

STUDENTS TRAINING IN “COMPOSITE STRUCTURES DESIGN AND MANUFACTURE” FOR AEROSPACE INDUSTRY

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Abstract. Due to increasing use of composite materials in aerospace industry it was decided in 1990 to start training specialists in composite structure design and manufacture area. The majors “Aircraft Manufacturing” and “Rocket Manufacturing” were narrow focused. That’s why there was no opportunity to train specialists that have a strong knowledge in mechanics of composite materials and structures, design, analysis and manufacturing of composite structures, as well as structural quality control and testing. This paper deals with information about history of this major establishment, the main fields and method of students training.

Keywords. Composite, Structure, Design, Manufacturing, Education.



Currently the majority of aerospace design offices and manufacturing enterprises see prospects of wide usage of composite materials. Experience of past 20 years showed that ordinary high skilled engineers are not experienced enough in composite structured design, stress analyses, manufacturing and testing. Mostly it is not a result of inappropriate level of training in institutions of higher education. The main reason of it is principal features of this new class of materials, specifically:

- necessity of composite laminate design (plies thickness and orientation, and lay-up sequence), because the physical and mechanical characteristics of finished material are unknown, usually properties of composite monolayer are set;

- forming of composites properties during structure manufacturing i.e. material is obtained simultaneously with a part that requires special cooperation between design engineer and technologist;
- necessity of material properties control as well as structures stress-strain state which led to dissension in established design algorithm.



Perhaps due to abovementioned the engineer training “Composite Structures Design and Manufacturing” was started under the guidance of scientists I.F. Obratzsov and V.V. Vasiliev and then it was implemented in “MATI” – Russian State Technological University at the end of 80-th of the last century. The main reason of this decision was availability of powerful scientific schools in the field of composite and appropriate laboratory facilities at those universities. The same situation was in KhAI where in 60-th...70-th for the first time in USSR flaps and fuselage of AN-2M airplane were manufactured of fiber-glass composite and successfully tested under the guidance O.K. Antonov, the Chief Designer of well-known Antonov Design Bureau. After that Ministry of Aviation Industry suggested to organize composite research laboratory in KhAI. On its basis engineer training on composite aircraft structures design and manufacturing was started under supervision of professor V.E. Gaydachuk.

Originally educational process was organized on the basis of “Aircrafts and Helicopters” specialty curriculum and students were taught almost all standard disciplines such as “Aircraft design”, “Aircraft stress analysis” etc. Then it has become clear that conventional curriculum and graduating programs have to be changed.

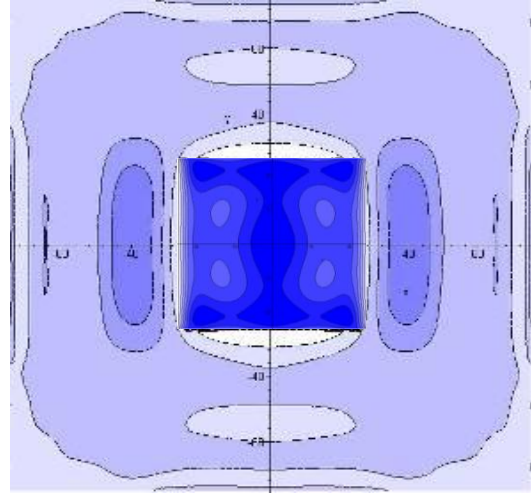
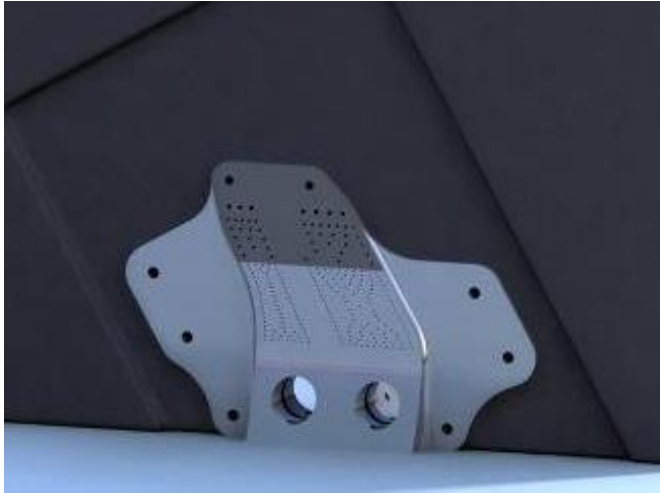


In spite of quite different and contradictive requirements of manufacturing enterprises and design bureau all over the world to engineer skill almost optimal and quite universal curriculum was developed in KhAI. It was grounded on the principle of teaching students to structural design and manufacturing made of categorized materials – i.e. material science aspects of reinforcing material and resin are not under consideration excepting physical and chemical interaction between composite components that provides required structural properties of the composition.

Physical, mathematical and general engineering disciplines of “Aircraft and Helicopters” specialty remain unchanged in academic curriculum of “Composite Structure Design and Manufacturing” specialty.

It is known that there are certain difference between composite application in aircrafts and rockets. Moreover fibers and resins technologies are developing continuously as well as composite structures manufacturing methods. That’s why educational process for engineers and master students at KhAI is based on thorough study of some simple and universal structures and manufacture processes. Such approach allows to cultivate basic engineering way of thinking and skills which could be used then in designing of more complex composite structures.

In addition to such general disciplines as “Mechanics of Materials” and “Structural Mechanics” students study “Mechanics of Reinforced Materials” (prediction of elastic and strength properties of unidirectional lamina and laminates), “Mechanics of Composite Structures” (stress-strain state determination in composite beams, panels, shells, thin-walled structures etc.), “Theory of Optimal Design”, “Physical and chemical fundamentals of composite components interaction” and “Chemistry of Polymers”.



These disciplines are basis for engineers training. Training in composite structural design includes designing, strength analysis and development of structural and technological solutions for typical elements such as laminate lay-ups (plies thickness and orientations), rods, beams, shells and composite structures joining. An aircraft wing could be assumed as a typical example of such complex structures which consist of standard elements (skin is modeled by laminated panels and plates, while wing-spars, ribs and stringers are considered as beams). On this training stage students use different CAD/CAE products based on finite element methods and mathematical software for numerical calculation that allows students to reduce the computation time and to become confident users of software products (CATIA, EUCLID, NASTPAN, COSMOS, MathCAD, Mathematica etc.).



Training in composite structures manufacturing consists of study of components preparation processes and their combining, selection and determination of curing process parameters, basic manufacture processes (lay-up, pultrusion, winding, vacuum and autoclave curing, machining processes) as well as necessary technological equipment and methods of structures assembly.

In the frame of these two series of discipline students also study “Quality Control of Composite Structure” (methods of nondestructive inspection), “Testing of Composite

Structures” (standard and nonstandard methods and facilities for composite materials and structures testing), “Integrated Design Technologies”.

Such arrangement and content of curriculum and syllabus allows to write and publish quite stable workbooks and to organize laboratory works on all these disciplines. More attention is paid to students individual trainings from third of fourth years of education. This is a great opportunity for students to

specialize in chosen area, to participate in research works, grants and competitions, and to find a desirable job position in future.



Students training is organized in close cooperation with other university departments (taking into account national and international research works) and different aviation and motor companies and design bureau (State Enterprise “Antonov”, State Design Office “Yuzhnoye”, State Enterprise “Ivchenko-Progress” etc.). From the one hand it helps students to keep abreast of companies needs; from the other hand trainees could make quickly corrections into content of trainings. Such cooperation determines topics of

student’s final thesis that could be implemented in enterprises or published as scientific articles or be groundwork for the further PhD thesis.

A good cooperation is formed between teaching staff and students that work together in one of the most perspective and continuously developing field. That’s why department doesn’t have any problems with students participation in different competitions and conferences, admission of Master and PhD students and job placement of graduates.