AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Module name: An introduction to high temperature corrosion

Academic year: 2019/2020 Code: ZSDA-3-0032-s ECTS credits: 3

Faculty of: Szkoła Doktorska AGH

Field of study: Szkoła Doktorska AGH Specialty: —

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

Lecture language: English Profile of education: Academic (A) Semester: 0

Course homepage: http://home.agh.edu.pl/~zbgrzesik

Responsible teacher: prof. dr hab. inż. Grzesik Zbigniew (grzesik@agh.edu.pl)

Module summary

Students obtain essential information about corrosion processes of metalic and ceramic materials applied at high temperature environments. They will gain knowledge on protection methods against corrosion. Practical examples of high temperature corrosion processes are presented.

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	understands the necessity of continuous education and upgrading professional competencies; understands the economic and ecologic aspects of protection against corrosion	SDA3A_K01	Participation in a discussion, Presentation, Activity during classes
Skills: he can			
M_U001	is able to investigate the results of corrosion degradation and indicate their reasons; is able to use the correct method of protection against corrosion	SDA3A_U01, SDA3A_U02	Participation in a discussion, Presentation, Activity during classes
Knowledge: he knows and understands			
M_W001	has basic knowledge on high-temperature corrosion processes of metallic and ceramic materials;	SDA3A_W01	Participation in a discussion, Presentation, Activity during classes

M_W002	understands thermodynamics of corrosion processes and knows the principles of oxidation kinetics and mechanism studies	SDA3A_W02	Activity during classes

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
30	20	0	0	0	0	10	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	understands the necessity of continuous education and upgrading professional competencies; understands the economic and ecologic aspects of protection against corrosion	-	-	-	-	-	+	-	-	-	-	-
Skills: he can												
M_U001	is able to investigate the results of corrosion degradation and indicate their reasons; is able to use the correct method of protection against corrosion	-	-	-	-	-	+	-	-	-	-	-
Knowledge: he knows and understands												
M_W001	has basic knowledge on high-temperature corrosion processes of metallic and ceramic materials;	+	-	-	-	-	-	-	-	-	-	-
M_W002	understands thermodynamics of corrosion processes and knows the principles of oxidation kinetics and mechanism studies	-	-	-	-	-	-	-	-	-	-	-

Student workload (ECTS credits balance)

Student activity form	Student workload
Udział w zajęciach dydaktycznych/praktyka	30 h
Preparation for classes	10 h
przygotowanie projektu, prezentacji, pracy pisemnej, sprawozdania	5 h
Realization of independently performed tasks	20 h
Summary student workload	65 h
Module ECTS credits	3 ECTS

Additional information

Module content

Lectures

1.Thermodynamics of high temperature corrosion
2.Corrosion rate
3.Corrosion mechanisms
4.Experimental methods of investigation of high temperature corrosion
5.Wagner’s theory of metal oxidation
6.Oxidation of pure metals and alloys
7.Corrosion in oxidants other than oxygen
8.Oxidation in complex atmospheres
9.Hot corrosion and salt-induced corrosion
10.Corrosion-erossion
11. Protective coatings

Seminar classes

1.Thermodynamic stability range of oxides
2.Temperature and pressure dependence of the oxidation rate of metals
3. Oxidation under thermal shock conditions
4.Liquid oxides and oxide evaporation
5.Oxidation in the presence of water vapor
6.Internal oxidation of alloys
7.Formation of higher oxide on lower oxide substrate
8.Erosion-corrosion of metals in oxidizing atmospheres
9.High temperature corrosion processes in modern industry

Teaching methods and techniques:

Lectures: Classical technique;
Self-organized Learning Enviroment
Seminar classes: Reverse teaching technique;
Self-organized Learning Enviroment;
Work in groups;
Brainstorm

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

In order to complete the seminar class, a presentation on a chosen subject must be given and the student must take part in a discussion, which will be positively graded. In order to pass the subject in the secondary term, a positive grade must be obtained from a test on the entirety of the material.

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

Lectures:
– Attendance is mandatory: No
– Participation rules in classes: Official permision is necessary for participating in classes
Seminar classes:
– Attendance is mandatory: Yes
– Participation rules in classes: Official permision is necessary for participating in classes

Method of calculating the final grade

Final grade = grade from oral presentation + grade from participation in discussions

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

If the requirements are met for obtaining a passing grade, the student is required to independently catch up with the material. If he/she fails to do so, he/she must obtain a positive grade on a test that pertains to the material discussed during his absence.

Prerequisites and additional requirements

None

Recommended literature and teaching resources

1.Z. Grzesik, Thermodynamics of gaseous corrosion, in: ASM Handbook, vol. 13a, p.90-96, ASM International, Materials Park, Ohio, USA, 2003.
2.S. Mrowec, An Introduction to the Theory of Metal Oxidation, National Bureau of Standards and National Science Foundation, Washington D.C., 1982.
3.S. Mrowec and T. Werber, Modern Scaling-Resistant Materials, National Bureau of Standards and National Science Foundation, Washington D.C., 1982.
4.P. Kofstad, High Temperature Corrosion, Elsevier Applied Science, London 1988.
5.P. Kofstad, High Temperature Oxidation of Metals, J. Wiley, New York, London, Sydney, 1988.
6.N. Birks, G.H. Meier and F.S Pettit, Introduction to the high temperature oxidation of metals, Cambridge, University Press, 2009.
7.W. Gao, Z. Li, High-temperature Corrosion and Protection of Materials, Woodhead Publishing in Materials, Cambridge, England, 2008.

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

1.G. Smola, R. Gawel, K. Kyziol, M. Miszczak, Z. Grzesik, „Influence of nickel on the oxidation resistance at high temperatures of thin chromium coatings”, Oxidation of Metals 91(5-6), 625-640 (2019).
2.R. Gawel, K. Kyziol, Z. Jurasz, Z. Grzesik, „Oxidation resistance of valve steels covered with thin SiC coatings, obtained by RF CVD”, Corrosion Science, 145, 16-25 (2018).
3.B. Kościelniak, G. Smoła, Z. Grzesik, A. Hernas, „Oxidation resistance of austenitic steels under thermal shock conditions in environment containing water vapor”, High Temperature Materials and Processes, 37(4), 341-350 (2018).
4.M. Drożdż, K. Kyzioł, Z. Grzesik, „Chromium-based oxidation resistant coatings for protection of engine Valves In Automotive Vehicles”, Materials and Technology 51(4), 603-607 (2017).
5.M. Żyła, G. Smoła, A. Knapik, J. Rysz, M. Sitarz, Z. Grzesik, „The formation of the Co3O4 cobalt oxide within CoO substrate”, Corrosion Science, 112, 536-541 (2016).
6. Z. Grzesik, A. Poczekajlo, G. Smola, S. Mrowec, „Marker method in studying the defect structure in products of the oxidation of highly disordered substrates”, High Temperature Materials and Processes, 35, 21-28 (2016).

7. Z. Grzesik, G. Smola, K. Adamaszek, Z. Jurasz, S. Mrowec, „Thermal shock corrosion of valve steel utilized in automobile industry”, Oxidation of Metals, 80, 147-159 (2013).
8. Z. Grzesik, G. Smola, K. Adamaszek, Z. Jurasz, S. Mrowec, „High Temperature corrosion of Valle steels
in combustion gases of petrol containing ethanol addition”, Corrosion Science, 77, 369-374 (2013).

Additional information

None