Case study tools in the multimedia interactive teaching-learning platform for energy technology

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Abstract: - The tools called case study are normally presented in the computerized educational (CompEdu) platform as short pages with popups giving precise short introduction into some narrow subject. The CompEdu is based on the multimedia interactive presentation of a slide show of lecturing material in a non-conventional way where the material is presented in a progressive and concise way ensuring the coverage of large portions of material in shortest number of pages. In this paper, some recent results in the development of case studies by different subjects with emphasize of the new combustion systems are presented and discussed. Also some methodological aspects and features are discussed concerning their advantages for intensive and easy (pleasant) form of teaching-learning using computerized system developed at EGI/KTH.

Key-Words: - CompEdu, Case Study, Interactive Teaching-Learning System, Multimedia.

1 History of the CompEdu platform

The interactive multimedia computerized educational (CompEdu) platform contains theoretical sections in the form of e-pages for each chapter of the subject studied in energy technology, which has a number of related interactive simulations, movies, animations, virtual laboratory exercises, study visits and realistic case studies (see Fig. 1). And what is most important, it is a platform for international life-long teaching-learning in the virtual university of collaborative consortium, which shares the best materials for teaching and learning.

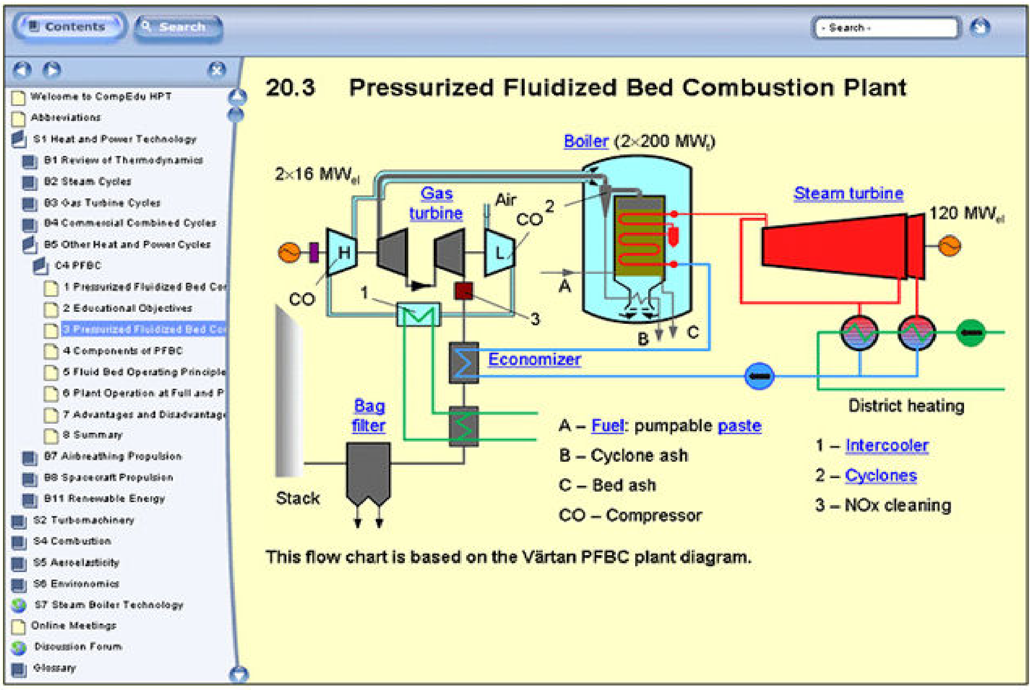

Fig. 1. General view of the online version CompEdu HPT platform, one page

The interactive multimedia computerized educational (CompEdu) platform contains theoretical sections in the form of e-pages for each chapter of the subject studied in energy technology, which has a number of related interactive simulations, movies, animations, virtual laboratory exercises, study visits and realistic case studies. And what is most important, it is a platform for international life-long teaching-learning in the virtual university of collaborative consortium, which shares the best materials for teaching and learning.

Historically the first CompEdu platform for the turbomachinery courses has been developed since 1996 at the Energy Technology Dept. at KTH [1-4] under leadership of its founder Prof. T.H. Fransson. It was used for lecturing, as well as for self-study by students in a several courses. Started from CD, then it was done on DVD, and then on two DVDs after it grew substantially by content. Recently it was transformed to the online version (see Fig. 1) for the internet world-wide teaching and learning inside virtual university claster [5]. It helped to increase dramatically a number of distant educational programs and students.

2 Case study pages in CompEdu

The success of the interactive teaching-learning system at the EGI/KTH has encouraged developers to investigate the multimedia tools and permanently modify and improve them with the ideas coming from teachers and students. The main objective was to establish a comprehensive learning and teaching tool, which would be comfortable and pleasant for the both, teachers and learners**.** The other objective of the CompEduHPT platform was building the computerized tool, which could be used as an international interactive computerized platform for a global learning, in which teachers from different universities cooperate with one goal to make the learning easily accessible for students anywhere in the world (Fransson, et al., [1]).

With the above ideas, one of the tools developed in CompEdu was case study, which might be stand-alone or connected to the existing chapter by subject, e.g. numerical methods, measuring technique, boilers, etc. Normally case study is a supplementary tool to the chapter by the same subject.

The concept of the interactive CompEduHPT platform is based on the idea that the design of the main pages has been given much attention in order to present an easily understandable material and to keep students' interest along the chapter providing them with the possibility to adapt their learning process to their needs. And the case study tools are going to give material for the short effective study by narrow subject.

In this paper we describe an example of the case study developed for CompEdu by the new combustion systems, which is supplementary to the chapter by the same subject.

3 Case studies by the new combustion systems

3.1 General view of the main page

The general view of the case studies main page in given in Fig. 2:

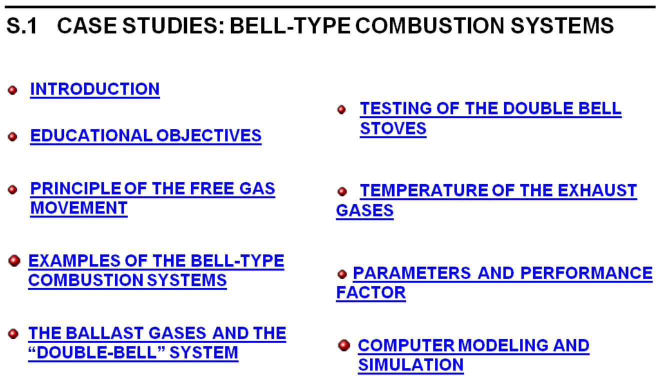

Fig. 2 Main page of the case studies tool

where it might be observed that the design of the main page represents the list of the most important subjects considered in this case study. All of them are connected to the specific hyperlinks, which may be done in two levels, when from the hyperlink of the first level there may be connection to the second-level hyperlink if any further clarification is needed. Normally it is done is the are a lot of materials, which cannot be placed on one hyperlink.

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3.2 Hyperlinks from the main page of the case studies

As one could see from the Fig. 2, on the main page there are introduction to the subject, educational objectives (two standard hyperlinks, which are done in every chapters and case studies), then all other hyperlinks are done according to the specific subject considered in case studies. In our case there are seven such subjects by hyperlinks.

3.3 Introduction to the case studies by new type of combustion systems

This case study provides the information about the free gas movement combustion systems and their difference from the well-known conventional co-current and counter-current combustion systems. Also it shows a few bell-type principles and combustion systems – stoves, boilers, pyrolysis combustion systems, etc.

3.4 Educational objectives by the case studies

The educational objectives by this case studies are study the basics of the free gas movement principle for the construction of the combustion systems and learn some examples of such systems: bell-type small and big stoves including the multifunctional ones, boilers, pyrolysis systems, etc.

4 Educational materials in case studies by the new combustion systems

4.1 The principle of the free gas movement

In the furnaces built in accordance with the principles of forced gas movement system the hot gases under the action of chimney draft are running along the channels to the top and to the bottom, to the left or to the right. Under such circumstances, when hot gases move over the channels, their heat energy is used for heating the walls, while the gases are cooled down in due time.

Thus, obviously the furnace is heated non-uniformly, due to that the danger of crack initiation becomes greater. These furnaces are not provided with any other space for placing the heat exchanger, except for the firebox.

In contrast to the above, in the free gas movement (FGM) systems, for instance, so-called channel-free-bell-shaped furnaces, the convective system consists of bells connected in series. When hot gases being lighter move through the bell, they rise up due to the thermal convection, then they are accumulated in the bell where they uniformly warm up the walls. If the heat exchanger is placed inside the bell, it removes partly heat from hot gases too. Cold gases being heavier are pushed down from the top by lighter hot gases and pass through the lower part of the bell into another bell or chimney exerting no influence on the heat exchanger. The bell is practically a vessel turned upside down.

Such multifunctional stoves may be done for three store houses with one combustion system on the ground store (see examples presented in Fig. 3 and in Fig. 4).

The Kuznetsov's heat-generating devices patented in 1992 in Russia are built in accordance with the formula "The stove's lower level and the firebox are combined to form a single space creating a lower bell". The essence of the formula concerns fuel combustion in the firebox placed inside the bell and optimal use of extracted heat energy. The conception is aimed at receiving the maximum amount of a heat from the fuel combustion and on using it efficiently; the design of heat-producing device shall meet functional requirements and ensure maximum heat transfer.

Fig. 3 Multifunctional stove built on free gas movement (beel-type) principle with fire place

Fig. 4 Multifunctional stove built on free gas movement (beel-type) principle with baking compartment

Let's fill the bell with a portion of a hot air. Hot air being lighter than surrounding colder air will rise up and push the colder heavier air out of the bell and will remain there until its heat warms up the bell's walls. As a result we will obtain a system accumulating heat of hot air in a limited space.

Hot air moves in the bell due to a thermal convection and does not require any external energy for this action. If hot air flow is going through the lower zone of the bell, the latter one will accumulate its heat (see Fig. 5). The heat of hot air will be transferred to the bell's walls and to the heat exchanger placed inside the bell, and the surplus of heat (cooled air) will be exhausted. Water boiler registers, air heater, retort for fuel gasification, etc. can serve as the heat exchangers.

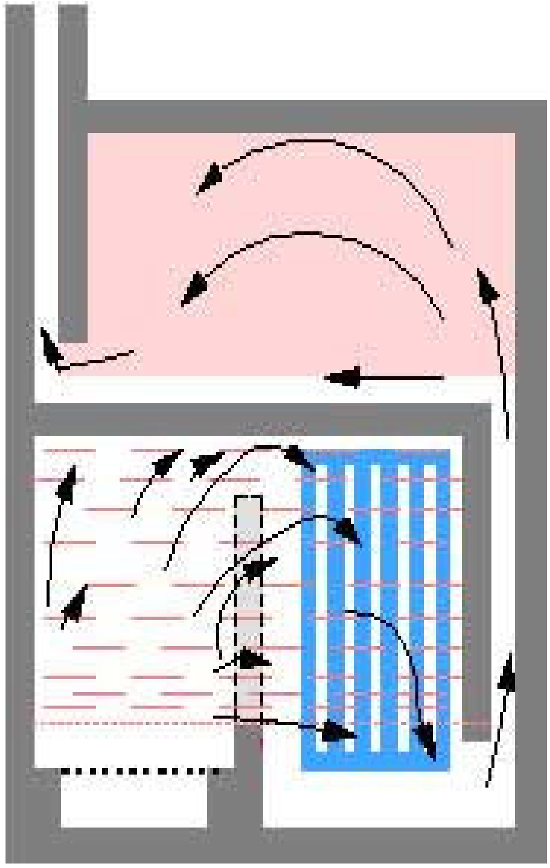

Fig. 5 To the principle of the free gas movement

The gas flow that runs in a heat-generating device with any convective system transfers heat energy and products of combustion. In order to understand the difference of gas flow mechanism in forced -and free gas movement system let's imagine that an electric heater is the source of heat. In this case it is not necessary to exhaust the products of combustion. In the system of free gas movement, for example in the double-bell furnace the heat transfer takes place due to natural forces even with a closed damper (without chimney draft). A certain time is needed to transfer heat and in case the bell or the heat exchanger do not have enough time to accumulate the entire heat generated by the electric heater, the surplus of heat in the form of waste hot air, will be transferred to the second bell.

The heat transfer in the second bell is made in the same way as the heat transfer in the lower bell. This process of heat energy transfer reflects the essence of the system's name" "the system of free gas movement". In order to exhaust the products of combustion, if fuel combustion is the source of the heat energy, chimney draft is necessary. It should be pointed out that gas movement inside the bell will be turbulent.

4.2 The free gas movement and bell-type stoves

The gas flow that runs in a heat-generating device with any convective system transfers heat energy and products of combustion. In order to understand the difference of gas flow mechanism in forced -and free gas movement system let's imagine that an electric heater is the source of heat. In this case it is not necessary to exhaust the products of combustion. In the system of free gas movement, for example in the double-bell furnace the heat transfer takes place due to natural forces even with a closed damper (without chimney draft).

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As distinct from the FGM system, the heat energy transfer in the system of forced gas movement is possible only in case the chimney draft is available. When hot gases run along the channels, their heat warms up the walls while the gases themselves get cooled down due loss of heat. The stove warms up non-uniformly; therefore the probability of crack initiation increases. These stoves are not provided with any other space for placing the heat exchanger, except for the firebox. Therefore this is the essence of difference in mechanism of transfer and usage of heat energy in the above-mentioned systems.

4.3 The ballast gases and the "double-bell" system

The ballast gases, being cold and heavy, do not go up and do it mainly through the dry joint. The largest part of the fuel energy is extracted in the first bell but in the upper bell, the combustion energy is increased to a higher level and the gasses continue to burn there until the temperature is at least somewhat higher than the temperature of exhaust gases from the lower bell. That is, until this heat is absorbed by the heat exchanger. The optimal use of the exhaust energy is realized through a use of the "double-bell" system.

The system is very flexible and provides an opportunity to adjust the design for various purposes. The bell may have any form and volume. A boiler, heat exchanger, steam generator, retort, heat-accumulating device providing a 24-hour heat output or other equipment may be installed inside of it. Unlike a forced-gas system, this system provides fuel combustion conditions matching the needs of the heat exchanger, that is, the heat emission can increase without adversely affecting combustion efficiency.

4.4 Temperature of the exosted gases

The temperature of exhausted gases is being optimized. It should be slightly over the condensation point, which is 42°C. Normally masonry experts state it at 70°C with account of stove work under low-temperature conditions during the winter time.

Besides the above-mentioned tests, another stove tested, similar to the first one, in which wood was laid vertically with a slight inclination aback was performed too. The stove was built without dry joints and registers. In this stove the grate was made of four fired elements in the form of triangles mounted on the base with a vertex on top. Between the elements there were crevices about 10 mm for primary air supply.

At the beginning of fuel combustion when carbons don't clog up the slots between the grates, combustion takes place quickly. Then smoke and fumes come out from the chimney, dirty burning is going in this case. When the slots become clogged combustion becomes cleaner. It is important to point out that the firebox door should not be open due to the fumes.

4.5 Parameters of the combustion system and performance factor

Based on the results of modelling, then by the parameters achieved the exhaust gas flow rate and the flow temperature are computed. By these parameters the performance factor of the stove is determined as the ratio of the utilized heat to the whole amount of a heat produced in a fire box.

To increase the performance factor or to achieve another goal, e.g. more uniform temperature distribution by the stove walls, one needs to perform simulation using control parameters including variation of the geometric ratios in different places of the stove, configuration of the fire box, intensity of the combustion, etc.

Based on the results of modelling and analysis, the new optimal construction and the corresponding stove parameters are sought in the computer simulation. Finally the optimal stove construction found by simulation is designed in the SolidWorks platform, which produces the stove detailed drawings for masonry. There were also another tools used for similar purposes, e.g. Archicad system but the SolidWorks platform is more powerful and allows easily construct and reconstruct the system, as well as compute physical processes taking part inside the system.

5 Computer modeling and simulation of the processes in combustion systems

5.1 The 3-D SolidWorks model

Finally the optimal stove construction found by simulation is designed in the SolidWorks platform, which produces the stove detailed drawings for masonry. There were also another tools used for similar purposes, e.g. Kuznetsov is using Archicad system but the SolidWorks platform is more powerful and allows easily construct and reconstruct the system, as well as compute physical processes taking part inside the system.

The objectives for computer simulation of the free gas movement and heat transfer in the new combustion systems have been stated in a following way:

- through the modeling and simulation get the features of the parameters' interconnection, their mutual influence and an influence on the combustion processes,
- create the tools and programs for computer design and optimization of the combustors and stoves depending on the specific needs of customer.

The 3-D model for one construction of the double-bell stove is presented in Fig. 6, where the stove made by bricks is presented layer-by-layer so that masonry may build it by such drawings even without any previous experience in building this type of systems.

Scientist or engineer can use it for modeling and simulation choosing the optimal construction by the criteria stated. This tool allows presenting the results of thermal hydraulic calculations in any cross section he likes.

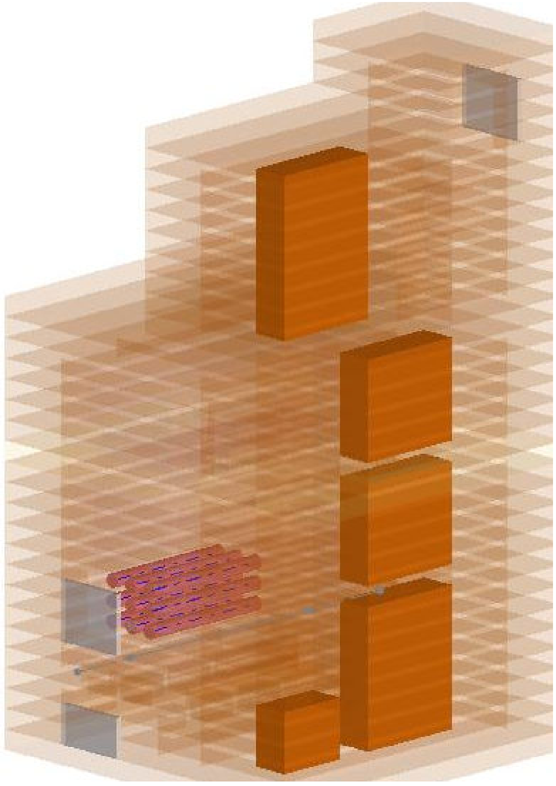

Fig. 6 The 3-D model of the stove construction

5.2 The results of computer simulation

The results of computer modeling and simulation are useful for understanding the processes inside the stove and thus for their optimization, what is highly important. An example of such simulation is presented in Fig. 7, where the temperature distribution is shown:

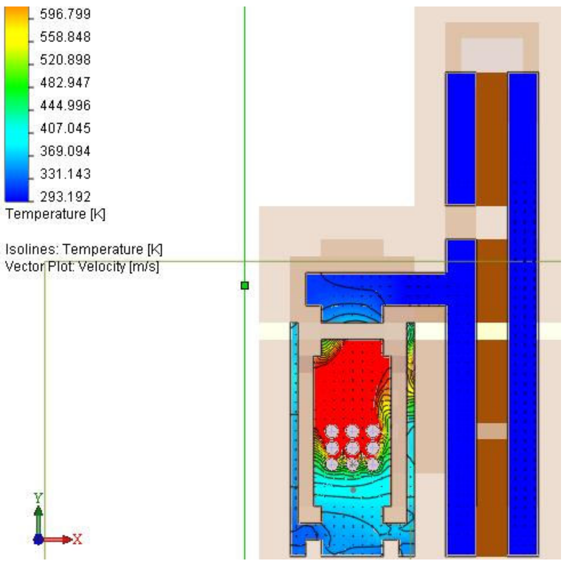

Fig. 7 Parameters of the thermal hydraulic processes inside the stove

From the results like the ones presented in Fig. 7 the peculiarities of the stove work are understable, e.g. the uniformity of the heat transfer and temperature field, the places with a highest and lowest temperature, temperature of the chimney gases. By these parameters the quality and performance of the combustion systems are estimated.

The construction maybe easily changed and in such a way there is possibility for searching the optimal construction by desired criteria.

6 Conclusion

The case studies by subjects as a tool in the CompEdu platform are successfully used for learning the specific subjects in general and maybe useful in further development and modifications of the multimedia platform.

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