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INNOVATION IN THE ELECTROCHEMISTRY IN RANGE FUEL CELLS

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Abstract: *The paper deals with the information about innovation in laboratory education from the area of electrochemistry. New technologies using during the lessons are described. Further, methods of creation new laboratory experiments are mentioned. Contribution and other objectives of innovation are discussed in the end.*

Key words: *Electrochemistry, fuel cell, laboratory education*

1 INTRODUCTION

Electrochemistry is important science branch which is being very quickly developed by virtue of technological methods and applications of nanotechnologies. In the terms of education we have to take into account this improvement. Nowadays, technology of fuel cell is been discussed. We mean electrochemical sources of electrical energy which tend to be considered as significant part of everyday life in near future.

2 MOTIVATION

Electrochemistry as subject of electrochemical faculty has multiyear tradition, and every student have to pass it. The subject is intended to introduce basic principles of electrochemical processes to students. These principles are electrolytic and redox formulas, galvanazataion, and osmotic processes. Within the practical laboratory exercises student should be allowed to verify theoretical, acquired knowledges. Every year we must optimise current laboratory experiments to achieve ultimate efficiency in education. Within the innovated education, implementation of new trends and technologies, requiring creation and initiation of new experiments is needed.

Nowadays we meet with the new learning of the area of fuel cells technologies. The new time for the area of fuel cells technologies has come. Therefore, an inclusion into education of electrochemistry became necessity. In tutotials considerable attation is payed to this technology, nevertheless the feedback executing by useful laboratory experiments was missing. The resources provided by FRVS were used to gain grant for innovation of education of electrochemistry in the area of electrochemical sources focused on fuel cells. This donation allowed us to create proper laboratory background which enriched the education with experimental technologies of fuel cells. By virtue of analysis of current laboratory exercises were chosen optimal technologies and equipments, which enabled us to bring a number of interesting and effective in education experiments. Thanks to them there was set in a connection with theoretical tutorial section. Several types of fuel cell are currently available in laboratory of electrochemistry, i.e.PEMFC, DMFC a AFC technologies. Some of them are also available in different outputs. Consequently they can be used for diverse application, from supply of mobile application to power application. In addition, PEM technologies enable reversing working, which is electrolysis. This is utilized in combination with photovoltaic systems for demonstration of accumulation electric energy. Alkaline fuel cell AFC from Astris Ltd. is the unique. In the Czech Republic it is the only educational experimental system.

The field of the measures and control of laboratory experiments is another area where the innovation has been reached. For acceleration of preparation and modification during education we had to create efficient measuring device. The former experience helped us to made concept of this measuring device consisting of mobile computer, precise measuring card and suitable software tool serving for formation controlling and evaluating program. The previous positive experience with LabView led us to choose this system from NI Company. This combination made possible to produce simple and stable application with modifiability. This innovation provided to create over new twenty laboratory experiments.

3 TECHNOLOGIES

Laboratory education of electrochemistry in domain of fuel cells expands by several interesting experiments using new attractive technologies that are in detail described below. Several new devices are based mainly on PEM technology; there is also power DMFC system and unique AFC fuel cell mentioned above.

STAXX SYSTEM

One of the most widely used laboratory devices is StaXX system, which is based on PEM technology. Device is built as system of electrolytic cell, supply network for water and gas fuel, and finally group of PEM cells as a power source. Whole system is made from transparent acrylate that allows visual monitoring of fuel transport.

Staxx PEM fuel cell

Electrode area	10 cell of 16cm^2
Power	5W at 5V DC
Operating voltage	4 – 10 V DC

StaXX electrolyzer

Electrode area	7 cell of 16cm^2
Power	50W at 14V DC
H2 production	230 cm3 / min

This system is suitable for experiments in field of measurements of VA load characteristics, measurement of polarization and dissociative voltage, verification of the first Faradays law of electrochemistry and another.

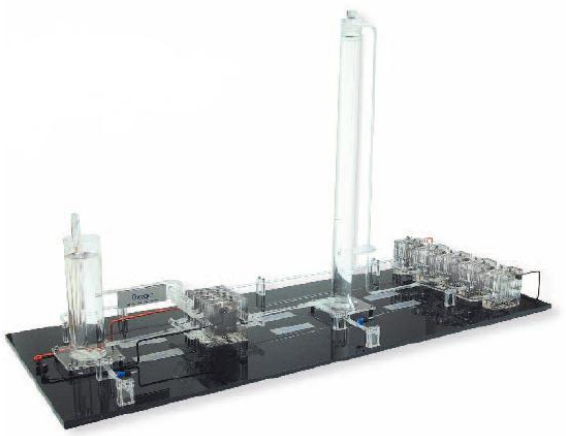

Fig.1.: Illustrative example of StaXX system.

POWER PEMFC

This PEM fuel cell is mainly used for power based experiments like electric traction power supply realized by direct current synchronous motor. Besides that, fuel cell is used for measurements of VA load characteristics, measurement of polarization and dissociative voltage.

System parameters:

Power	27 to 36W at 3.6V
Fuel/Oxidant	H_2/ Air or O_2
Fuel pressure	1 bar for H2/Air or 1.2 bar for H2/O2
Membrane area	36 cm^2
Weight	900 g
Dimensions	9 x 9 x 5.5 cm

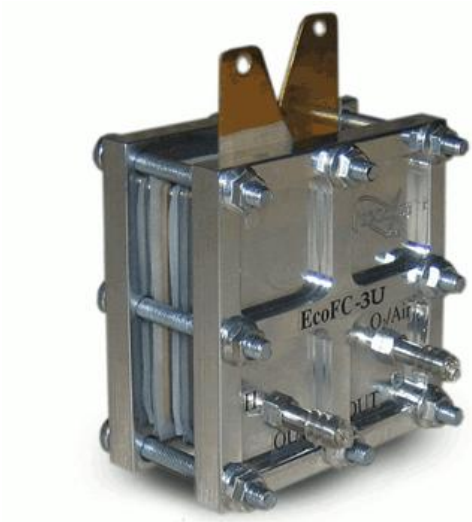

Fig.2.: Illustrative example of PEMFC

METHANOL BASED DMFC SYSTEM

Methanol based DMFC fuel cell TekStak™ is nowadays the most powerful education device on the market. It uses standard 1M concentration methanol solution as a fuel. Within the laboratory exercises, the DMFC fuel cell is used for measurements of VA load characteristics, measurement of polarization and dissociative voltage, measurement of influence of fuel composition to output power of fuel cell and long-run experiments.

System parameters:

Electrode area	10 cell of 16cm^2
Power	3W at 5V DC
Fuel / Oxidant	CH_3OH / Air or O_2
Weight	400 g
Dimensions	9 x 9 x 8 cm

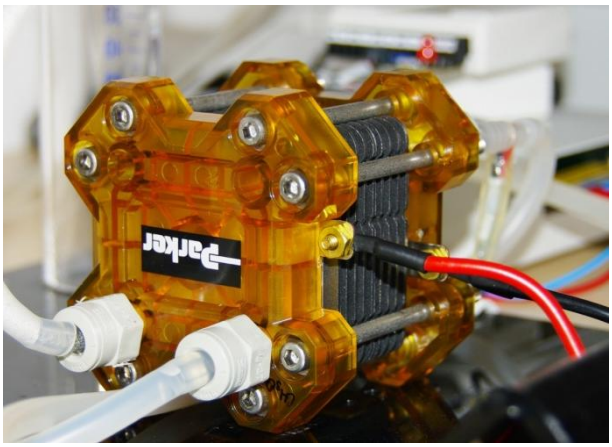

Fig.3.: DMFC system

ALKALINE FUEL CELL AFC

Alkaline fuel cell AFC technology from Astris s.r.o. is the one of the oldest kind of fuel cell at all. It has been used for example in NASA space program Apollo, where functioned as the source of energy and water for the space modules. Our AFC can be entitled as an unique because according to the Astris Ltd. information our department is the only one in Czech Republic who owns this kind of technology. The Astris Ltd. also provided us

with frond-end system of current load [1], which is perfect device for difficult measurement of VA characteristics of fuel cell.

System parameters:

Power	40W at 15A
Max output current	25A
Fuel / Oxidant	H_2/ Air or O_2
Electrolyte	KOH (6,6M)
Fuel pressure	0,8-2 kPa for H_2 0,5 - 6 bar for Air / O_2
Membrane area	4 x 250 cm^2

This ACF device is used mainly for power based experiments like electric traction power supply realized by direct current synchronous motor. Next, it is able to realize measurements like VA load characteristics, measurement of polarization and dissociative voltage, measurement of influence of electrolyte composition, purity and temperature to output power of fuel cell or influence of fuel consumption and pressure to output power.

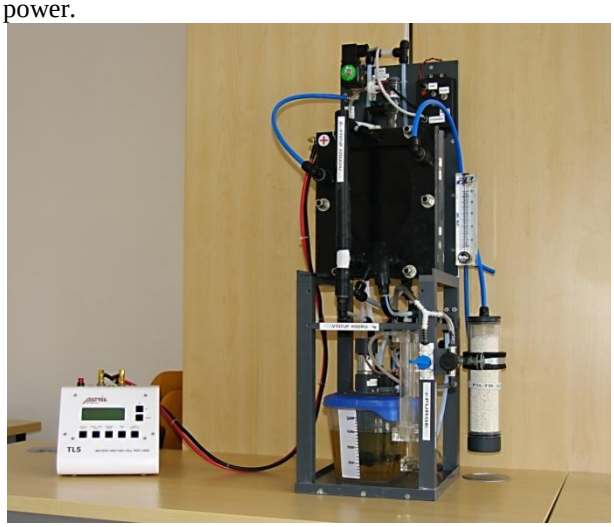

Fig.4.: Astris AFC system

There are a lot of advanced experiments, which should be realized on mentioned technologies. These experiments are destined for senior students within work on their bachelor or diploma thesis. It is mainly about research in areas like the influence of fuel parameters and surrounding conditions to system power or fuel parameters optimization for given applications. Other is material measurement area. Interesting are measurements of water and gas diffusivity through polymer electrolyte, effect of membrane hydration to proton conductivity and others.

In terms of annual educational evaluation experiments are evaluated from the point of view of education efficiency and knowledge output of students. Those observations are used for next optimilization.

4 DEVICES

During the innovation process of electrochemistry subject was essential to solve another important problem, large number of students. There are more than 500 students that have to attend the subject in summer semester. Main problem was insufficient cooperation of lecturer with students, caused by weak laboratory equipment. Problem was solved by creating of four computer based measurement stations, made up from notebook, universal measurement card and measurement software, created in NI LabView environment [2]. Main goal during program proposal and development was ability of easy modification of actual measurement exercise into new one. Thanks to universal USB-6008 measuring card and instructions during the running of program is possible to reduce time requirements to measurement modification from tens to ones of minutes. This way doubled laboratory experiments during one exercise and this allowed us to direct and active connect students to an experiment preparation and its realization.

USB-6008 measurement card:

Bus	USB
Analog Inputs	8 SE/4 DI
Input Resolution (bits)	12
Max Sampling Rate (kS/s)	10
Input Range (V)	±1 to ±20
Analog Outputs	2
Output Resolution (bits)	12
Output Rate (Hz)	150
Output Range (V)	0 to 5
Digital I/O Lines	12
32-Bit Counter	1
Trigger	Digital

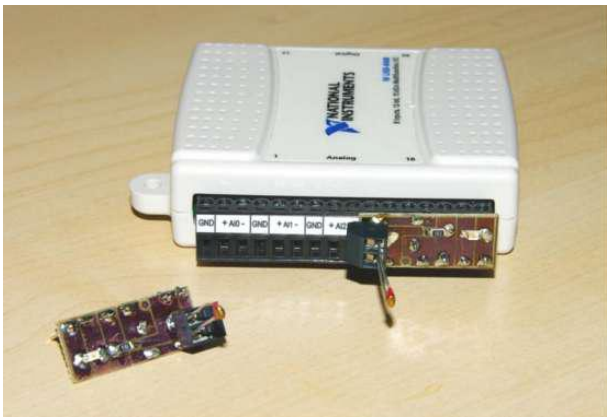

Fig.5.: USB-6008 with temperature module.

Measuring card can be used for a lot of laboratory experiments due to its universal properties. Thanks to full compatibility with LabView environment and attractive price should be this card used in a number of interesting applications in a lot of education fields.

5 EXPERIMENTS

As an example, there is a sample of a new laboratory exercise of VA characteristics measurement on PEM fuel cell. The goal of exercise is to introduce to students the power characteristics of PEM, which are used for comparison PEM and other power sources.

Supporting documents of a laboratory exercise in digital form for students are available at the university internet portal of electrochemistry. Lecturer prepares only notebook, measurement card, fuel cell, electric load, and accessories. Students arrange measurement only by help

of measurement program instructions and digital documentation. After verification of proper connection by the lecturer, students continue measurement using program instructions explicitly. Program automatically checks every students step and in case of error, it notice students about this error.

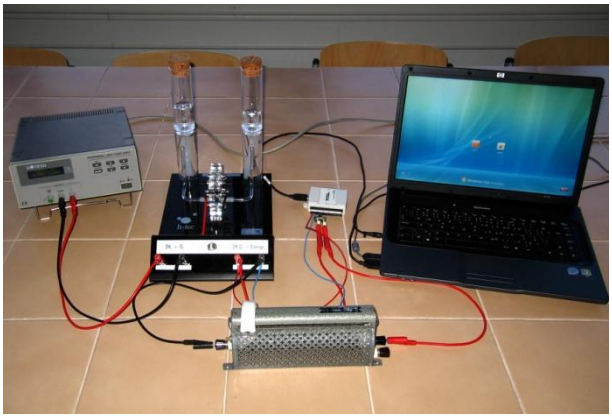

Fig.6.: Illustrative example of measurement connection

Figure 7 shows user interface of measuring program. Interface has been created in order to clearance and easy control during the measurement. Whole program has been created with previous LabView [3,4] software experience and with reference to efficiency and safety of running measurement.

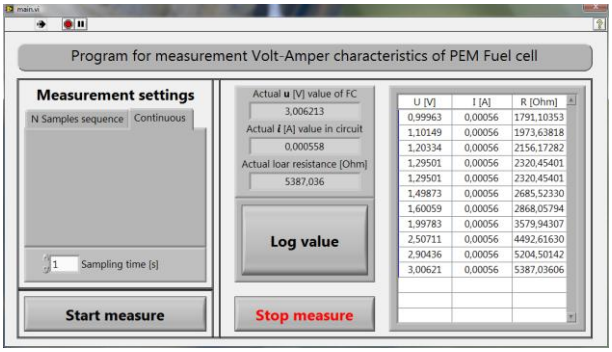

Fig.7.: Measurement program UI

Within frame of innovations in electrochemistry laboratory exercises, it was created more than 20 new laboratory experiments. As a short view, there are some examples:

- Measurement of load characteristics of fuel cell.
- Temperature cell characteristics.
- Pressure cell characteristics.
- Measurement of the influence of fuel composition to fuel cell output power.
- Measurement of the influence of fuel concentration to fuel cell output power.
- Water and gas diffusion through polymer membrane.

6 CONCLUSION

The paper informs about innovation of electrochemistry subject in area of fuel cell technologies. This innovation had been tested during summer semester and new measurement approach and experiments has been tested on more than 500 students. Results meet expectations and in some cases exceed them.

A positive evaluation is that students have more active access to education, because innovation improved possibilities to verify their theoretical knowledge practically. Also results of the subject leaving exams have higher rating than in previous years.

Another positive is laboratory acceleration of exercises and increasing the number of executed experiments. This is given by new measurement method with use of notebook, measuring card and suitable measuring program. This approach has been rated positively in most of cases. As an important advantage is a spared time, that can be used for deeper understanding of actual topic.

Next optimization step include new modifications of current experiments due to new experience from summer semester in year 2009 and thanks to new financial support from grant FRVŠ 598/2009 will be created new several exercises based on not only the fuel cell technology, but also in area of other alternative power sources as electroosmosis and photovoltaic.

7 REFERENCES

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