Information Technologies In Training Nuclear Fusion Engineers

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Abstract

The construction of the International Thermonuclear Experimental Reactor in Cadarache (France) is one of the largest-scale science projects in the field of power engineering. The project country-members (the European Union, Japan, the People´s Republic of China, India, the Republic of Korea, the Russian Federation and the USA) are intensively working on the improvement of engineering training programs, so that future engineers could master state-of-the-art and promising fusion technologies, and by the time the full-scale reactor is operational (in 2018), could operate it to conduct long-term research. The engineering training programs place an ever-increasing emphasis on design training, engineering analysis, and remote technologies for conducting experiments and real-time data processing, all based on modern information and telecommunication technologies.

Introduction

The Bauman Moscow State Technical University, the oldest technological university of the Russian Federation, is taking part in training engineers for the field of controlled thermonuclear fusion for maintenance of the Experimental Thermonuclear Reactor (ITER) and conducting comprehensive research. The engineering training programs are agreed upon with the leading research institutes in the field.

The thermonuclear fusion subject areas cover a broad spectrum of knowledge in different fields of science and technology: high-temperature plasma physics, cryogenic equipment, vacuum equipment, superconductors, nuclear technologies, etc. To become proficient in such a great number of various subjects is impossible without using modern information technologies. At Bauman University these technologies are used in design training, studying modern simulation techniques and comprehensive engineering analysis, methods and tools for real-time experimental data processing, and in the area of distance-control technologies for complex technical systems. Great significance in engineering training is attached to the provision of modern teaching aids, practical and laboratory training manuals (including electronic ones), to conducting experiments on sophisticated experimental facilities and using modern graphical and CAD environments. Bauman University achieves this by means of close contacts with one of the leading research institutes in the field of controlled fusion - the Nuclear Fusion Institute of the Russian Scientific Center “Kurchatov Institute”, making use of its experimental equipment and attracting its personnel to the training process.

Design Training

For detailed study of ITER subsystems developed by the leading specialists of the international community of ITER project members, Bauman University together with the Nuclear Fusion Institute has created the electronic Atlas of ITER assemblies based on published materials. The Atlas requires only an Internet browser and a PDF reader program, and used by other Russian universities involved in ITER specialist training.

All menu directives in the Atlas are written in two languages – Russian and English, the latter being adopted as the official language of the international ITER project. This approach enables students to get used to the international terminology for units, assemblies and the main systems of thermonuclear reactor, which will make it easier for them to navigate in the international and national ITER developers’ sites, as well as to read scientific literature. The graphical menu system is designed to fully reflect the structure of the ITER reactor and its main units, and is sufficient for the initial familiarization with the reactor structure and configuration.

The Atlas main menu contains sections corresponding to the main reactor systems: magnet system, in-vessel compo-

nents, cryogenic system, vacuum-tritium complex, remote handling equipment, additional heating and current drive systems, diagnostics.

The dynamic menu makes it possible to visually demonstrate to the user the layout of the reactor units and assemblies. As the mouse cursor points to a menu directive (Fig.1) the corresponding reactor unit is colored red in the reactor sketch map. Clicking on a Menu directive takes the user to the selected section (Fig.2). At the top and bottom of the page there are hierarchic menus for easy navigation and memorization of the reactor system structure and configuration. The main units of the assembly are provided with information on their function and necessary comments.

By clicking on the appropriate link the user can move over to the pages containing icons with reactor subsystem images (Fig.3); and clicking on an icon will bring him to the corresponding drawings (Fig.4).

Fig.1. Main page of the Atlas of ITER assemblies

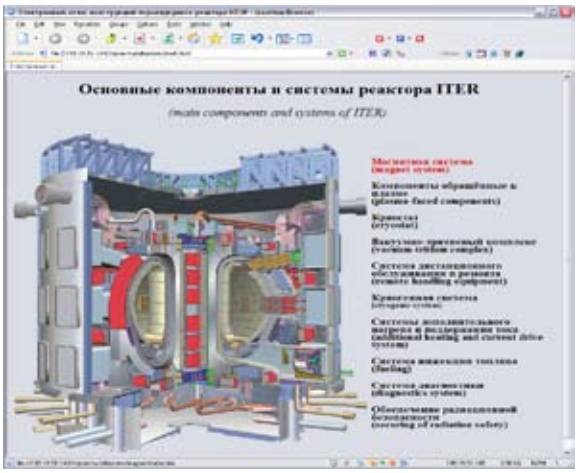


Fig.2. Section “Divertor”

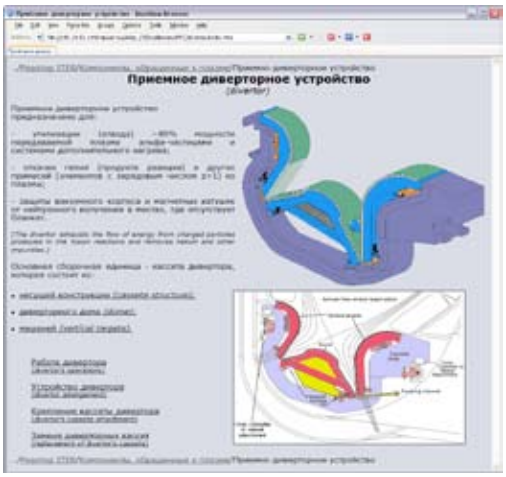
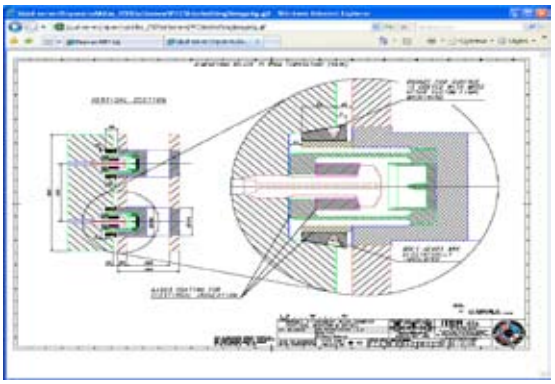


Fig.3. Image map with links to drawing files

Fig.3. Page with assembly unit drawings



It should be noted that the assembly files are presented in GIF or PDF formats suitable for local and network browsing. To make a reactor unit drawing for a term project students must use some graphics editor program.

At the next stage of design training students can make use of modern CAD systems. Bauman University has student versions of the CATIA packet which allow users to edit geometric models of elements and units for term and diploma projects. (Fig.5). To study engineering analysis students can use modern finite element packet programs. Fig.6 demonstrates the ANSIS packet window, whose educational version is also used in training process.

Apart from the packet programs developed by foreign companies, we also use the software environments developed at Bauman University.

Fig.5. Geometric model editing in the CATIA packet

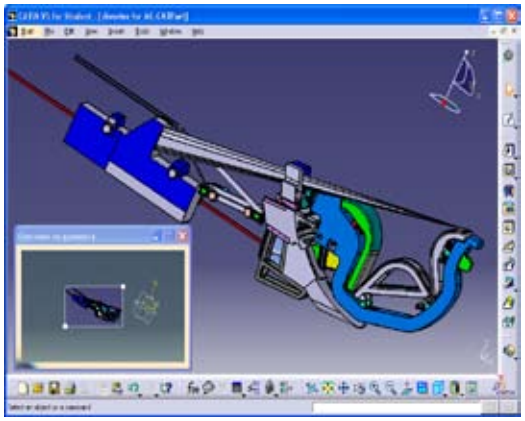


Fig.6. The ANSYS packet window for finite element analysis

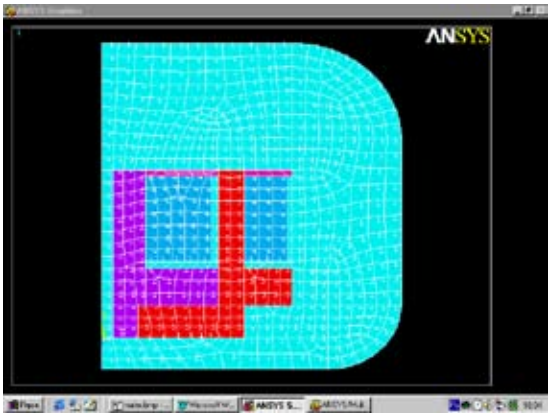


Fig.7. Dynamic Characteristics Analysis in the “Modeling in technical devices” packet

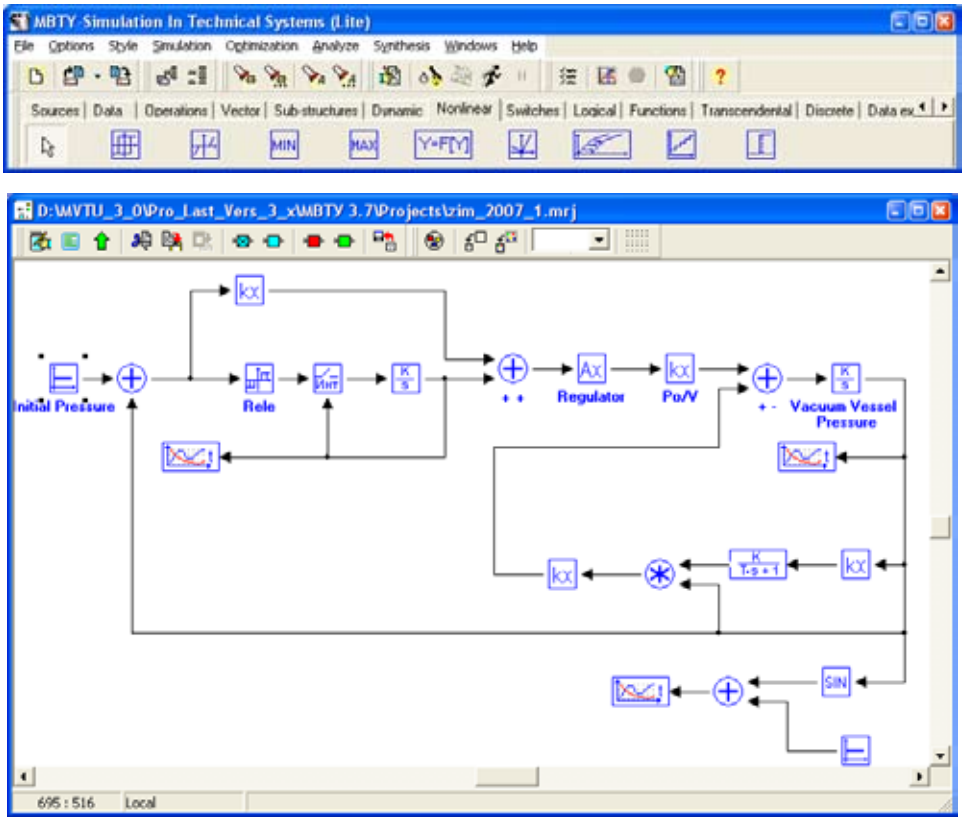


Fig.7 shows an example of calculation of the automatic control system dynamics in the software packet “Modeling in technical devices” [1,2] developed under the guidance of O.S. Kozlov, Associate Professor of Bauman University.

Remote Control and Experimental Data Network Processing Systems

Laboratory training and student research work are highly important components of engineering education. Developing skills in using diagnostic instruments and mastering the latest research techniques are the key elements for practical training of fusion engineers. In order to improve and individualize the engineering practical training, Bauman University widely uses methods and technologies of remote control of sophisticated experimental facilities [3]. In [4] we gave an example of applying modern research techniques and diagnostic instruments for practical training

in High Temperature Plasma Physics (Fig.8). Today we have a technology to control the diagnostic spectrometric instruments over the Internet for analyzing the properties of plasma obtained in magnetic configurations which are used for modeling of plasma interaction with the first wall of ITER (see for example [2]).

Fig.8. Scheme of Remote-Access Laboratory training in Plasma Diagnostics

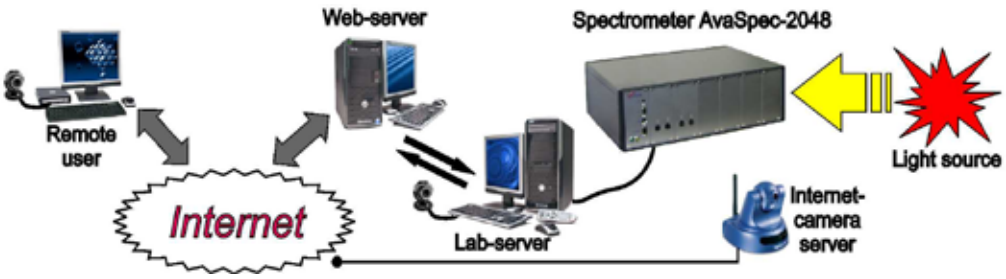
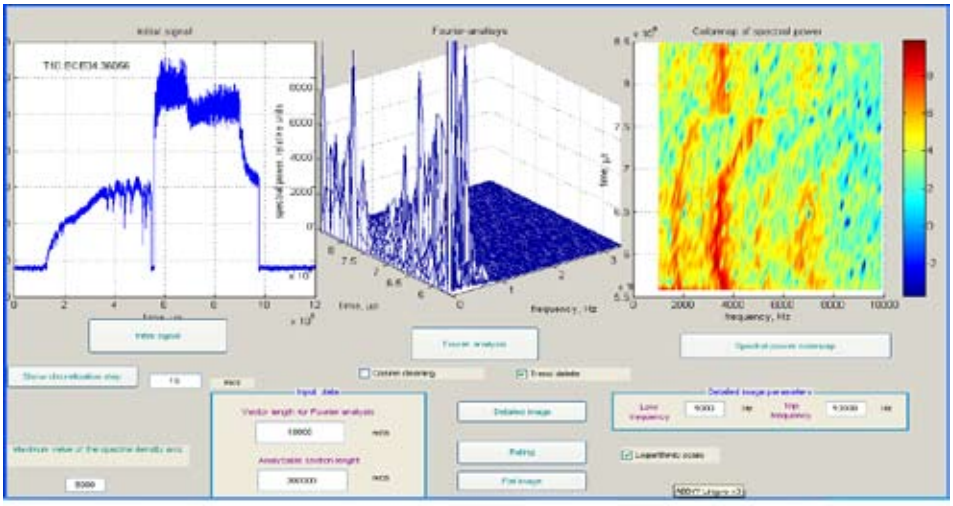


Fig.9. Interface of the digital signal analysis program



The remote access to the data bases of the experiments conducted on large thermonuclear facilities is also used for creating network tools for data processing. These programs are developed by students in their term paper research. Fig. 9 shows as an example the Windows-based application interface for the analysis of saw-tooth fluctuations in plasma temperature in Tokamak T-10 with the Fourier method. The program has been developed in the education version of the MATLAB packet.

Conclusion

Modern information and telecommunication technologies are widely used at Bauman University for training fusion engineers.

Training in design and engineering analysis involves both educational versions of famous software packets, and electronic educational resources developed at Bauman University. The latter include the networking Atlas of ITER assemblies, remote access tools for conducting experiments via the Internet, network software for experiment data processing. A number of remote trainings have been created, which are available via the Internet and used by other Russian universities involved in training fusion engineers.

The wide use of information technologies provides an up-to-date and promising level of specialist training for the research activities on the ITER.

References

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