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MACHINING AUTOMATED SYSTEM FOR DRILLING AND MILLING OF POLYMER COMPOSITE MATERIALS

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Abstract. The article presents the relevance of the production of acoustic sound absorbing structures of aircraft engines. Describes technological problems arising during machining of products from polymeric composite materials, for example, drilling and milling sound-absorbing structures of aircraft engines. It is shown that the economically more rational than lathes, for drilling and milling of polymer composite materials to apply automated machining system based on robot. Proposed machining complex with the selected components. The complex is introduced for the production of sound-absorbing panels.
Keywords: robot, polymeric composite material, drilling, milling, sound-absorbing panel, noise, hole, aircraft.

1. Introduction

Now polymeric composite materials more used in such industries as aerospace rocket, aircraft engineering, shipbuilding.

Wide dissemination of polymer composite materials due to the fact that these materials have low specific weight and high mechanical, chemical and antifriction properties, the ability to absorb and absorb vibrations and noise.

Noise reduction aircraft on the areas is an urgent task. EU States and a number of other countries have imposed restrictions on flights with certain undesirable acoustic noise. Reduction of the radiated noise aviation using sound-absorbing panels may carry out on the aircraft.

Since January 2006 has introduced provisions on noise levels of the aircraft (Chapter 4 ICAO Standard), applicable to various types of aircraft.

For the competitiveness of aircraft families Il-96-300, Tu-214/204 (aircraft engines PS-90A), and the Superjet 100 (aircraft engines SaM-146) must reduce their emitted noise by 10 - 15 dB (EPN) using sound-absorbing panels.

2. Technological features for drilling and milling of polymer composite materials

In a fig. 1, 2 assembly unit of the sound-proof panel is given.

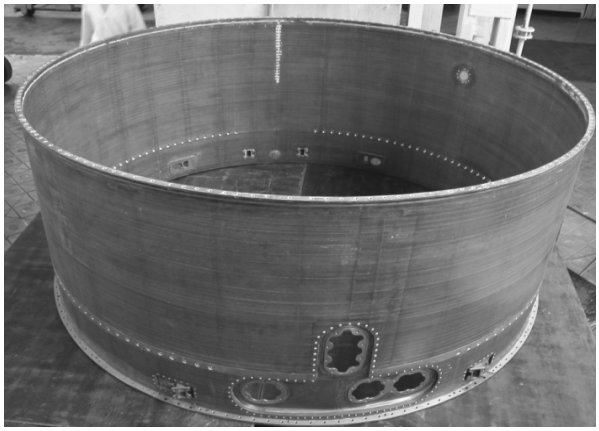

Fig. 1. Shell sound-absorbing panel aircraft

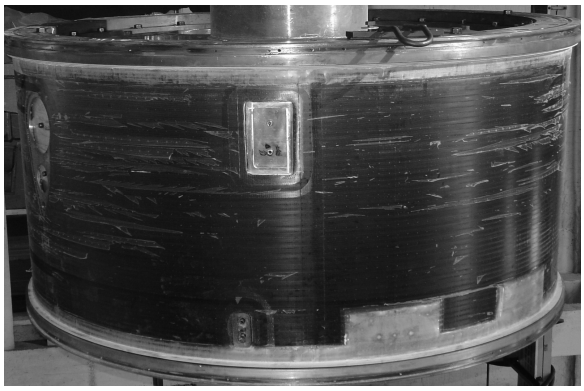

Fig. 2. Shell sound-absorbing panel aircraft

Sound-absorbing panels contain a huge number of holes, which have different meanings (for noise absorption - small apertures holes with diameter 1,6 - 2 mm, for fasteners from 6.5 mm). In one of the sound-absorbing number of small holes to absorb noise reaches 200 thousand holes.

Sound-absorbing panel has two perforated surface (sandwich construction). Perforated surface is from the inner side. The outer layer is solid. On Fig. 3 shows a perforated sound-absorbing panel.

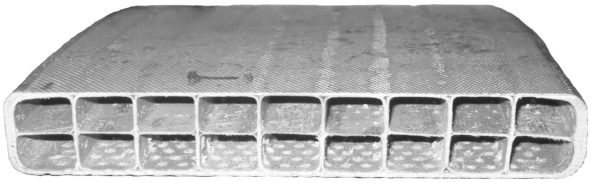

Fig. 3. Element of sound-absorbing panel of the engine

The outer wall of the need to save the whole, are not permitted wall panel to punch through (Fig. 3).

Mechanical treatment of parts made of composite materials of high complexity. Drilling and milling parts made of composite materials has the following features [1]:

– chipped material in the places of entry and exit instrument of the holes, because of the low adhesion due filler and binder;

– the difficulty of obtaining the necessary roughness of the processed surfaces of polymeric composite materials, pronounced anisotropy of properties that requires accounting for structure reinforcement individual selection of cutting conditions and the tool geometry;

– low thermal conductivity of the material, causing the bad drawing the heat out of the cutting area (tool absorbs 80 - 90% of the heat);

– intensive abrasive effect of filler cause of nose instrument due to the high hardness of the filler and the presence of large areas of the contact on the rear surface;

– destruction of polymer binder in the cutting zone. Under the action of mechanical and thermal loads chemical destruction of polymer composite materials;

– low productivity of the process, due to low cutting speeds as limited use of lubrication-cooling fluids;

– specific safety requirements related to you by dividing volatile fine particles of polymer composite materials cutting.

For shaping of the holes in the sound-absorbing panels at the enterprises of the aviation industry is often used manual labor.

Holes to absorb noise diameter 1,6 - 2 mm in the nodes of sound-absorbing panels punching manually, that is the limiting factor in the development of production of the plant, because:

– manual labor low efficiency;

– ongoing cost of manufacturing guides conductors;

– process of drilling and milling accompanied by emission of harmful finely dispersed particles.

To resolve operational problems of manufacture of sound-absorbing panels, taking into account the technological features of processing of polymeric composite materials tasks were set:

– design of high-technology complex 5-axis machining (perforation holes and milling) products of complicated geometrical form;

– development of technologies for perforation holes and milling;

– development of a technique for tracking breakdowns small cutting tools when you hit the wall sandwich panels;

– the decision of questions of machine control over the trajectory of movement of the working bodies and the possibility of adjusting the positioning of the tool to coordinate processing;

– tooling design for fastening products;

– development of algorithms of control programs;

– selection of components of a complex (high speed spindle, ventilation system).

3. The content of the project

To solve the above mentioned tasks proposed the modern productive robotic complex for mechanical processing of polymeric composite materials with automated operation mode.

Complex on the basis of an industrial robot-manipulator is a universal flexible system [2]. Advantages of robotic complex in comparison with machine tools are the following [3, 4, 5]:

– cost robotic complex is several times lower than similar in functionality of the machining center;

– room robotic complex economical machining center;

– robot is used to tell the tool to 12 synchronous coupled degrees of freedom, that is a tool able to move on any complex trajectories in three-dimensional coordinate system;

– free installation of the robot on the floor, wall or ceiling, and a working area of up to three meters allows you to work with large components;

– term of operation of the robots (from Germany, Japan) 12 years round the clock work when maintenance every 5000 running hours.

The designed complex is located base is a robot-manipulator. Typical examples are the robots-

manipulators, produced by the leading manufacturers of industrial robots Kawasaki (Japan), Kuka (Germany), ABB (Sweden) and others.

On Fig. 4-6 shows the robots KUKA KR 60 HA, Kawasaki RS060N and ABB IRB 4600-60/2/05.

Fig. 4. Robot KUKA KR 60 HA (Germany)

Fig. 5. Robot Kawasaki RS060N (Japan)

Characteristics of robots-manipulators are given in Table I.

Comparison of technical characteristics robots chosen the most accurate model of the robot (Kuka KR 60 HA).

Fig. 6. Robot ABB IRB 4600-60/2/05 (Sweden)

Table I

Characteristics of robots-manipulators

Model		Kuka KR 60 HA		Kawasaki RS060N		ABB IRB 4600-60/2/05	
Country		Germany		Japan		Sweden	
Type		Articulated		Articulated		Articulated	
Number of axes		6		6		6	
Maximum reach, mm		2033		2100		2050	
Position-ing repeatability, mm		±0,05		±0,07		±0,05-0,06	
Maximum total load, kg		60		50		60	
Range of motion software-limited		Range/ degrees	Angular speed, radian/s	Range/ degrees	Angular speed, radian/s	Range/ degrees	Angular speed,
Number axis	Axis 1	±185	2,23	±180	3,14	±180	3,05
	Axis 2	+35/ -135	1,78	+140/ -105	3,14	+150/ -90	3,05
	Axis 3	+158/ -120	2,23	+135/-155	3,22	+75/ -180	3,05
	Axis 4	±350	4,53	±360	4,53	±400	4,35
	Axis 5	±119	4,27	±145	4,53	+120/-125	4,35
	Axis 6	±350	5,61	±360	6,27	±400	6,27
Maximum linear speed flange 6 axis, mm/s		No information		13400 804 m/min		No information	
Weight, kg		665		555		435	

In result of study of technical solutions specification of the complex includes the following main compo-

nents:

– robot Kuka KR 60 HA, with capacity of 60 kg;

– dustproof sealed cover for the robot;

– remote control with the controller;

– computer software package for working with CAM-files;

– high-speed spindle capacity of 8 kW and maximum speed of 24 000 rpm;

– positioner one-axis with vertical axis of rotation, with a payload of at least 500 kg;

– system scanning laser tracking sensor trajectory of the tool concerning surfaces of the product;

– control system of the zero point of the tool;

– a system of sensors, tracking breakage small cutting tools;

– ventilation system with local fume extraction and vacuum filtration plant;

– replaceable cartridge spindle;

– collets for different instruments (diameters 2, 4, 6, 8, 10, 12, 16 mm);

– cassette auto for ten rounds;

– tool (drills, milling cutters);

– device for fastening products;

– fencing and security locks.

In computer three-dimensional environment modeled schematic diagram of the robotic complex (Fig. 7).

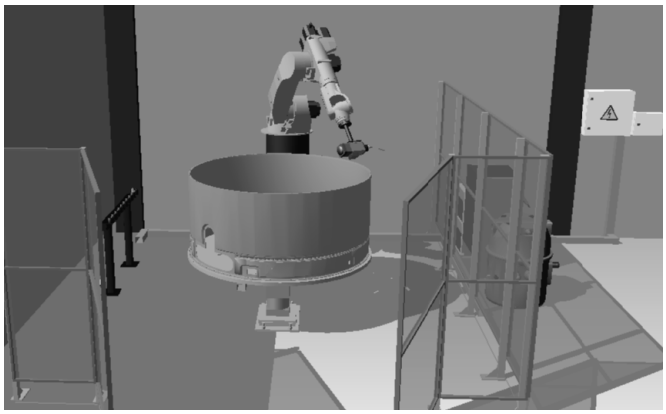

Fig. 7. Layout of robotic complex

Overall dimensions and weight of processed parts: diameter 2500 mm; height 1500 mm; weight up to 500 kg.

The developed complex (Fig. 8) allows you to perform operations perforation holes and milling in the products of the type of multilayered shells.

Materials of the processed products: polymer composite materials, wood, non-metals materials.

Station automatic change of the cutting tool is a modular system. In completing the robotic complex, includes several stations with a stand.

In the composition of the robotic complex includes active and passive safety systems to prevent the ingress of staff in the danger zone of the industrial equipment.

Fig. 8. General view of the complex for mechanical processing

4. Conclusion

Creation of new robotic complex for mechanical processing of products made of composite materials is a high-tech production platform.

In the result of development and introduction of robotic complex, the following results were obtained:

– reduced the high cost of manufacturing of units of polymeric composite materials by replacing manual repetitive work on a more powerful robotic;

– improved working conditions in the workshop of the manufacturer, so as performers isolated from harmful factors;

– new equipment will allow to increase volumes of manufacture of products from polymeric composite materials in accordance with modern growing needs.

In Russia there are no analogues created robot-technical complex. The main foreign alternative option is a system LASERDYNE SYSTEMS company PRIMA North America, Inc. (USA), commissioned the company Boeing[1].

Acknowledgement

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