the design of materials used in electrical applications i.e. OHL conductors, flexible cables, elements of railway tractions etc.

Teaching methods and techniques:

Lectures: Treści prezentowane na wykładzie są przekazywane w formie prezentacji multimedialnej w połączeniu z klasycznym wykładem tablicowym wzbogaconymi o pokazy odnoszące się do prezentowanych zagadnień.
Project classes: Studenci wykonują zadany projekt samodzielnie, bez większej ingerencji prowadzącego. Ma to wykształcić poczucie odpowiedzialności za pracę w grupie oraz odpowiedzialności za podejmowane decyzje.

Warunki i sposób zaliczenia poszczególnych form zajęć, w tym zasady zaliczeń poprawkowych, a także warunki dopuszczenia do egzaminu:

Lecture: the test
Project: obligatory presence, presentation

Zasady udziału w poszczególnych zajęciach, ze wskazaniem, czy obecność studenta na zajęciach jest obowiązkowa:

Lectures:
– Attendance is mandatory: No
– Participation rules in classes: Studenci uczestniczą w zajęciach poznając kolejne treści nauczania zgodnie z syllabusem przedmiotu. Studenci winni na bieżąco zadawać pytania i wyjaśniać wątpliwości. Rejestracja audiowizualna wykładu wymaga zgody prowadzącego.
Project classes:
– Attendance is mandatory: Yes
– Participation rules in classes: Studenci wykonują prace praktyczne mające na celu uzyskanie kompetencji zakładanych przez syllabus. Ocenie podlega sposób wykonania projektu oraz efekt końcowy.

Method of calculating the final grade

Final grade: 50% of the lecture test result + 50% of the result of the execution of the project

Sposób i tryb wyrównywania zaległości powstałych wskutek nieobecności studenta na zajęciach:

individual arrangements

Prerequisites and additional requirements

Basic knowledge of:
a) the processing of non-ferrous metals,
b) technologies of manufacturing products from non-ferrous metals,
c) production techniques,
d) integrated production systems

Recommended literature and teaching resources

1. T. Knych: Energetyczne przewody napowietrzne. Teoria, materiały, aplikacje, Wyd. AGH, 2010
2. K. Żmuda: Elektroenergetyczne układy przesyłowe i rozdzielcze. Wybrane zagadnienia z przykładami, Wyd. Politechniki Śląskiej, 2011
3. A. Mamala: Model wielodrutowych monomateriałowych elektroenergetycznych przewodów napowietrznych, Wyd. Nauk. AKAPIT, 2012
4. B.Florkowska, J.Furgał, M.Szczerbiński, R.Włodek, Materiały elektrotechniczne.Podstawy teoretyczne i zastosowania, Wydawnictwo AGH, 2011
5. T.Skarżyński, H.Kończykowski, Z.Koteras, Przewody elektryczne, WNT 1973
6.H.Mościcka-Madej, Inżynieria wysokich napięć w elektroenergetyce, Wydawnictwo Politechniki Poznańskiej, 1996
7.S.Stryszowski, Materiałoznawstwo elektryczne, Wydawnictwo Politechniki Świętokrzyskiej, 1999.
8. Z.Celiński, Materiałoznawstwo elektrotechniczne, Oficyna wydawnicza Politechniki Warszawskiej, 2005
9.Z.Rdzawski, Miedź stopowa, Wydawnictwo Politechniki Sląskiej, 2005
10.Przewody elektroenergetyczne, Wydawnictwo przemysłowe WEMA, 1998,
11.L.Mondolfo; Aluminum alloys : structure and properties, London, Boston : Butterworths, 1976
12.J.R.Davis, ASM Speciality Handbook: Aluminium and aluminium alloys, ASM International, 1993
13.J.R.Davis, ASM Speciality Handbook: Copper and copper alloys, ASM International, 1993
14.H.Pops, Nonferrous wire book, The Wire Assocition International, 1995
15. R.Bartnikas, K.D.Srivasteva, Power and communication cables, theory and applications, A John Wiley & Sons, 1999
16.F.Cverna, electrical and magnetic properties of metals,ASM International, 2001
17. M.Ashby, D.R.H.Jones, Materiały inzynierskie-właściwości i zastosowania, WNT1980
18.M.F.Ashby, Dobór Materiałów w projektowaniu inzynierskim,WNT,1992
19.Dybiec H., Submikrostrukturalne stopy aluminium, Wydawnictwo AGH, 2008
20.PN-EN 50183, Przewody do linii napowietrznych – Przewody gołe ze stopu aluminium zawierającego magnez i krzem, grudzień 2002
21.PN EN 50189:2002: Przewody do linii napowietrznych – Przewody stalowe ocynkowane
22. PN-EN 61232:2002(U): Druty stalowe aluminiowane do zastosowań elektrycznych.
23.ASTM 941-05: Heat resistant aluminium-zirconium alloy wire for electrical purposes
24.IEC 62004: Thermal resistant aluminium alloy wire for overhead line conductors
25.PN EN 1715-2: Walcówka okrągła ze stopu aluminium EN AW 6101
26.IEC 104:1987: Aluminium-magnesium-silicon alloy wire for overhead line conductors
27.ASTM B 398: Standard Specification for Aluminum-Alloy 6201-T81 Wire for Electrical Purposes
28.SS 424 08 13: Aluminium alloy wire for stranded conductors for overhead lines – Al59 wire
29.PN-EN 1715-2:2008 (U): Aluminium i stopy aluminium. Materiał wyjściowy do ciągnienia. Część 2: Specyficzne wymagania do zastosowań elektrycznych.
30.ASTM B524 / B524M – 99 (2005): Standard Specification for Concentric-Lay-Stranded Aluminum Conductors, Aluminum-Alloy Reinforced. ACAR, 1350/6201
31.PN-EN 573-3: Aluminium i stopy aluminium. Skład chemiczny i rodzaje wyrobów przerobionych plastycznie. Część 3: Skład chemiczny. 2005

Scientific publications of module course instructors related to the topic of the module

1. B.Smyrak, Procesy reologiczne przewodowych stopów Al-Mg-Si w ujęciu fenomenologicznym, Wydawnictwo Impuls, Kraków, 2013, ISBN 978-83-7850-449-8
2. Smyrak B. Knych T. Mamala. A., Korzeń K.: Rheological Inactivity of AlMgSi Conductors (AAAC) in trend of negative stress gradients, Materials Science Forum, vol. 765, 2013, str. 808-812

3. Osuch P., Smyrak B., Knych T.: Effect of precipitation hardening on the structure and properties of AlMgSi conductor alloys in different technological routes, Materials Science Forum , vol. 765, 2013, str. 823-826
4. Walkowicz M., Knych T., Smyrak B.: A study of oxygen-free copper for the electronics and electrical engineering applications, Electrical Review, nr 2a, 2013, str. 40-44. (IF 0.244)
5. Kawecki A., Knych T., Sieja-Smaga E., Mamala A., Kwaśniewski P., Kiesiewicz G., Smyrak B., Pacewicz A., Fabrication, properties and microstructures of high strength and high conductivity copper-silver wires, Archives of Metallurgy and Materials, Volume 57 2012 Issue 4, str. , (IF 0.487)
6. Knych T., Smyrak B., Osuch P., Szajding K.: A study of the influence of strain hardening and precipitation hardening sequence on development of mechanical properties of AlMgSi conductor alloys, Materials Science Forum, 2011 vol. 690, TransTech Publications, Switzerland, str. 45–48
7. Osuch P., Knych T., Smyrak B., Mamala A.: Analysis of the technology for manufacturing heattreatable AlMgSi alloy wire rod, in terms of physical phenomena that affect the structure and properties, Materials Science Forum, 2011, vol. 690, str.149–152
8. Jabłoński M., Knych T., Smyrak B.: Effect of iron addition to aluminium on the structure and properties of wires used for electrical purposes, Materials Science Forum, lipiec 2011 vol. 690, 83 str. 456-462
9. Smyrak B., Knych T., Mamala A., Uliasz P., Jabłoński M.: A study of a new generation of multifunctional aluminium alloys for the power industry, Materials Science Forum, lipiec 2011 vol. 690, 83 str. 439 442
10. Knych T., Smyrak B., Walkowicz M.: Research of oxygen free of Upcast® technology for electric and electronic uses, World of Metallurgy, Erzmetall, Internationale Fachzeitschrift für Metallurgie, 2011 vol. 64 no. 1 str. 16–25
11. Knych T. Smyrak B.. Walkowicz M., The characterization of the oxygen free-copper technology production applications for electrical uses, Electrical Review, , 2011 R. 87 No. 2 str. 195–200 (IF – 0,196)
12. Knych T., Mamala A., Smyrak B.: Phenomenology of the creep process of a precipitation-hardenable AlMgSi alloy wires for overhead power lines. Experimental tests. Simulation, Mechanics of TimeDependent Materials, 13, 2009, str. 163-181 (IF 1,051)
13. Jabłoński M., Knych T., Smyrak B., New aluminium alloys for electrical wires of fine diameter for automotive industry, Archives of Metallurgy and Materials, 7, 2009, (IF – 0,187)

Additional information

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