In absence of full Trimmed body model it is allowed to make first estimations of LDS on the Frame. However, when the Trimmed body model is available it is needed to update the results, especially for low frequency range.

ACKNOWLEGMENTS

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INTEGRATED SYSTEM AS TOOL FOR IMPLEMENTATION OF SIMULATION- AND OPTIMIZATION-BASED DESIGNMETHODOLOGY

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I. INTRODUCTION

Today in the world design engineering practice, two approaches to design of structures can be distinguished. The first, more traditional, is that the designer on the basis of operational requirements and his experience invent a sketch of the structure, which then turns into a CAD-model. After that, a real prototype is created and full-scale tests are carried out. CAE calculations are also performed, mainly to verify those loading cases that have not been tested in full-scale tests. In case of dissatisfaction with some requirements, the model is returned to the designer, and loop is repeated.

With the traditional approach, in the world the engineers use other approach, based on mathematical modeling and optimization methods. Using this approach, called simulation- and optimization- based approach, allows you to get a design of structure under specified operating conditions as a result of the use of computer simulation and optimization. This approach is currently being implemented by leading Western industrial companies in the development of new aircraft, ground vehicles, etc. A key role in this approach is topological optimization, allowing for predetermined loads to predict the most effective material distribution in structure.

This work is devoted to the development of a tool for implementing the design approach based on mathematical modeling and optimization. The work includes the development of an integrated computer design and engineering system, a topological optimization module in the ANSYS APDL environment, and demonstrates obtained solutions.

I. TOPOLOGY OPTIMIZATION PROGRAM MODULE

The problem of topological optimization, in the classical formulation, is the problem of choosing the optimal distribution of material in fixed space. For each point of the body, we should answer the question whether there is material in this place or not. To look at this initially discrete problem as on the continuous problem we use the SIMP (Solid Isotropic Material with Penalization) method, which allows to associate the elastic properties of a material with an additional parameter called "density" [1]. In ANSYS APDL, this was implemented by assigning each finite element its own material. The further task is to achieve a minimum of the functional of external forces work, when the equilibrium condition of the system is satisfied. For this goal, we use the Method of Moving Asymptotes (MMA) [2]. To apply this method, it is necessary to define the partial derivatives (sensitivities) of objective with respect to design variables. In the case of minimizing the compliance of the system with a constraint on the volume, these derivatives are related to the potential deformation energy at each point. In ANSYS APDL, the procedure for finding sensitivities is consist in performing FE calculation and getting strain energy in each finite element. After that, a convex approximation of objective function is analytically constructed, and minimum of that can be easily determined by method of bisection. The founded solution is the next calculation point for the approximation. The iterative process is repeated until the results converge.

The mapping of optimization results was performed by the exclusion those finite elements, which density parameter is less specified level. To ensure the possibility of the designer to work with obtained optimal not-smooth finite-element model, the postpcrocess procedure based on Laplacian smoothing algorithm is carried out. This algorithm was implemented in ANSYS ADPL program module by triangulation of the surface of the optimized finite element model, and further iterative process of averaging the coordinates of vertices of neighboring finite elements (Figure 1).

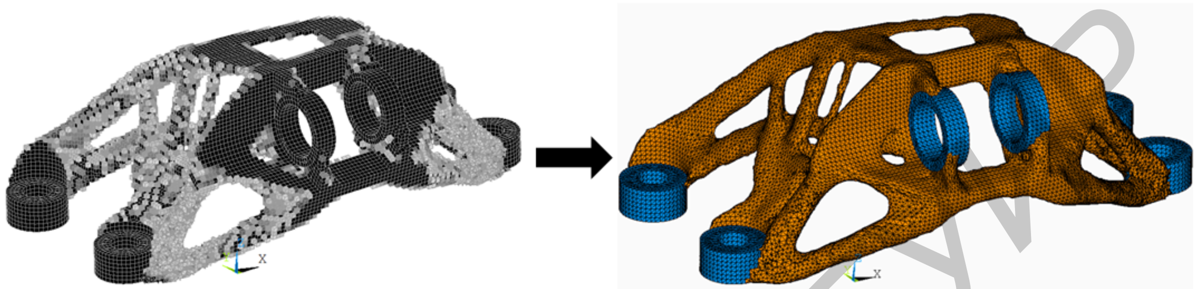

Figure 1 – Laplacian smoothing as postprocess tool

II. INTEGRATED SYSTEM OF COMPUTER DESIGN AND ENGINEERING (ISCDE)

For simulation- and optimization- based design, only topological optimization is not enough. This approach requires the following functionality:

- You need to know the layout volume, interface elements, and functionality of design structure. For this you need a hierarchical database of structures. This database should also contain information about all loading conditions for structure.
- Both for structural or parametric optimization, you need to know the technological limitations – this requires a technology database.
- To perform engineering and optimization calculations of structures, a database of materials, available for design engineer, is needed.
- To ensure simultaneous access of specialists of all profiles and levels to the design process, the system should have a client-server architecture.
- In order to cover all nuances of design behavior in simulation, the system must integrate the best world modeling and optimization solutions: ANSYS, DS Simulia ABAQUS, MSC NASTRAN, Alatair Optistruct, DS Simulia Tosca Structure, Esteco modeFrontier. The system also integrates the developed topological optimization ANSYS APDL module (for case, if company have no optimization software).
- The system should have automated postprocess tools to track the specified target values during simulations.

All this was implemented in the integrated computer design and engineering system (ISCDE) (Figure 2).

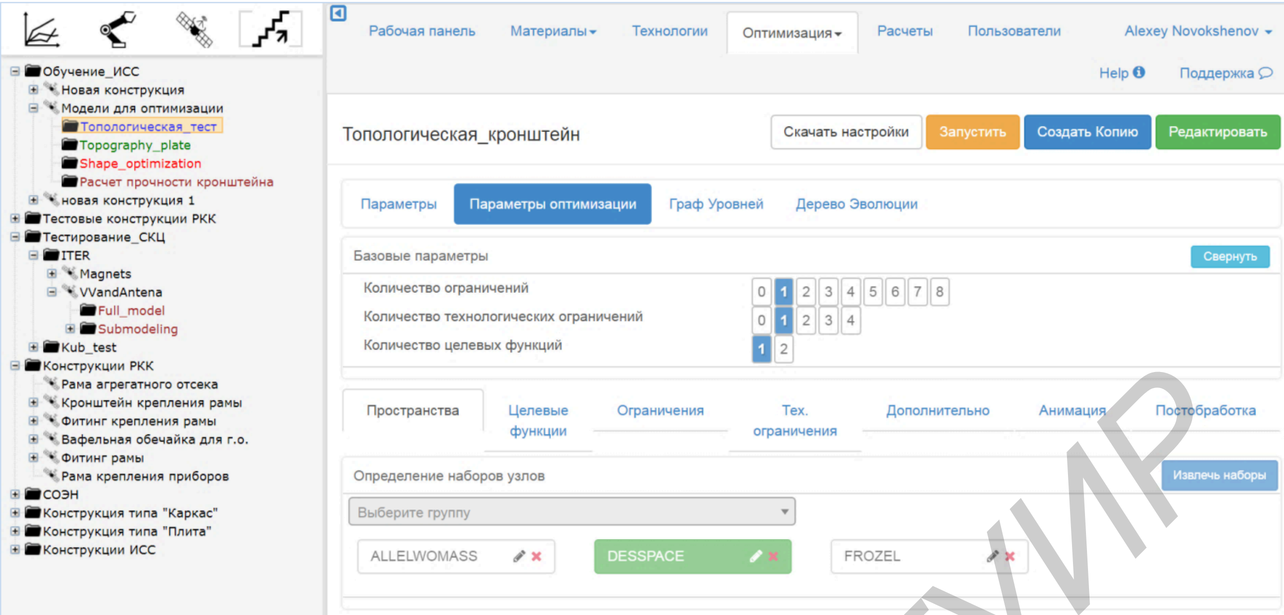

Figure 2 – The ISCDE interface in case of optimization with DS Simulia Tosca Structure

The developed system have a server and a client part. The server part is written in JAVA, the client – is in JavaScript, the used database is PosgtreSQL. The system includes a tree of materials (homogeneous and composite), a tree of technologies, a hierarchical tree of constructions, and a calculation and optimization module. The system implements User Account Control (UAC). The Figure 2 shows the interface of the system (available through the browser) when optimizing the design in DS Simulia Tosca.

III. EXAMPLES

Topology optimization of the space bracket

Topology optimization of bracket with Altair Optistruct through ISCDE was performed (Figure 3). Mass reduction is 43%. The bracket was manufactured using the technology of titanium 3D printing. For optimal design all restrictions (such as stress safety factors, natural frequencies) are satisfied.

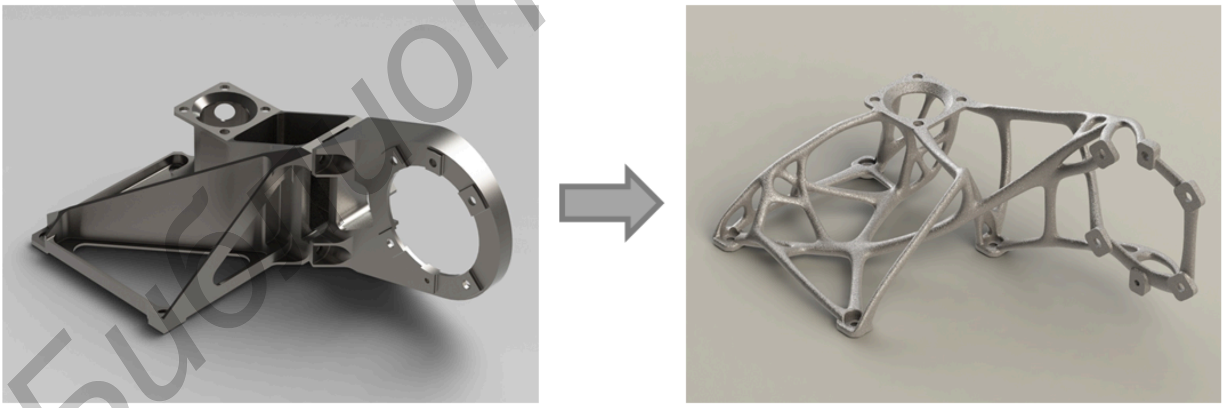

Figure 3 – Topology optimization of space bracket

Parametric design optimization of space waffle shell

Parametric design optimization of space waffle shell with Esteco modeFrontier through ISCDE was performed (Figure 4). Mass reduction is 32%. SIMPLEX algorithm was used. For optimal design all restrictions (such as stress safety factors, natural frequencies, buckling safety) are satisfied. The original shell is manufactured from aluminum billet by milling.

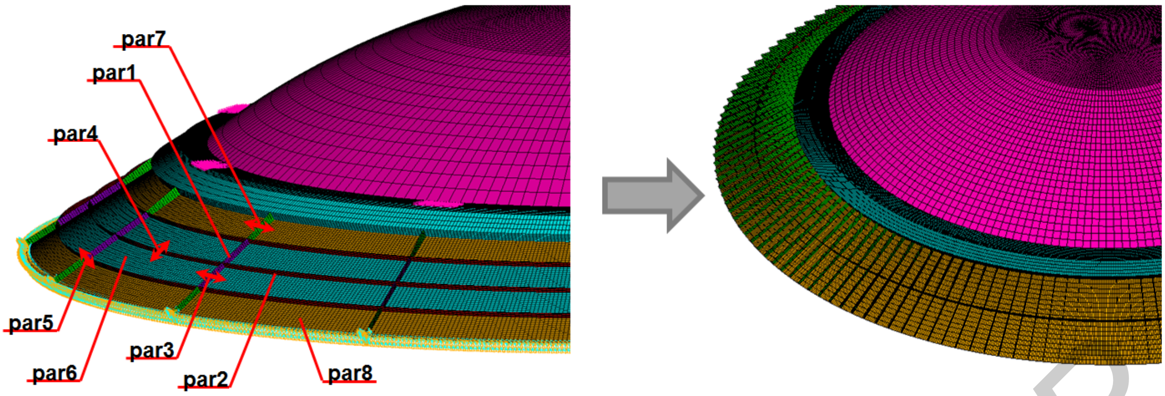

Figure 4 – Parametric design optimization of space waffle shell

IV. CONCLUSIONS

Within the framework of the work, topology optimization program module and integrated computer-aided design and engineering system were developed. Topology optimization of bracket and parametric design optimization of space waffle shell were carried out through ISCDE. The obtained results will be used in Russian space companies.

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MODELING OF HEAT TRANSFER IN BUILT-UP CURVILINEAR PLATE

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I. INTRODUCTION

One of the important direction of modern industry is creation of new materials based on additive technologies, i.e. technologies of buildup of various solid bodies. Chemical vapor deposition (CVD) is one of such technologies that represents the deposition of a film or a coating, i.e., a continuous layer, including a nanocrystalline material, on a cooled plate [1].

The current work considers buildup of the most general case: that of a curvilinear surface and includes special for this process boundary conditions. This work also shows modification that allows to consider diffusive transfer of material and linear change of curvature along the plate thickness. In the work, a numerical algorithm for finding the temperature profile at any instant of time has been constructed, and results of numerical calculation for different materials have been given.