Education of indoor environmental engineering technology

P. Kic[1] and M. Zajicek[2]

[1]Czech University of Life Sciences, Prague, Faculty of Engineering, Kamycka 129, 165 21, Prague 6, Czech Republic; e-mail: kic@tf.czu.cz
[2]Institute of Information Theory and Automation, The Academy of Science of The Czech Republic, v.v.i., Pod vodarenskou vezi 4, 182 00, Prague 5, Czech Republic; e-mail: zajicek@utia.cas.cz

Abstract: This paper is focused on the problems of teaching at a study course specialised in indoor environmental engineering technology for students of study programs Agricultural and Biosystems Engineering. Lectures and seminars cover all principal problems related to the environmental engineering technique for buildings in agriculture and Biosystems engineering. Special attention is paid to new methods of individual study with e-learning, modern methods of designing with specialised and commercial software, and programs (e.g. CFD Fluent, OpenFOAM, etc.). Seminars and laboratory work complete the education with practical or experimental measurements of all main microclimatic parameters (data loggers and sensors of thermal state, purity of air, noise, illumination, etc.), reports and designs prepared by students individually and presented during seminars at the end of semester.

Key words: Biosystems engineering, indoor environment, study, programs.

INTRODUCTION

Education specialised in agricultural engineering has a long tradition in the Czech Republic. During the last decades great changes in the economy and policy of the country have resulted in changes of the educational system. Many universities have decided to prepare new study programmes according to the priorities and interest of the young generation.

Currently, after the many changes taking place during the nineties and the first years of this century, Faculty of Engineering is educating graduates for the whole of the agri-food sector including the design of technological equipment of buildings in food industry and agriculture, road automobile transport, and trade and business involving machinery (Kic & Jurča, 2006).

A three year Thematic Network entitled 'Education and Research in Biosystems or Agricultural and Biological Engineering in Europe; a Thematic Network (ERABEE TN)' has connected universities from all European countries which are dealing with these problems, including several non-EC countries. Participation has helped to exchange information and prepare some new ideas for development and better education in all the active countries. New curricula together with methods for education and research have been proclaimed (Kic & Jurča, 2009).

It was obviously necessary to prepare a new course which would provide students with knowledge of theoretical principles, designing procedures and practical performance aspects of technical systems and equipment used for environmental control in buildings for production, storage, processing, and other purposes in agriculture, waste technology, and related branches of industry (Wang, 2001). This course should therefore cover all the main problems of heating, ventilation, and air-conditioning (HVAC) (Nový, 2000).

From the point of view of Engineering Education, one of the main common problems for all study programs is the question of air flows, air patterns, and air distribution inside the ventilated spaces.

These problems can be solved by several different approaches:

- Exact physical modelling
- Empirical equations based on experience from previous similar buildings
- Computer Fluid Dynamics.

The limited amount of time can be spent on such methods during education, but they are very important for engineering practice. The important points of the educational process and structuring of course curricula are described in this paper.

MATERIALS AND METHODS

Agricultural and Biosystems Engineering (ABE) encompasses a broad range of engineering disciplines, including mechanical, electrical and electronic, chemical and civil engineering, together with applied physics and several related sciences and technologies.

Parallel to the Technical Engineering orientation, ABE involves also a vital part of Biological and Human Engineering. Agricultural and Biosystems Engineering skills are also widely involved in developing and running the management and controlling systems of various agriculture and biosystems based processes.

The mission of Agricultural and Biological Engineering (ABE) as a profession is to combine technical, biological and human engineering in a well balanced way. The skills of ABE profession are needed everywhere when natural resources are used and processed to serve the welfare of the mankind.

Biosystems Engineering encompasses research in the physical sciences and engineering to understand, model, process or enhance biological systems for sustainable developments in agriculture, food production, land use, and the environment.

Faculty of Engineering CULS Prague covers practically all the main parts of the branches from the first definition of Biosystems Engineering by its courses and research activities. In the area of new emerging discipline we could include studies specialising in waste management technology besides the study of information and control technology in Agri-food Complex.

The aim of the course

The curricula and content of the new course should cover a theoretical background, practical laboratory experiments and informative knowledge of the new design methods.

The modern methods of computer fluid dynamics (CFD) are used as one of the tools which are suggested to students for the HVAC simulations and can also be used for their individual projects. Mainly the OpenFOAM (Open Field Operation and

Manipulation), an open source CFD software package produced by a commercial company, OpenCFD Ltd., is being used. It has a large user base across most areas of engineering and science, from both commercial and academic organisations. OpenFOAM has an extensive range of features for solving anything from complex fluid flows involving chemical reactions, turbulence, and heat transfer, to solid dynamics and electromagnetics. For teaching purposes we use just fluid flows and thermal simulations. Moreover, the commercial CFD package Fluent (Ansys Inc.) is considered part of the course with practical demonstration (Kic & Zajicek, 2010) of a complex model with the evaluation of velocities, temperatures, and species concentrations (Fluent, 2006).

The education process is not influenced by the kind of problems solved by the above methods as it covers a wide range of study programs and applications with similar physical background. It is important to choose technical problems which would be easily understandable and interesting for students of all study groups.

The study course schema shown below (Table 1) includes a comparison with the standard EurAgEng classification.

Table 1. Study Course: Environmental Engineering Technology (EET).

Course EET Included in curricula	Year of study	Existing study programs: FE at CULS Prague	Programs of studies (ABE): EurAgEng
Obligatory	5	Waste Disposal Technology and Techniques	Waste management
Obligatory	5	Technological Equipment of Constructions	Structural systems and materials
Obligatory	3	Information and Control Technology in Agri-food Complex	Information technology and automation
Obligatory	4	Maintenance Engineering	Mechanical systems and mechanisms
Voluntary	4	Agricultural Machinery	Mechanical systems and mechanisms
Voluntary	4	Machinery for Landscape Reclamation and Maintenance	Mechanical systems and mechanisms
Voluntary	5	Trade and Business with Machinery	No

Laboratory equipment

The older laboratory equipment was completed with some new instruments, e.g. thermovision camera IR Flexcam Pro, mobile weather station, Ahlborn measuring instruments, and sensors with ALMEMO connectors for measurement of all main parameters needed for this area of research and education, e.g. temperature sensors with NiCr-Ni thermocouples, Pt100 and NTC, thermowires and compensation lines, capacitive humidity sensors, psychrometer, thermoanemometers, air flow, comfort index measurement in room conditions, WBGT measurement, measuring thermal transmittance and heart flow for building physics, sensors for measuring moisture in materials, surface temperature, soil humidity measurement, global radiation, light, luminous intensity, gas concentration in air (oxygen, carbon dioxide, carbon monoxide, ammonia, hydrogen sulphide, etc.

Software

Appropriate software is used for data evaluation from measuring devices during the course. Mainly the thermovision data has to be evaluated with such kind of software.

As it was mentioned, students have also the possibility to use open source CFD software OpenFOAM to compare simple two dimensional models with their measurements.

RESULTS AND DISCUSSION

Study Course: Environmental Engineering Technology (EET)
Code: TGT10E
Department: Department of Technological Equipment of Buildings
Masters, semester 10.
Form of Study: Lectures, seminars and laboratory training
Type of Exam: Written and oral

Description of the course

The course includes theoretical bases, principles, designing procedures, basic calculations, practical measurement and evaluation of the main parameters of environmental control engineering. Seminar content covers measurements with basic instruments as simple designing activities (design of technical systems and equipment in environmental engineering).

Knowledge

Students have theoretical knowledge in the area of exact processes in projecting and problem solution of environmental engineering technique based on mathematical and physical principles, with application to specialised modern information technologies and processes, which means mainly knowledge of how to evaluate comfortable environment and principles of technical solutions for indoor environment improvement, above all ventilation, air-conditioning, and heating. The obtained knowledge forms the basis for original thinking and enables participation in research. The understanding of principles, theories and methods corresponds to their position in management, leadership and research. Graduates can work in research, development and production at medium level or top management. They have critical awareness of their knowledge and ideas about the content of their further study in their branch.

Skills

Students are able to use their knowledge by solving problems in designing, development, research and innovations. They are able to integrate knowledge from different branches into practical applications and create new knowledge and processes at the level of small and medium companies, as leaders of creative teams. They can creatively apply their theoretical and special knowledge in designing, production, business and production conditions of different enterprises.

Competence - judgement formation

Students are able to work creatively and take initiative. They are able to look up and use suitable data, information and sources. On the basis of the obtained knowledge they are used to considering the whole complex of the existing situation. They can choose new strategic methods in solving and management projects.

Competence - communication

Students are prepared for team work at different levels of their position in team. They can formulate and present their own opinions, ideas and information. They are able to concretize solutions and results, evaluate the positive and negative aspects of different variants with the aim to optimize results with respect to social responsibility.

Competence - ability of further learning

Students have the capacity of autonomy in learning, there are able to study individually, follow special sources of information, and decide their own needs of self education and other sources of information. They can critically evaluate the obtained information in the changeable conditions. They are able to identify their own suitable rate of study according to the needs of the existing situation.

Lectures

1. Introduction; aim of environmental control engineering; quality of indoor environment and its principal properties. Thermal state of environment;
2. Noxious gases and odour microclimate. Aerosols and microbial microclimate;
3. Ionization microclimate. Daylight and artificial lighting. Technical acoustics;
4. Parameters of outside climate. Properties of humid air and its basic changes;
5. Calculation of air flows for ventilation and air-conditioning. Distribution of air inside the ventilated space;
6. Calculation of heat losses and their reduction;
7. Calculation of heat losses in ventilation and air-conditioning. Principles of low energy cooling;
8. Types of ventilation systems. Natural and forced ventilation. Local ventilation and exhaustion;
9. Fans; tubes; inlets; outlets; regulation components. Sound control and silencers. Filters and separators;
10. Heaters and coolers of air. Systems of heat recuperation and regeneration. Humidification of air. Cooling systems in air-conditioning;
11. Air-conditioning systems, components and equipment;
12. Ventilation and air-conditioning in agriculture;
13. Ventilation and air-conditioning in industry, workshops and service buildings;
14. Heating. Principles and application.

Laboratory and seminars

1. Introduction, program of the course, requirements of laboratory and seminars. Individual semestral projects (ISP) – home work – application study;
2. Excursion in air-conditioning in the central air-conditioning chamber. Standards and designing principles in EET. Description and definition of main parameters. Control of topics of ISP;
3. Standards, methods and instruments for measurement of air temperature and humidity. Measurement, evaluation and test report;
4. Standards, methods and instruments for measurement of air velocity and air flows. Measurement, evaluation and test report. Control of progress in ISP;
5. Standards, methods and instruments for measurement of surface temperatures. Measurement, evaluation and test report;
6. Standards, methods and instruments for measurement of thermal state of environment. Measurement, evaluation and test report. Control of progress in ISP;
7. Standards, methods and instruments for measurement of indoor environment quality – noxious gases; aerosols, dust and microbiological microclimate. Measurement, evaluation and test report;
8. Standards, methods and instruments for measurement of light and illumination. Measurement, evaluation and test report. Presentation of ISP;
9. Standards, methods and instruments for measurement of noise. Measurement, evaluation and test report. Presentation of ISP;
10. Parameters of outside climate, calculation of humid air parameters and its changes – application in designs. Presentation of ISP;
11. Calculation of air flows for ventilation and air-conditioning – application in designs. Natural ventilation – application in designs. Presentation of ISP;
12. Calculation of heat losses and heat loads in ventilation and air-conditioning – application in designs. Presentation of ISP;
13. Fans – application in designs of forced ventilation. Presentation of ISP;
14. Presentation of ISP. Evaluation of semester and credits.

Numerical simulation results

The typical outputs of students' ISP are shown below. Fig. 1 shows the graphical representation of temperature profile in the whole cross-section of the building. Fig. 2 shows the graph of temperature profile in two levels above the floor with corresponding measured values, and Fig. 3 is a graphical visualization of the concentration of iso-surfaces for a 3D model of a farm building.

An important part of laboratory seminars has to be the discussion of results, which makes the students analyze the variation of numerical solutions according to measurements and also according to simplifications which are always included in the model. The trust of numerical results must always be strictly critical and the student has to understand such a fact as part of their work.

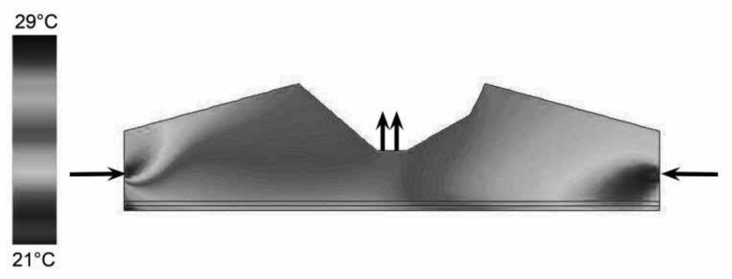

Figure 1. Temperature profile of a special shaped building. Inputs and outputs are indicated by arrows.

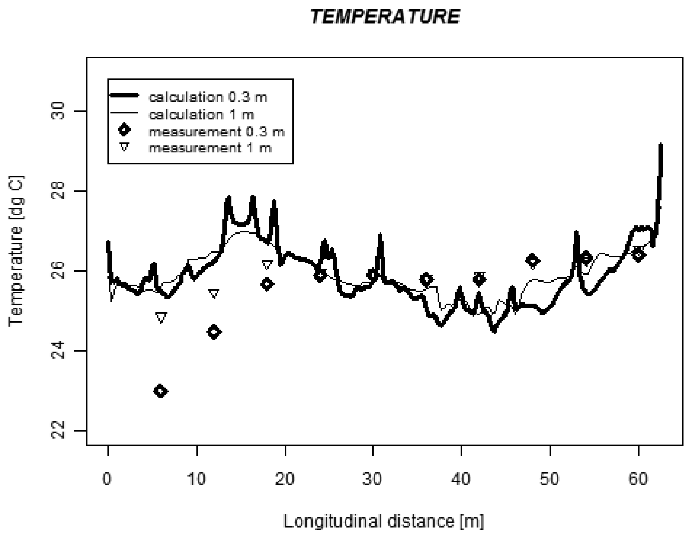

Figure 2. The comparison of temperature profiles along the broiler house, comparison of calculated and measured values.

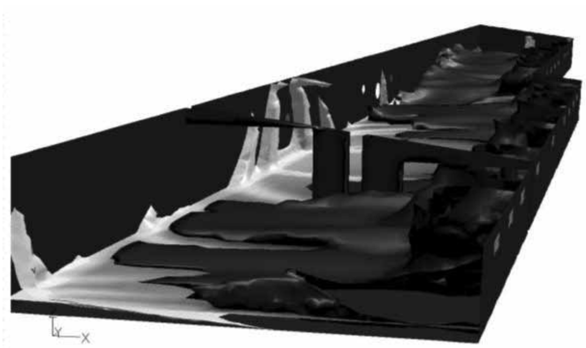

Figure 3. Iso-surfaces of NH_3 mass fraction value in a cross ventilated narrow building. The dark one belongs to the higher concentration.

CONCLUSIONS

A lot of one term works from the course were developed, as well as Bc. and also MSc theses as final projects for graduation were finished. Several interesting PhD. theses based on the knowledge studied first in this course were defended.

This course is a very important source of basic knowledge and skills for a future chartered (accredited) engineer by Czech Chamber of certified professional engineers and technicians active in construction. Authorized Person (AO) is required to carry out activities for which it was granted authorization in accordance with generally binding legal regulations and in accordance with professional and ethical regulations. Several graduates are owners of their company for designing, installation and also production of equipment for HVAC.

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