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3D MODELING IN THERMAL POWER ENGINEERING

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Abstract. In scientific work the basic principles of 3D-modeling of thermal power projects are considered. Addition to traditional visualization methods of computation will not only accept the principle of the maximum and external similarity of equipment-forging, but also optimize the analysis of heat and mass transfer processes occurring in this equipment. As a visualization object it was chosen steam generator brand E-75-42-440 CT, it is equipped with the necessary pipelines within it and fixtures, as well as devices for sampling and boiler feed water, saturated and superheated steam This unit is designed and manufactured in the block, as boiler design allows installation stature blocks or assembly in mounting blocks.. To create a 3D-model of the steam generator E-75-42-440 CT it is used software KOMPAS-3D ASCON. In the article are identified advantages and disadvantages of the software in the design of heat and power facilities based on the analysis of its capabilities. To consider export of models from medium COMPASS to other CAD (computer-aided design) systems, allows you to create rendering model; perform animations, as elements of the equipment and heat-exchanging processes occurring in this model equipment; conduct an in-depth analysis of Heat and Mass Transfer-processes.

Keywords: 3D modeling, thermal power, engineering, CAD, steam generator

Introduction. In studying and designing of heat and mass transfer processes common means of computation are widespread. Usually such studies performance becomes a complex task that requires a significant amount of time and effort, especially if there is a need to investigate the processes of evaporation in real industrial facility heating equipment, which usually has a complex structure and considerable dimensions. Complex calculations and their obdurate character do not let to pay attention to the main purpose of the design - the perception of complex heat and mass transfer processes occurring in the heat engineering equipment, and the relation between parameters and characteristics. The complexity of the overall computing resources makes it impossible to carry out in-depth research, optimize the various parameters and characteristics, create or modify the actual heat equipment. Development of adequate physical models, is possible in the transition from complex calculations to computer-aided design systems.

Materials and Methods. Design and drawing is strict information area that requires precise graphical and descriptive instructions. Terms of drawings and specific disciplines (architecture, mechanical electricity, process, geodesy, structure, construction, etc.) are transferred from traditional drawing on the board into automated drawing [1].

In today's production computer-aided design (CAD, computer aided design) is widespread, which allows you to reduce time and money of design processes and increase the accuracy of the processes and processing programs, that reduces the cost of materials and processing time due to the fact that the processing modes are also calculated and optimized using EOM. Technical support CAD is based on the use of computer networks and telecommunication technologies of personal computers and work stations [2].

Computer-aided design can significantly reduce subjectivity of decisions to improve the accuracy of calculations, select the best variant for implementation based on rigorous mathematical analysis of all or the most of the variants of the project with the evaluation of technical, technological and economic characteristics of the production and operation of the proposed facility [3].Currently three-dimensional modeling is not widespread, mathematical modeling of the process of heat and mass exchange is often used.

Results. As the modeling object we have chosen the steam generator E-75-42-440 CT. To create a 3D-model we used software KOMPAS-3D of ASKON Company. Offered 3Dmodel satisfies dimensional characteristics of the steam generator E-75-42-440 CT, namely the combustion chamber completely shielded pipe Ø60×3 mm to 100 mm on the side, front and rear walls. On the side wall of the furnace there are 2 burners. Superheater - vertically spaced coils, two-stage, made of pipes Ø42×3 mm. Number of coils - 18. The lateral spacing tubes - 75 mm, the location - the corridor. Economizer - Steel, Smooth pipe, coiled, staggered pipes Ø32×3 mm. The lateral spacing tubes - 75 mm, a longitudinal - 55 mm. Air heater - tube, vertical, staggered pipes Ø40×1,6 mm. The lateral spacing tubes - 60 mm, a longitude - 42 mm [4].

Approximate parameters: the nominal steam capacity of 75 t / h; the working pressure in the boiler drum 44 kgf / cm^2; operational pressure at the out let of the super-heater 40 kgf / cm^2; Superheated steam temperature 440°C; flue gas temperature of 180°C; hot air temperature of 190°C [5]. Its geometry is a set of complex curved surfaces, holes, chamfers and rounding (Fig. 1). Each commissioned has a copy of the operation of the steam generator and has a number of (approved) deviations from the drawing sizes, which are recorded into the passport of the steam generator.

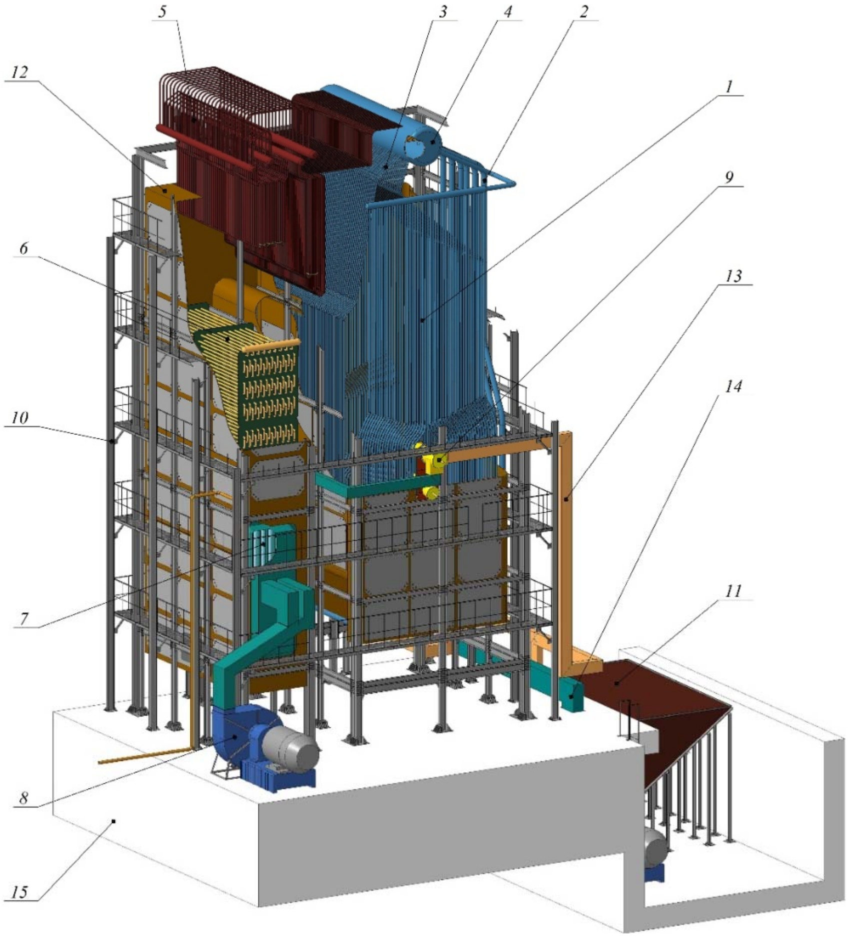


Figure 1. Sectional drawing 3D model of the steam generator E-75-42-440 CT:
1 - front-line screen pipes; 2 – stand pipe furnace tubes; 3 - side-wall tubes; 4 – drum separator; 5 –steam heater; 6 – the economizer; 7 – air pre heater; 8 – draft blow installation; 9- burner; 10 - frame; 11 - bunker coal-air mixture, 12 – walling of the steam generator; 13 – the pipe line of coal-air mixture; 14 – air pipe; 15 - foundation.

The problem in the design of the model is the proximity of mathematical approximations in operations with mathematical models of complex geometric objects: arcs of circles, spines; curved surfaces and "solid" bodies. Line based on points, surfaces - on the support lines and the creation of the body is based on surface creates a closed space, truncating the "extra". We are talking about operations such as the creation of complex lines and surfaces, cutting them into pieces, the underlying commands such as "New item", "Create assembly", "Operation extrusion", "Cut extrusion", etc. [6].

Some approximations are replaced by others, errors accumulate and lead to the fact that smooth, but dissected, and surfaces appear like small ledges. Such defects prevent further operations and could lead to complete failure in their performance, to hang a program or the end of its work. A significant amount of work was carried out with the help of the library "Pipelines 3D". Pipe systems are modeled by automatic means, or manually, the construction of the pipeline on the trajectory coordinate points, the location of which can be calculated from the dimensions given in the passport data of the steam generator [7].

The second, and the most important problem when creating a model - creation of a unified system of hollow pipes and tanks, the closure of the tube bundles into sewers, pipes placed in the tube sheets (Fig. 2).

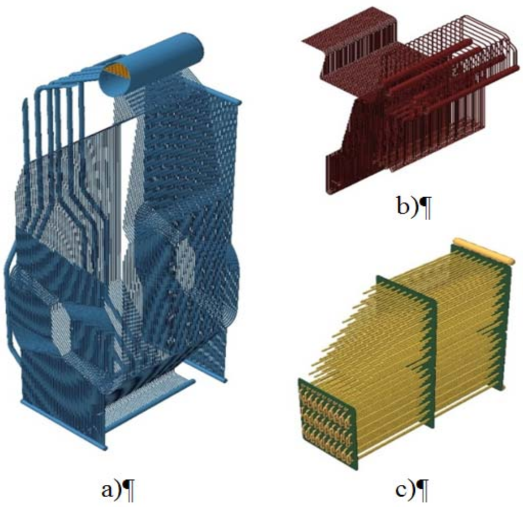


Figure 2. Pipe system 3D elements of steam generation system E-75-42-440 CT *a*) furnace screens; *b*) steam super heater; *c*) water economizer

Geometric operation can be performed without problems, sometimes there are problems when creating a final element mesh, or the apparent success of its creation, the appearance of the final elements, degenerate or nearly degenerate. To avoid this problem, you must minimize the amount of dissection operations; it is desirable to abandon the mat all. It is quite possible in block principle to create geometry. Large enough to create a characteristic blocks (Fig. 2) on which operations are only a few blocks are joined into a single hollow tube system.

To construct a 3D model of the core of the steam generator, the main goal was to perform it as close to the size of the drawing, which recorded and entered into the passport of the steam generator. It is necessary to impart the desired strength and configuration of model steam generator units, which allows a 3D model of the steam generator as a basis for the study of different heat-exchange processes and calculations of materials strength. For creation a 3D model of the steam generator framework is largely used library «Metal 3D»is largely used [8]. This standard library, which is included in the package program COMPASS -3D, you can quickly and accurately simulate the metal structure, the dimensions of which recorded and entered into the passport of the steam generator (Fig. 3).

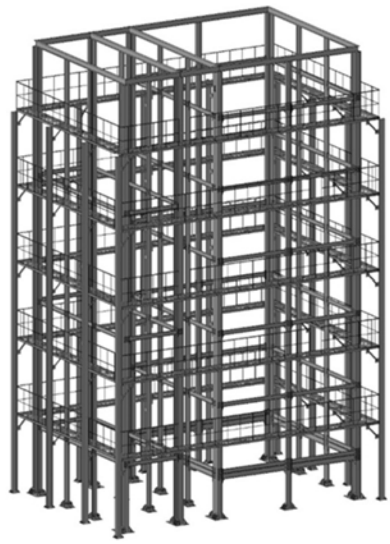
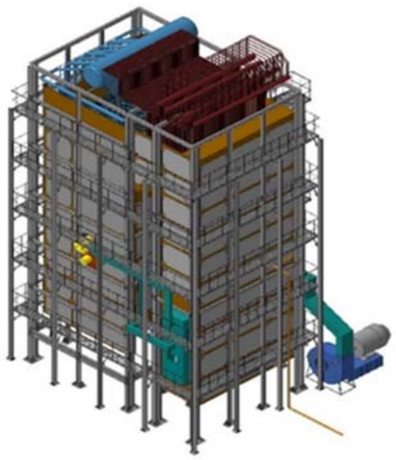
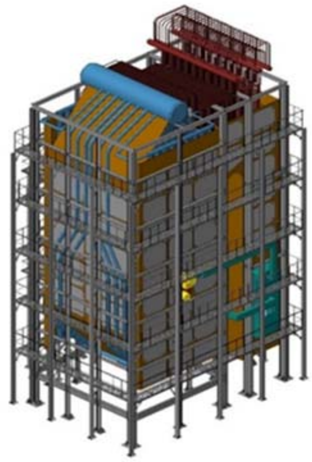


Figure 3. 3D wireframe model of the steam generator E-75-42-440 CT

Figure 4 shows a 3D geometric model of the steam generator E-75-42-440 CT, created with the use of recommendations on the basis of documentation of the unit. After finishing work on the 3D geometry of the steam generator and cleaning it from the "extra" it may be that the final element mesh refuses to be created for the entire model automatically. There are many reasons for it. Usually the automatic creation of 3D final element mesh is first based on the layout of all the edges, and then on each surface, and then, using the grid as a supporting surface, fill the volume finite elements. When the operation is successful, the optimization network nodes move in order to get better network performance. Layout options can vary.



a)



b)

Figure 4. 3D model of steam generator: a) isometric projection XYZ; b) isometric projection ZYX

This 3D model of steam generator E-75-42-440 CT, is built by a student of the group TEP-11 SIHE "Krivoy Rog National University" M.I.Shepelenko led by, Professor O.V.Zamytskyi. The model is part of the project "energy block of thermal power plants", which won the first place in the "heavy" weight class engineering - more than 1000 items, at the XII competition "Future professionals of computer 3D-modeling", which was held in St. Petersburg, 2014 (Russia).

3D models are developed in COMPASS 3D environment can be imported into other environments CAD (ANSYS, Solid Works, etc). System, except it allows the computer to create the rendering of the model; animate as processes that occur in the unit and moving parts, and most important - to conduct studies of the physical processes occurring in the unit [9].

System ANSYS / Metaphysics, ANSYS / Mechanical, ANSYS / Professional ANSYS / FLOTRAN let us solve problems of heat transfer. The basis of thermal analysis in ANSYS is a heat balance equation, based on the law of conservation of energy. (Details are in the ANSYS Theory Reference).The last element solution obtained by using ANSYS, determines the temperature in the nodes, which are then used to obtain other thermal quantities. The program ANSYS allows to expect all three types of heat transfer: conduction, convection and radiant heat exchange. [10]

Using Solid Works also allows us to solve the problem of heat transfer. The main functional limitation of thermal analysis module COSMOS works is that the temperature of the environment effects the convection and radiation does not depend on the temperature state of the model. During steady-state calculation it consciously constant, and in unsteady calculation can vary only under the control of the user. However, the surface characteristics (face and body surface itself) - the coefficient of heat transfer, radiation and heat flux and power - may depend on the temperature. Dependence is described by a broken line passing through the points defined by the user. [11]

The program allows you to play the effect of changes in heat transfer properties in the area of the mating parts. It may be due to the presence of the adhesive layer, imperfect contact. Function Thermal resistance (thermal contact resistance) allows us to refine the calculation and significantly reduce the dimensionality of the problem. The Help system provides indicative values of contact resistance for a number of materials with different surfaces. [11]

It is impossible in calculating the surface models to take into account the temperature distribution along the shell thickness in COSMOS works. Therefore, when you specify a temperature sufficient to assign it to one side of the shell. If you still try to make it different on opposite faces of a single surface, then the program will recognize the last entered value. [11]

Conclusions. Thus the use of 3D models as a basis for the study of thermal power facilities allows linear, dynamic and thermal calculations to solve contact problems, conduct geometrically non-linear calculations and optimization; to solve the problems of radiation heat transfer; the non-stationary and stationary modes of heat and mass transfer.

In future it is planned on the basis of the model steam generator E-75-42-440 CT to create a physical model of heat-mass exchange and hydro-processes in the boiler (water circulation, the combustion process, the process of vaporization), and to simulate other processes occurring in the TPP equipment of power generation.

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