Control and Modelling of Fuel Cells Systems Intensive Program

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Abstract

This paper presents the experience of the participation of researchers and students of ETSID in the Erasmus founded Intensive Programme (IP) "Automation and Modelling of FC-based Energy Systems (AMES)". The IP is an intensive course where different approaches in modeling and automation of fuel cells systems with different renewable energy sources and aspects of the Hydrogen Technology with practical training are provided to students from engineering.
AMES is leaded by the Fachhochschule Stralsund - University of Applied Sciences and participate other European universities from: Estonia, Lithuania, Poland, Norway, Finland and Spain (ETSID). The intensive course is hosted in the Fachhochschule Stralsund.
Last year students from industrial, electrical, mechanical, electronic, chemical and power engineering are eligible to be involved in the project. Researchers and lecturers from the partner institution provide lectures and laboratory sessions on the different topics of the IP, namely, Hydrogen based PEMFC-systems, Automation of PEMFC-Systems, Hydrogen in the mobile sector, Hydrogen race cars for the shell eco marathon, etc. The IP is hosted by the Laboratory for Integrated Energy Systems at the Fachhochschule Stralsund. Along 10 days, students from partner universities complement their formation on renewable energies and gain international experience working in multicultural teams.

Introduction

The experience of the participation of researchers and students of ETSID in the Erasmus founded Intensive Program (IP) [1] "Automation and Modeling of FC-based Energy Systems (AMES)" is presented in this paper. The IP is an intensive course where different approaches in modeling and automation of fuel cells systems with different renewable energy sources and aspects of the Hydrogen Technology with practical training are provided to students from engineering.
Thanks to the effort performed by the Fachhochschule Stralsund - University of Applied Sciences [2] that is the leader and organizer of this course, other European universities from: Estonia, Lithuania, Poland, Norway, Finland and Spain (ETSID) can participate in this important experience by sending undergraduate, Ph.d. students and lecturers to this event. The whole intensive course is hosted in the Fachhochschule Stralsund.
At ETSID, students from industrial, electrical, mechanical, electronic, chemical engineering are eligible to be involved in the project [3]. Researchers and lecturers from the partner institution provide lectures and laboratory sessions on the different topics of the IP, namely, Hydrogen based PEMFC-systems, Automation of PEMFC-Systems, Hydrogen in the mobile sector, Hydrogen race cars for the shell eco marathon, etc. The IP is hosted by the Laboratory for Integrated Energy Systems at the Fachhochschule Stralsund. Along 10 days, students from partner universities complement their formation on renewable energies and gain international experience working in multicultural teams [4].
The rest of this paper is organized as follows: section 2 presents the ETSID selection procedure of candidates, section 3 describes the program of the course, different experiences developed by the students are shown in section 4,

concluding remarks are sum up in section 5.

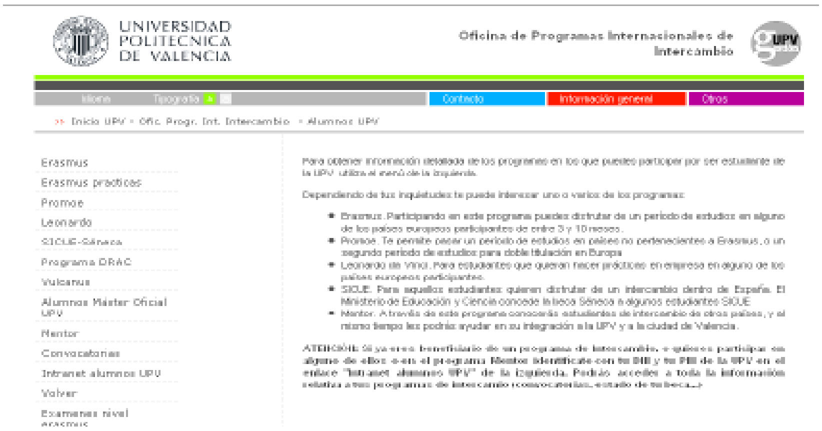
Candidate Applications

Requirements

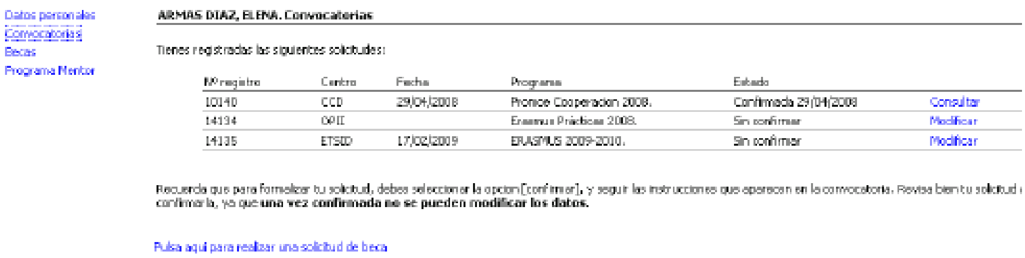
The ETSID applicants must be enrolled as regular students in one of these degrees: Electronics, Electrical, Chemical, Mechanical and Industrial Management Engineering. They also have to prove their knowledge of English. It should be good enough for attending classes in that language. In order to confirm that circumstance, the students must get through a special test.
Furthermore, they must have passed a minimum of 150 credits of their grades that match up with half the total number of credits.

Application Procedure

As any other students interested in going abroad within an exchange programme, students who want to apply for IP STRALSUND, have to go in the intranet that UPV provides to their regular students.



After identifying them self, they can see the screen:



From this moment on, all the introduced details are forwarded to our central data management application, API-WEBS. This software is used by the International Office to manage everything related with academic exchanges.
The applicants need to fill in their personal details and confirm the option they want. Automatically, the system generates a document that they must submit to the International Office at ETSID, with a curriculum vitae and transcript of records.

Selection procedure:

After the application deadline, we remove the candidatures that do not fulfill with the requirements. For this purpose we use the same application that the students had to use for applying. This programme has an import facility which allows obtaining data like marks, credits, etc. from our registration system in a spreadsheet file fashion. With that information we can put into practice an evaluation formula:

$$75*(AM)+15*(EP)+5*(ES)+5*(mentor)$$

Consequently, the factors that are valued in the selection procedure are: Average mark (AM), if the student participated in Exchange Programmes (EP), if she/he took subjects taught in English (ES) and if is registered in the Mentor Programme (programme that involves UPV students to help foreign exchange students when they arrive at UPV).

From the first edition in 2005, we usually receive 20 applications on average for the 5 available vacancies. Most of them belong to students from Chemical, Electrical, Electronics, Mechanical and Management Engineering.

Course Description

Programme of the Course

From the first day, there are laboratory sessions where different works are carried out, usually in the afternoon. Several visits/tours are programmed, such as an excursion to the Isle of Ruegen, by train, a technical tour to Greifswald + Peenemünde (including a visit to the Max-Planck-Institut für Plasmaphysik - IPP, in Greifswald) and a visit to the Hannover Fair.

After finishing the lectures and lab work, students have to prepare their presentations of lab results and to take an examination to evaluate their achievements. Also, during the last weekend, each group of students does a presentation of their home universities and their experiences in research projects.

Main content of the lectures

In order to bring the spring school on level with regular school, interesting lectures are programmed. On eight occasions during the 10 days, spring school students could learn about five subjects from different lecturers. There is an introduction into the topic in which the students learn about different methods to produce hydrogen: from natural gas or biogas on the one hand, and by various means of electrolysis, including photo-biological electrolysis, on the other hand. Also, background information important for the understanding of materials is given, as well as the characteristics of the system equipment and security measures. The lecture finishes with an excurse on storage and problems of distribution of hydrogen.

In the following days, several lectures on different subjects related to 'fuel cells' (FC) are given, starting from basic principles and the general ideas behind fuel cells and going on with the role of hydrogen as an Energy Carrier. Many types of fuel cells have been developed that differ primarily in the type of catalysts. Further, there are two days focused on theory and characteristics of FC.

In order to gain deeper insights into the industrial application and the demands of producers, a representative of the industry is invited. With the diversity of offered lectures, the spring school meets the demands of all invited students, regardless of their prerequisites. There also is plenty of opportunity for questions and discussions.

Laboratory experiences

Model of an electrolyser

One has to produce hydrogen before one can work with it. In this experiment, water is split into oxygen and hydrogen by electrolysis [5]. The electro-technical and electro-chemical behaviour of the electrolyser shall be determined in the process.

First, the volume of gas produced at varying currents is measured. Applying Faraday's law, the energetic contents of the gas is then compared to that of the input current. The differences between the values expected from theoretical considerations and the actually measured values must be explained. This results in some surprising realizations.

Aside from a common power supply, 3 solar panels are available for the experiment. The power difference in the case of series connection and parallel connection of the modules is of special interest.

Fig.1. Students working on Electrolyser. (Courtesy of FH Stralsund)

For bigger hydrogen consumers, the FH also has a 20 kW electrolyser supplied by its own 100 kW windmill. The hydrogen produced there is stored in a 200 Nm_ pressure tank. In the following experiments, this supply shall be used in ever bigger fuel cell systems.

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Efficiency of small fuel cells

During the first practical training, the participants have the chance to carry out measurements on small fuel cells for themselves [6]. They get to know how to measure the electric efficiency with only a very small PEMFC, which stands for Proton Exchange Membrane Fuel Cell. The calculation consists of the CHEMICAL energy of hydrogen which flows into the system and the ELECTRICAL energy which is gained and used here by a little fan as the load. A reflection about the behaviour of two different PEMs shows the main problems for constructing fuel cells, like humidity or gastight coats. In spite of the bad results of the electricity production here, the procedure has many things in common with the function of modern and more automatic analysing systems that are used in the next experiments of the spring school.

Fig.2. Fuel Cell practice. (Courtesy of FH Stralsund)

Self-sufficient 12V supply

In order to also give them an impression about the work of the students at the college, the 50W power supply for 12V loads on fuel cell basis developed by students is introduced. It is based on a normal fuel cell which is controlled by means of an SPS. The experiment is meant as a demonstration of a typical example for the utilization of fuel cells. It provides a sound foundation for discussions of different topics, such as storage types, humidification, controlling and cooling, among others. During the demonstration, all processes are explained to the participants. Adequate to the intended purpose, and well received by the audience, a car radio is used as 12V load. However, it also can be shown that the installation is operative without the accumulator – so that the fuel cell can supply the load directly. The experiment is, therefore, an excellent conclusion to the basic experiments regarding fuel cells and a good transition to the experiments in the multi-component laboratory.

Fig.3. Power supply practice. (Courtesy of FH Stralsund)

Social events

Visit of Peenemunde and Greifswald

On the weekend, there is an excursion to Greifswald and Peenemünde. The guest students are guided through the most interesting centre for energy research, the Max-Planck-Institut für Plasmaphysik (IPP) in Greifswald. The focus there is on basic research for a fusion power plant that will produce energy from the fusion of atomic nuclei, like on the sun. A guided tour through the assembly hangar, an inspection of one of 50 planned super-conductive stellarators, and an introduction of project WEGA (a medium sized classical stellarator) give interesting insights. Project WEGA clarifies basic properties of low-density plasmas. As long as the hangar for the stellarator concept Wendelstein 7-X is empty, however, it won‘t be as hot there as on the sun. The next destination, the Historic-technical Centre of Information at Peenemünde, illustrates man‘s dream of flying to other planets. Here, the world‘s first long-distance rocket has been developed during the Nazi era. Although tainted by militaristic intentions, this development also implied technical breakthroughs that were later utilized by both the USSR and the USA in their space programs. At Peenemünde, other aeronautic and communication technology had been developed as well. All this is on display there. The use of hydrogen as fuel for rockets shows the wide spectrum of purposes that hydrogen technology can be used for. May research in the years to come bring us further interesting results!

Qualitative results

Students that have participated at IP of Stralsund manifest every year their satisfaction with the course because they learn techniques applied to different renewable energy sources and aspects of the Hydrogen Technology and they perform practical training on specialized laboratories, which allow them to complete their engineering curriculum. Many of them have continued their specialisation on topics of renewable energies at UPV and some of them have continued their studies in a master on fuel cells at FH Stralsund. Lecturers that have taught in the course have recommended us the continuation of the IP due to the good technical program and installations that FH Stralsund provides.

Conclusions

This year the intensive course on Automation and Modelling of FC-based Energy Systems (AMES) developed at FH Stralsund is on its 18th edition, which represent a big success. Since a big number of students are aware about the quality of the course, the selection of candidates' procedures at ETSID has been presented. A sample of the different lectures and laboratory experiences performed within the IP are also detailed.

ETSID students and lecturers are very impressed about the complete study program and very good laboratory installations at FH Stralsund, where they can practice and design the different experiments related to Fuel Cell systems. Likewise, our students are very happy with the warm hospitality of the organizers and they are very pleased with the visits to the Max-Planck-Institut für Plasmaphysik (IPP) in Greifswald.

Acknowledgement

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