FUEL CELLS

(3 ECTS) ***Elective***

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The hydrogen technology consists of three functional steps: (i) production, (ii) transport and storage and (iii) utilization of hydrogen fuel. Two first steps will be described in the lectures very briefly. The emphasis will be put of fuel cells (FC): fundamentals of their operation, thermodynamics, types, technology and at last applications.

Learning outcomes:
After the course, the students understand importance of sustainable energy development, in particular diversification of energy sources, various energy carriers and different methods of energy conversion. They are aware of role of emerging technologies with emphasis put on hydrogen economy. The lectures and laboratory exercises make them familiar with fundamentals of operation and technologies of fuel cells of various types. They know how to use the particular fuel cell fed with a given type of fuel for the electricity production. The students are able to:

- assembly the single fuel cell of the following types: PEMFC (Proton Exchange Membrane Fuel Cell), DMFC (Direct Methanol Fuel Cell), SOFC (Solid Oxide Fuel Cell) and DCFC (Direct Carbon Fuel Cell);
- operate the fuel cell and optimize the operational conditions of fuel cell according to the type of fuel cell and requirements of the load;
- to build configuration of fuel cells according to the requirements of the system;
- to determine the maximum power of fuel cell and fuel cell system;
- to determine the electric efficiency of the fuel cell;
- to recognize the limitations of the output power of the cell due to the activation, ohmic and concentration polarization

The students know how to use fuel cell systems in nowadays applications as electric cars, submarines, mobile and auxiliary power sources and special applications.

Course main content
Lectures (15 h): Fundamental knowledge of hydrogen economy and fuel cell including role of hydrogen as an energy carrier, hydrogen production, transport and storage, energy conversion in fuel cells. Fundamentals of electrochemistry: electrodes, electrolytes and galvanic cells. Fuel cell theory: thermodynamics, polarization, efficiency.

Laboratory exercises (30 h): production of hydrogen by membrane electrolysis, decomposition voltage of water, efficiency; assembling and operation of various type of fuel cell, determining characteristics of fuel cell, maximum power, efficiency of operation.

Literature:

1. Fuel Cell Handbook, fifth ed., Parsons Inc., U.S. Department of Energy, Morgantown, 2000
2. G. Hoogers, (Ed.), Fuel Cell Technology Handbook, CRC Press, Boca Raton, 2003
3. C. Singhal, K. Kendall (Eds.), High Temperature Solid Oxide Fuel Cells: Fundamentals, Design and Applications, Elsevier, Amsterdam, 2004
4. S. Srinivasan, Fuel cells. From Fundamentals to Applications, Spronger, 2006

5. A. Zuttel, A. Borgschulte, L. Schlapbach (Eds). Hydrogen as a Future Energy Carrier, Viley-VCH, 2008

Assessment:

Successful participation in laboratory exercises, test

Rules of credit: Laboratory (60%), test (40%)