About the partnership between the United Aircraft Corporation (UAC) "Irkut " and university researchers for creating high-tech aircraft production

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Abstract. The article describes the experience of partnership between the Irkutsk National Research Technical University and the Irkutsk Aviation Plant, a branch of PJSC Scientific production Corporation “Irkut”. Here are presented the results of the joint implementation of complex projects aimed at creating a number of high-tech industrial technologies throughout the entire cycle of manufacturing aircraft products in accordance with the Order of the Government of the Russian Federation of April 9, 2010 No. 219. This study presents the solutions that are ready for copying in such areas as machine processing, metal-cutting tools production, forming and setting, surface hardening, non-destructive testing, assembling and connecting, and technological production planning.

1. Introduction

Irkutsk National Research Technical University is one of the largest universities in Eastern Siberia. Assigning to it the status of the National Research University allowed to bring the competence of the university in the field of aviation and mechanical engineering to a new qualitative level. For this purpose in 2010 the university formulated the Priority growth area "High-technology, high-performance production technology of machinery and equipment". In 2013, the University was included in the number of supporting universities of the United Aircraft Corporation.

Scientific production corporation "Irkut" is the main consumer of the University's services in the field of aircraft and mechanical engineering. Collaboration between the university and the corporation has a long history and is implemented in such areas as staff training, creating academic and research infrastructure, doing research, development and engineering works (RD&E).

Within the expansion program of the Ministry of Science and Higher Education of the Russian Federation for developing staff training system of the military-industrial complex the IrNRTU carries out target training specialists in such areas as high-performance mechanical processing; automation of production processes; computer-aided design and creation of automation equipment; assembly operation used digital technology.

To train students collaboratively the IrNRTU created specialized department “Air-mechanical engineering” in accordance with the business profile of the IAP, aimed at strengthening the practical orientation of the educational process by attracting highly qualified plant specialists to teach using high-technological equipment in educational process.

2. Results

To carry out research and development work in the field of aircraft engineering, a specialized infrastructure
has been organized at the Technical University - the Common Use Center (CUC) “Advanced Technologies for Aviation Engineering Production”, which includes five technological laboratories specialized in almost the entire airplanes production cycle. A branch of the Center operates on the territory of the plant, where workplaces are organized for University employees combining teaching activities with work in production.

The existence of research infrastructure and scientific and technological groundwork provided an opportunity for university and corporation to win in two competitions on the development of high-tech production of the MC-21 medium-range aircraft in accordance with the Order of the Government of the Russian Federation of April 9, 2010 No. 219 "About the state support of development of innovative infrastructure in federal educational institutions of higher education" (Current state on 25.05.2016)

The scope of work on projects covered almost the entire production cycle of manufacturing aircraft products. The main part of research is focused on creating new and improving existing technological processes.

The most important link in the technological chain of producing aviation equipment is the mechanical processing of parts. Introducing modern equipment to increase productivity in the production process requires a large amount of work on technology adjustment, especially when new products are launched. Taking into account the growing need for enterprises to conduct such research, the university organized a specialized laboratory. The result of the performed R & D projects is an elaborated technique that allows to reveal the optimal range of processing modes based on the dynamometric and modal analysis of technological systems that increases the processing efficiency by 30-50% (Figure 1).

![Figure 1](image1.png)

**Figure 1.** Optimization of milling technology for parts "Support": a) test vibration instrumental setup; b) part process on the machine HSC75V

One of the significant cost items for processing aircraft parts is the cost for cutting tools. To reduce costs, designs and technologies for manufacturing procedure of end mills on the plant equipment have been developed for machining parts on CNC machines (Figure 2a). Producing a cutting tool for processing composite materials was a particular area of work. Within the framework of the projects, special drills were developed for obtaining accurate holes in mixed packages of titanium alloys and polymer composite materials (Figure 2b).
Testing the tools, manufactured at the IAP, was conducted on the basis of laboratories of the university. The cost of such a tool is up to 5 times lower in comparison with the imported counterparts.

A significant reduction in labor intensity and quality improvement of mechanically machined parts allows to introduce mechanized operations for deburring and sharp edges rounding. One of the directions of the performed work is related to the elaborating of recommendations for manufacturing finishing parts on mechanized and automated equipment: vibrogrinding, processing with rotating brushes, processing with the use of robotic complexes (Figure 3).

**Figure 3.** Testing the technology of robotic finishing of the aircraft parts edges in the laboratory of IrNITU

The development of technologies for forming aircraft parts is one of the traditional areas of collaboration between the university and the corporation. Within the projects, a complex of automated equipment has been created for forming lengthy panels and complex-shaped skins using combined methods. As a result of the introduction of the development into the production of wing panels of the BE-200, high rates of productivity and quality of parts were achieved, and the possibility of rapid personnel training was proved (Figure 4).
A major concern arising in manufacturing reinforced parts of the aircraft frame from thermally hardened blanks is the buckling of low-rigid parts. To solve this problem, a technology and a special tool for forming and straightening parts by methods of local plastic deformation, eliminating the cracking characteristic of press methods, have been developed (Figure 5).

A prospective line for developing blank and stamping production is to elaborate and implement the technology of forming structures in the superplasticity mode (Figure 6).
The use of this technology, along with the significant advantages in terms of technical and economic indicators, allows to create prospective elements of aircraft structures.

Created by IrNRTU techniques on replacing expensive experimental work on virtual modeling of casting and die forging processes are aimed at improving the efficiency of metallurgical production (Figure 7).

An important task, aimed at ensuring the life extension of parts, is to improve surface hardening technology. During the project a method for objective monitoring of the results of hardening fillets and grooves of power docking bolts has been developed (Figure 8).

Another task, aimed at bringing the applied surface hardening technology in compliance with the requirements of international standards, was to develop control methods based on determining the intensity of shot- and vibration treatment using saturation curves and home witness samples to manufacture which a special technology was developed (Figure 9).
Figure 9. Control plates samples manufactured in accordance with the requirements of SAE J443 (a); calculation of the intensity of surface hardening from the saturation curve (b)

One of the project directions is associated with an improvement of work efficiency on assembling and joining products (Figure 10). The equipment developed by IrNRTU and equipped with functional elements of automated positioning, and the technology of assembly devices installation provide a significant increase in productivity and make it possible to change over a reference-free production method.

Figure 10. Production and technological complex of assembly tooling automated installation

We should pay attention to the developed systems of computer-aided design of technological processes and equipment, ensuring an efficiency improvement of design and engineering preproduction. These systems allow you to create knowledge bases of designers and technologists.

Figure 11. CAD systems developed in the framework of the projects: a) to analyze the workability of industrial products; b) to design production tooling
More than 100 university and corporation employees, including 30 doctors and candidates of science, participated in the execution of projects under the Order of the Russian Government No. 219. More than half of the team was young scientists, engineers, graduate students and students. From 2010 to 2015 more than 100 scientific papers had been published, more than 30 patents and certificates had been obtained. The introduction of technologies developed in the course of projects implementation had a significant economic effect. Thus, according to the report of PJSC “Corporation Irkut” on high-tech products created (developed) as a part of the complex project 2010-218-02-312 for 2014, the cumulative annual economic effect from the implementation of the work results obtained in 2013 was 156 million rubles.

After the budget funding of R & D was completed in 2015, the collaboration of the plant and the university was continued at the expense of the corporation directed to develop the obtained results. In order to improve the efficiency of research and development in the field of aircraft construction, in 2017, the university organized a research, development and design institute of aircraft engineering technologies, which included 16 research laboratories with specialization of covering the entire aircraft manufacturing cycle.

Currently, there are the works, carried out in the following areas:

- optimization of the technology for machining aircraft parts and geometry of the cutting tool;
- development of technology for shaping and editing low-rigid frame parts using the landing method;
- development of the technology for forming wafer-finned panels;
- development of technology for editing parts of extra high rigidity;
- development of automated technologies for processing parts edges;
- development of technology for processing high-precision holes in mixed bags with reconditioning maintenance;
- improvement of the technology of strain hardening of rotation surfaces;
- development of the combined technology “Preventive deformation - shot-blast hardening” of parts such as supported rims and walls;
- measurement of the geometric characteristics of parts and equipment according to production program of the MC-21 aeroplane;
- development of technology for optical scanning of parts and accessories;
- development of digital technology for coordinate control of the installability of wing devices into a theoretical profile;
- development of the technological process for forming sheet parts, combined with cutting-punching elastic fluid;
- development of technology to perform pintle-rivetted joints with interference.

3. Conclusion

Thus, in addition to achieving technical and economic indicators, the development of research infrastructure and the strengthening the scientific and technological potential of both organizations can be considered as the most important results of projects by the corporation and the university within the framework of implementing the program of state support of development of innovative infrastructure in federal educational institutions of higher education.

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