Education of indoor environmental engineering technology

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Abstract: This paper is focused on the problems of teaching of a study course specialised on indoor environmental engineering technology for students of study programs of 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 the new methods of individual study with e-learning, modern methods of designing with use of 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 word: Biosystems engineering, indoor environment, study, programs

INTRODUCTION

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

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

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 active in these problems from all European countries including several non EC countries. Participation helped to exchange the information and prepare some new ideas for development and better education in all active countries. New curricula and methods for education and research were proclaimed (Kic & Jurča, 2009).

There was obviously necessary to prepare a new course which will 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 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 for such methods during education, but they are very important for engineering practice. The important points of 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 consist 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 of Agricultural 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” is research in the physical sciences and engineering to understand, model, process or enhance biological systems for sustainable developments in agriculture, food, land use and the environment.

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

Aim of the course

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

The modern methods of the computer fluid dynamics (CFD) are used as a one of tools which are suggested to students for the HVAC simulations and also can be used for their individual projects. Mainly the OpenFOAM (Open Field Operation and Manipulation), which is an open source CFD software package produced by a commercial company, OpenCFD Ltd. 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 to solve anything from complex fluid flows involving chemical reactions, turbulence and heat transfer, to solid dynamics and electromagnetics. For the teaching purposes we use just a fluid flows and thermal simulations. Also the commercial CFD package Fluent (Ansys Inc.) is shown as a part of the course with practical demonstration (Kic & Zajicek, 2010) of complex model with evaluation of velocities, temperatures and the species concentrations (Fluent, 2006).

The education process is not influenced by the kind of problems solved by the methods because it covers wide range of study programs and applications with similar physical background. There is important to choose technical problems which can be easy understandable and interesting for students of all study groups.

The study course schema is shown bellow (Table 1.) includes the 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

The 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 the 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, seminary 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 main parameters in environmental control engineering. Content of seminars covers so measurement using 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 problems solution of environmental engineering technique based on mathematical and physical principals, with application of specialised modern information technologies and processes, which means mainly knowledge of evaluation of comfortable environment and principles of technical solutions for indoor environment improvement above all ventilation, air-conditioning and heating. Obtained knowledge forms the basis for original thinking and enable participate in research. The understanding of principals, theories and methods corresponds to their position in management, leading and research. Graduates can work in the 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 the practical applications and create new knowledge and processes at level of small and medium companies, as leaders of creative teams. They can creatively apply their theoretical and special knowledge by designing, in production, business and production conditions of different users' enterprises.

Competence - judgement formation

Students are able to work creatively and initiatively. They are able to search out and use the suitable data, information and sources. On the base of obtained knowledge they are used to consider the whole complex of the existing situation. They can choose new strategic methods in solving and managing projects.

Competence - communication

Students are prepared for team work in 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 the social responsibility.

Competence - ability of further learning

Students have the capacity of autonomy in learning, there are able to study individually, follow the special sources of information, and decide their own needs of self education and other sources of information. They can critically evaluate obtained information in the changeable conditions. They are able to identify their own suitable rate of study according to 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. Principals 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 according 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 student's ISP are shown bellow. 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 iso-surfaces for 3D model of farm building.

The important part of laboratory seminars has to be a discussion of the results, which leads the students to analyze variation of numerical solution according to measurement and also according to the simplifications which are always included into the model. The trust into numerical results must be always strictly critical and student's has to understand such fact as a matter of course for their work.

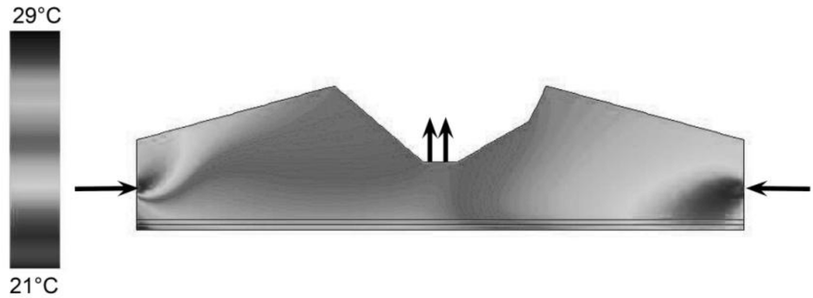

Figure 1: Temperature profile of the special shaped building. Inputs and outputs are indicated by arrows.

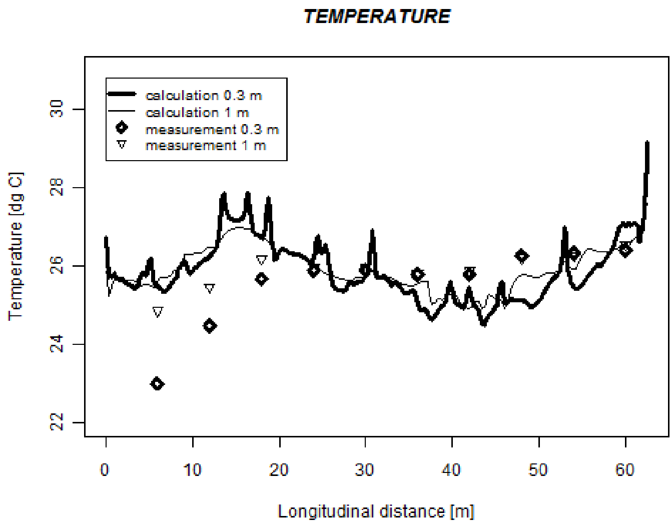

Figure 2: The comparison of temperature profiles along the broiler house, comparison of calculated and measured values.

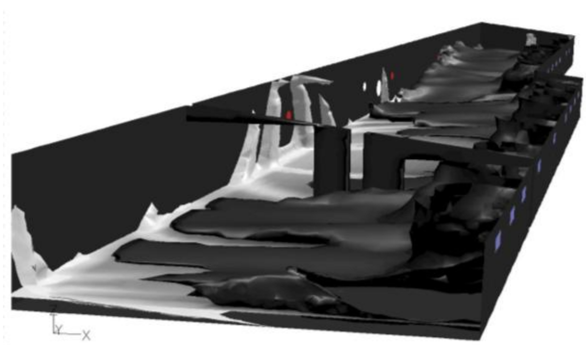

Figure 3: Iso-surfaces of NH_3 mass fraction value in cross ventilated narrow building. The dark one belongs to the higher concentration.

CONCLUSIONS

A lot of one term works from the course was developed, as well as Bc. and also MSc thesis as final projects for graduation were finished. Several interesting PhD. thesis 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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