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MASTER COURSE IN ENERGY MANAGEMENT FOR MECHANICAL ENGINEERING

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Abstract: The adaptation of the curricula at German Universities to the Anglo American standards like Bachelor of Sciences and Master of Engineering is the most ambitious political goals of the ministers for higher education of the federal countries in Germany. This new frame work for higher education increases the opportunities for the Universities of Applied Sciences for more application oriented education and research work, and also enables the graduates of their Master courses for the continuing PhD. studies e.g. in field of measurement and Control Engineering and energy management in the faculties of mechanical Engineering.

Exponential growing in application of intelligent and sophisticated measurement Instrumentation & Control (MI&C) systems in all part of techniques, but also in research and development is a significant indicator for demand of well trained engineers at the Universities of applied sciences . Based on 10 years of experiences of the author in teaching of (MI&C) engineering in the faculty of mechanical engineering at the University of applied Sciences Cologne, this paper introduces a new curricula in Bachelor of mechanical engineering and an upgraded Master of engineering in Energy management systems.

Keywords: Master course, measurement & Control Engineering, energy management

1 INTRODUCTION

The new academic area for the **U**niversities of **A**pplied **S**ciences (UASC.) is an opportunity, to improve, change and extent their average teaching hours to an additional 75 semester hour by introducing of a four semester Master courses. The new Master course in **B**uilding **E**nergy **M**anagement **S**ystems (BEMS) is a result of author's 10 years experiences in application oriented teaching in **M**easurement, **I**nstrumentation and **C**ontrol (MI&C) engineering at the faculty of mechanical engineering.

Today's distributed MI&C-Systems in buildings co-operate with similar systems from different manufacturers within an **O**pen **S**ystem **I**nterconnection (OSI) Network System. Considering the new technological aspects for distributed (MI&C) tasks for BEMS, a training pyramid (see figure 1) demonstrates, how the requirements for a modern teaching in (MI&C) engineering can be implemented in a new curricula. Following topics have been added to the classical curricula in MI&C-Engineering for mechanical engineers.

- MI&C information processing and communication technology
- Intelligent sensor and actuator systems embedded in local area network technology
- Measurement systems and communication buses.
- Network circuit technology, network based control strategies
- Multiple control information processing via open network systems

Using computerised distributed MI& C-systems for BEMS requires deeply knowledge in information processing of the measurement values in different automation level of a distributed, MI&C- Systems for BEMS aspects. Figure 1 illustrates the distributed intelligent process instrumentation and automation system with all the features as described before.

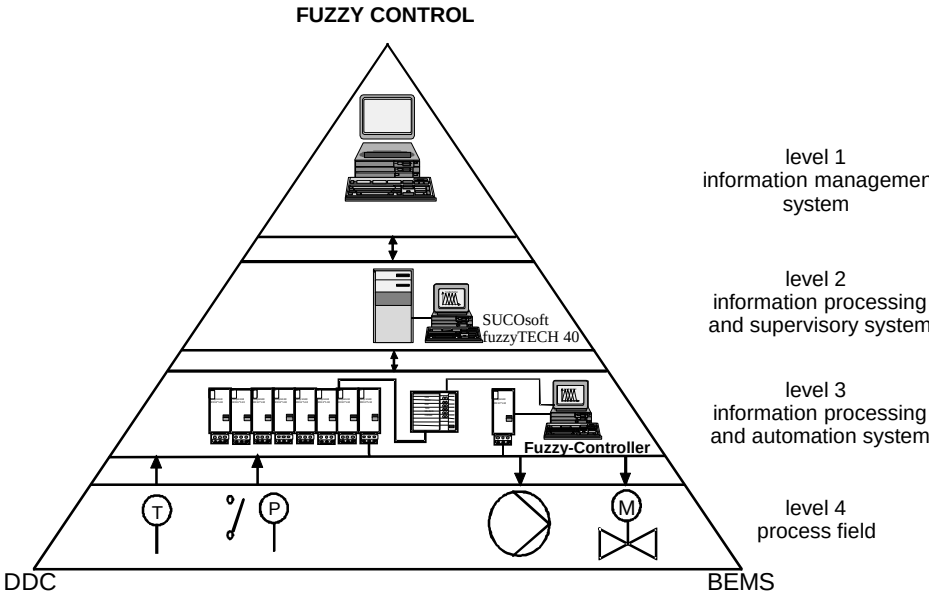

Figure 1. Distributed intelligent process instrumentation and automation system.

2 AN INNOVATIVE EDUCATION METHODE IN APPLIED MI&C – ENGINEERING

2.1 Qualification of graduates at the Universities of Applied Sciences

An inquiry made by companies being involved in process engineering, MI&C industry demonstrates that the graduates generally should acquire project design knowledge beside of their theoretical knowledge in schools of engineering. Some of the results of the inquiry evaluated by author is given here as following [1,2]

- Beside of the good fundamental knowledge in automation and instrumentation, it is very important for the students to be involved in the design of a whole processing project including the MI&C systems. They have also to analyse the start up of the system and evaluate their design results.
- The theory oriented education at the university is removing itself form the practice .The graduates need a long period of training in the companies, in order to fulfil the industrial requirements. This way of getting knowledge in MIC- engineering delays the career of young graduates.
- Co-operation between universities and industry is useful, in order to compensate the lack of their graduate's practical experiences in MI&C–systems. Co-operation will also ensure a bi-directional know how transfer between the University and industry .
- A very decisive opportunity for managing MI&C tasks in the m & p engineering field is a reasonable educational offer in schools of engineering for applied MI&C-science in theory and experimental exercises in the Lab.

Considering industrial requirements for the education in MI & C-engineering at the faculties of mechanical engineering, following different level of training could be considered as shown in figure 2:

2.1.1 Industrial oriented training in MI&C engineering

2.1.2 Teaching of Fundamentals and Principles in MI&C engineering

Only engineers can be classified as well trained in MI&C-engineering, when they have deeply knowledge in theoretical basics of MI&C science. The basic course should also consider the general basics of MI&C science without specialising in m&p engineering. By teaching of measuring principles, it can be useful to select measuring tasks from m&p engineering field. The selecting of measuring methods in connection with the application fields can also motivate the students, in order to be more interested in the subject.

The pedagogical background for teaching of principles should be based on philosophy: how and why a certain measuring principle does work. That means which physical features of certain materials is dominant for the measuring effect, and which physical laws build up the scientifically background of the measuring principle. Further theoretical contemplation is necessary in analysing of whole instrumentation systems in case of the interaction of the measuring system with the process[1,2].

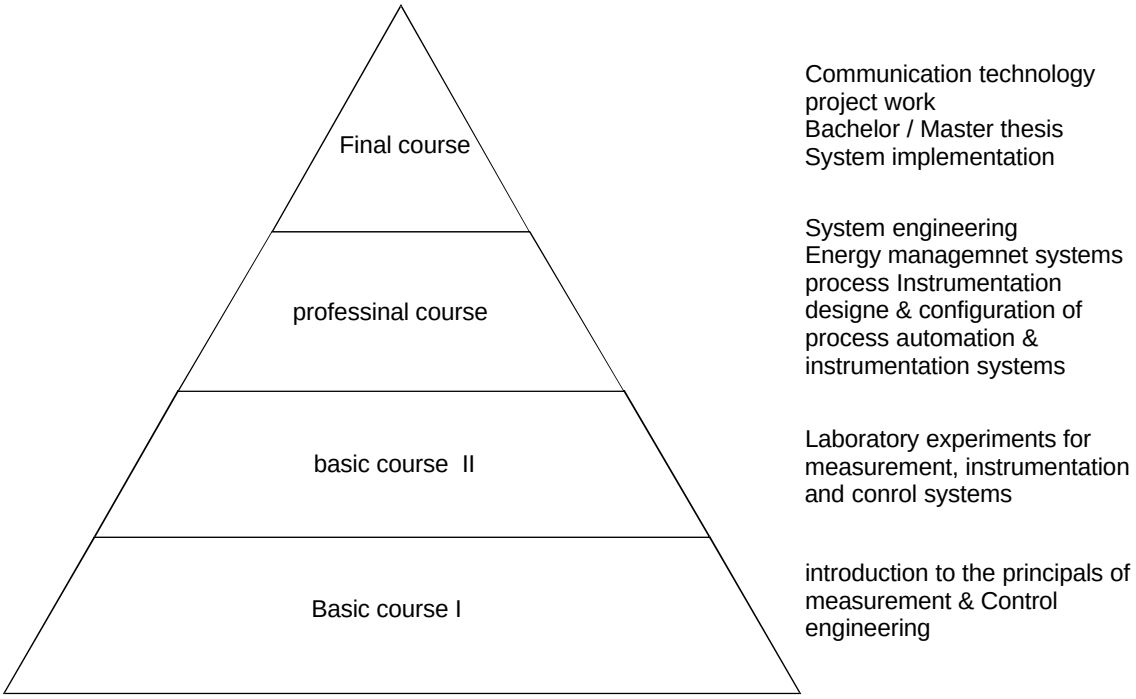

Figure 2. Industrial based training in Process automation and instrumentation systems

2.1.3 Laboratory Experiments as an important part of Innovative Teaching Method

The main goal of the laboratory experiments should be, firstly to intensify the theoretically acquired knowledge in MI&C, and secondly to analyse the interchanging influences of measuring system and the measuring process or object. For a successful graduating of laboratory exercises, it is very important, that the theoretically knowledge of the students must have a reasonable level before joining the Lab work, in order to solve the tasks and to prove the experimental results in MI&C fundamentals as efficient as possible.

Besides of experimental works in the Lab it is very important to analyse the measuring system in combination with the real process. Therefore it is necessary, that a real processing system should be installed in the Lab. Computer aided modelling, simulation and analysing of different processes, for instrumentation as well as for automation purpose of the process. Using of simulation technology increases the flexibility of Lab work for different instrumentation tasks. It is more comfortable to maintain special condition of process behaviour on a simulation system then on a real process.

2.1.4 Application oriented Project design Course

This teaching course is based on the basic level and on the graduated Lab. exercises in MI& C. In this course the student should get a deeply insight in hardware and software of integrated MI&C-process automation and controlling systems as the basis for design of a project. Based on examples for required process handling conditions, the student should be able, to define specifications for the necessary and efficient instrumentation and automation systems.

The next step of the course includes investigation of the functionality's of the instrumentation in combination with different steps of processing. Ending of this course should maintain a project work by a team of students where an integrative solution for processing and instrumentation assignments of an industrial oriented project is completed.

2.1.5. The FH (UASc)-Diploma Thesis as the final level of higher education .

For the most students who are interested to get higher qualification in MI&C engineering, completing of their FH (UASc)- Diplom thesis in this field is the best opportunity. Finishing an experimental oriented Diplom thesis in co-operation with M&I industry is a good opportunity to start in industrial life successfully. The teaching method described here, is already realised by the author at the department of measurement and Control engineering in the faculty of mechanical engineering.

3 NEW MASTER COURSE IN BUILDING ENERGY MANAGEMENT

3.1 Current teaching courses for m&c engineering for mechanical engineers

The main obligation of the faculty of mechanical engineering at the University of Applied Sciences Cologne is, to train engineers for building services like Heating Ventilation Air conditioning and chilling (HVAC)-Systems. Therefore the existing curricula as the FH-Diploma is at least 10 years old and had not enough teaching hours for measurement and control engineering. Only students with extremely high interest in this filed could reach the full qualifications described in part 2of this paper, by finishing a diploma work in the field of measurement and Instrumentation or building energy management.

Intensified co-operation between the department of MI&C engineering and the industrial companies in the last then years, was a good opportunity to increase the number of students interested in m&c engineering. More then 10 graduates have been awarded for the best thesis in the filed of BEMS. They are working at present, by leading companies for building automation systems. The topics of MI&C engineering and process automation could also win the interest of the faculty members and they also indicate more acceptance for the extending of teaching hours for this filed.

As a result of this situation, new courses and additional teaching materials for BEMS was formulated , in order to consider the qualification profiles of the graduates from industrial and technological point of view. Other aspects of this new course consider also offering of applied mathematics in Master course, in order to enable the graduates for more theoretical based Master work and for continuing PhD. Studies at the UASC or at other Universities.

3.2 Bachelor and Master courses at the faculty of mechanical engineering

The following tables 1-3 illustrates the new curricula for the Bachelor of engineering in building service engineers at the faculty of mechanical engineering of the UASC-Cologne.
Tables 4+5 illustrates an upgraded curricula for the Master of engineering in energy management systems based on the Bachelor courses .

Table 1. 1st year of Bachelor

Course	1st. semester			2nd. Semester		
	Lectures	Tutorials	Laboratory	Lectures	Tutorials	Laboratory
Chemistry	2	2				
Material sciences	2	2	1			
Mathematics I	4	2				
Mathematics II				2	2	
Information technology I	2	1				
Basics of electrical engineering	1	1		1		1
Analogue and digital electronics				1	1	
Fluid mechanics				2	2	
Physics	2	2				
Measurement techniques				1	1	
Heat transfer				1	1	
Thermodynamics				2	1	
Mechanics	1	1	2			
Computer aided design				2	2	1
Total hours	14	11	3	12	10	2
Total hours 1st year						**52**

Table 2. 2nd year of Bachelor

Course	3rd. semester			4th. Semester		
	Lectures	Tutorials	Laboratory	Lectures	Tutorials	Laboratory
Control engineering	2	2				2
Basics of electrical engineering	1	1	1			
Fluid mechanics	2	1	1			
Measurement techniques			1			
Economics for engineers	2	1		2	1	
Heat transfer	3		1	1	1	
Thermodynamics	1	1	1	2	1	
Heating systems				2	1	1
Air conditioning systems				2	1	1
Sanitary & Gas supply systems				4	1	1
Technical English				2	1	
Total hours	11	6	5	14	7	5
Total hours 2nd year						**48**

Table 3. 3rd year of Bachelor study

Course	5th. semester			6th. Semester		
	Lectures	Tutorials	Laboratory	Project	Bachelor	Thesis
Technical English	2	1				
Electrical engineering for buildings	2	2				
Building automation systems	2	1	1			
Process Instrumentation	2	1	1			
Heating systems	4	1	1			
Air conditioning systems	4	1	1			
Sanitary & Gas supply systems	4	1	1			
Project work				3		
Bachelor thesis					Bachelor	Thesis
Total hours	16	5	4			3
Total hours 3rd year			**28**			

3.3 Master course in building energy management systems

Table 4. 1st year of Master course

Course	7th. semester			8th. Semester		
	Lectures	Tutorials	Laboratory	Lectures	Tutorials	Laboratory
Applied mathematics	2	2		2	2	
Technical English- English	2	2				
Electronic circuits and Network	2	1	1			
µC-Operation systems and data networks	2	1	1			
Sensor and Actuator systems	2	1	1			
Information technology II				2	2	
Measurement &signal processing				2	1	1
Environmental measurement & energy management systems I				2	1	1
Electrical engineering for buildings				2	2	1
Energy management systems I	2	1	1			
Energy management systems II				2	1	1
Total hours	12	8	4	12	9	4
Total hours 4th year						49

Table 5. 2nd year of Master course

Course	9th. semester			10th. Semester	
	Lectures	Tutorials	Laboratory	Project	Master Thesis
Project management	2	2			
Computer aided Facility management	2	1	1		
Energy management systems III	2	1	1		
Environmental measurement & energy management systems II	2	2			
Total Quality management systems	2	1	1		
International Standards	2	2			
Project work in Energy management				1	
Master thesis in Energy Management					Master thesis
Total hours	12	9	3	1	
Total hours 5th. year (9.th Semester)			25		

Teaching will be as shown here, multilingual in German and in English based on the European Credit point Transfer System (ECTS), in order to enable the students to study partly at any European university with ECTS-System as they want.

4 CONCLUSIONS

The final version of the new curriculum for Energy Management System at the faculty of mechanical engineering has been formulated in accordance with the requirements for optimal teaching in Measurement Instrumentation, Control engineering and process automation for distributed, network oriented intelligent management systems in buildings.

The teaching hours for imparting application oriented knowledge in faculties of process & mechanical engineering, is extended as the response of educational establishments to the demands of well trained engineers from the view point of the industry as the future employers of their graduates.

This new curricula opens real opportunity at the faculty of mechanical Engineering for a full scale theory and application based teaching in energy management systems with a higher weighing of measurement control, information technology for the network oriented automation systems beside the other topics of energy management. The graduates will be well prepared for PhD. studies but also for a project management position by global market oriented companies of measurement and control engineering.

The author is the leader of a team in the faculty of mechanical engineering of the University of Applied Sciences of Cologne, and is responsible for the implementation of this new curriculum for Bachelor of Eng. for Building Service Engineering and Master of Eng. For Building Energy Management Systems at the faculty of mechanical engineering.

This new Curricula will be introduced to the interested public at the Exhibition “Light & Building” with the topic: -meeting point future for students- in Frankfurt / Germany from March 19-March 23 , 2000

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