Repair of an Unmanned Aerial Vehicle Airframe with a Composite Material

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Abstract: The article considers the elements of repair of UAV airframe made from composite material. The causes of defects in maintenance and the sequence of the technological process of repair work are demonstrated.

Keywords: UAV - unmanned aerial vehicle, PCM - polymer composite materials.

In order to ensure high reliability, durability and aerodynamic properties of the UAV in the process of repair of the airframe made of composite materials must be preserved and restored: the original strength of repaired parts (units, assemblies); accuracy of external contours and smoothness of external surfaces; specified weight, geometric and leveling data of the airframe; reliable corrosion protection of repaired elements.

The acceleration of scientific and technological progress in aviation is primarily a significant expansion of the range of materials and technologies used. Modern high-strength PCM, carbon and organ plastic composites, as well as honeycomb structures have great efficiency due to the reduction of aircraft weight and simplification of its production technology. Increasing their use requires the development of new and existing repair technologies. In addition, honeycomb structures are the most thin-walled, on the outer contour of the aircraft. They are more sensitive to concentrated loads than others and are often damaged by foreign bodies. During operation, latent defects that were not detected during production of the structures are revealed.

Repair of UAV airframe cladding involves the repair of typical defects such as loose scratches, delaminating, peeling, dents, holes, cracks, and in some cases, panels or parts of the airframe are replaced if significant damage has occurred.

Therefore, the main causes of failures (complete or partial) of PCM are as follows:

Scatter of physical-mechanical and geometrical parameters of the matrix and reinforcing material;

Insufficiently good adhesion and cohesion characteristics of the matrix and reinforcing material, adhesive materials;

Residual stresses in the matrix;

Internal technological micro defects of fibers, matrix at the interface "fiber - matrix" (pores, cracks, delaminating, shells, folds);

Surface defects (risks, scratches, creases, cracks, overlaps of prepreg, etc.).

On this basis, defects can be divided into two classes: defects that do not develop during the operation of a PCM structure and defects that develop during operation and cause deterioration of performance and sometimes lead to catastrophic consequences.

The following defects are possible when determining:

- scratches in the matrix occur over the entire field of the unit, the type of defect is slotted non-cutting damage, the cause of these defects is negligent transportation, storage, operation;
- shallow scratches in the filler (in the fabric, ribbon) occur throughout the entire field of the unit defect depth of scratches is less than 25% of the shell thickness, the cause of these defects negligent: transportation, storage, operation;
- delaminating occurs throughout the entire unit field, characteristic of the defect is a violation of the interlayer bonding of the cladding, caused by a violation of the construction technology (vacuum bag depressurization during cladding molding, poor quality prepreg, substrate film residues);
- cellular filler, cladding-framework; cellular filler-framework; frame-framework; defect characteristic - failure of adhesive joints, cause of occurrence violation of assembly technology - gluing of units, unacceptably high acoustic loads, accumulation of moisture;
- cellular filler trim is damaged; the defect is a deformation of the trim and the cellular filler, caused by negligent transport, storage, mechanical damage due to collision with foreign objects;
- the defect can be of two types: single-sided and through, and occurs throughout the entire unit field, characteristic of the defect is local destruction in one or both sides of the shell and honeycomb core, cause of occurrence negligent transport, storage, mechanical damage due to collision with foreign objects;
- Crack occurs across the entire unit field, characteristic of the defect crevice through-hole failure of the shell integrity, cause of occurrence unequal stresses, unacceptably high loads.

The specific defects and the reasons for them exist in the joining of parts with hollow rivets, core rivets and rivets with high shear resistance. The results of testing the mechanical properties of samples with various riveting defects show a reduction in tensile force of up to 30% when the thickness of the rivet head is low and sheer force of up to 15% when there is a gap in the parts pack. Corrugation of sheeting usually occurs within the cage formed by stringers, ribs, ribs, ribs and other frame strength members. The cause of this defect is the loss of sheeting stability due to structural deformations caused by high in-flight overloads or rough landings. If the corrugations (or "flaps") are small, the sheeting is reinforced by corners riveted on the inside. If the skin loses stability in a large area, it is completely replaced in one or more cells.

To prevent cracks in the cladding up to a length of 50 mm from developing further, drill them through with a 2 mm drill bit. A reinforcing plate is riveted on the inside, which must overlap the ends of the cracks by 25 mm. For pinholes up to 15 mm in size, a circular or oval hole is cut in the liner and the deformed edges are removed; the reinforcing pad is riveted on the inside. The outer surface of the lining is filled with glue BK-9 and the surface is painted after it has dried.

Repair of skins with cracks longer than 50 mm or punctures larger than 15 mm in the absence of damage to the force-frame includes the following operations:

- ✓ cutting out the defective section of sheathing along a smooth rectangular contour with rounded corners, circular or oval; in doing so, leave a part of the old sheathing at least 25 mm away from the frame parts for the riveting joint;

- ✓ creating and riveting a support area from the inside in the form of a solid pad or a split pad that overlaps the window cut out in the cladding by 20 mm;
- ✓ Making, fitting to the contour of the cut-out and riveting the pad-filler (insert) to the supporting surface.

Backings are usually riveted with normal rivets. Filler pads are riveted with blast, pin and other special rivets if there is no two-way approach to the riveting point. Sometimes countersunk screws and anchor nuts are used. The rivet material is selected according to the tables.

Sealing of paneling dents is done with filler paste. Dents in the skin of subsonic airplanes up to 1 cm in depth and up to 100 cm2 in area can be sealed with a special epoxy resin paste. This method is recommended for sealing a minimum of three cents per m2 of shell where there is no internal access to the defective area, particularly if thermal insulation elements are attached to the shell.

Remove the old paintwork from the damaged area, including 20 mm away from the dent. Remove the old paintwork with AFT-1, SD or 30% thinner mixture of P-5 and 70% petrol B-70. The surface of the dent is cleaned, degreased with benzene BR-1 (Galosha) or acetone and dried within 30 min. Paste is applied to the damaged area and smoothed flush with the trim with a trowel. After the paste has hardened, sand the surface with abrasive paper No. 16 and paint.

Detachment of the liner from the honeycomb core on units which are not subjected to acoustic and vibration loads and have no special purpose can be eliminated by splicing adhesive into the defect and installing plugs made of aluminum alloy (if the liner is GRP) or titanium (Fig. 1). Holes for splicing glue and stopping plugs are drilled in a staggered pattern, 20 mm apart, if the defect is wider than 40 mm. Drilling depth 3-5 mm. After drilling the holes, remove dust and chips from the machining area with a hoover.

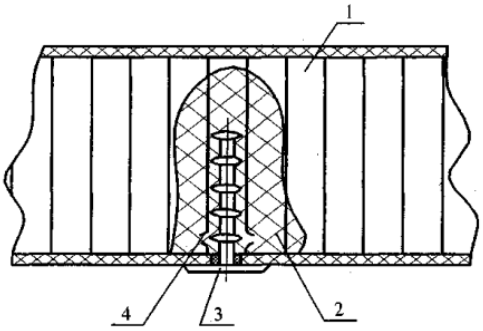

Fig.1. Repair of delamination with installation of "Screw" type plugs:

1 - unit to be repaired; 2 - glue sprayed into the repair area; 3 - plugs; 4 - hole in the honeycomb wall for glue to flow in.

When repairing units that are in an area that could be exposed to heated engine gases, the sealing should be done with adhesives that have increased heat resistance.

Plugs may only be fitted to the lower surfaces when the aircraft is parked, as they are fitted at the same time as the adhesive is applied to the defect. If plugs have to be installed on the upper surfaces of the unit, the unit must be removed from the aircraft. To ensure that the adhesive is spread evenly and completely over the entire defect surface between the skin and the honeycomb core, the honeycomb core walls are drained with a special device (Figure 2).

The holes in the honeycomb walls must be round and located 0.5...1.5 mm from the drilled skin.

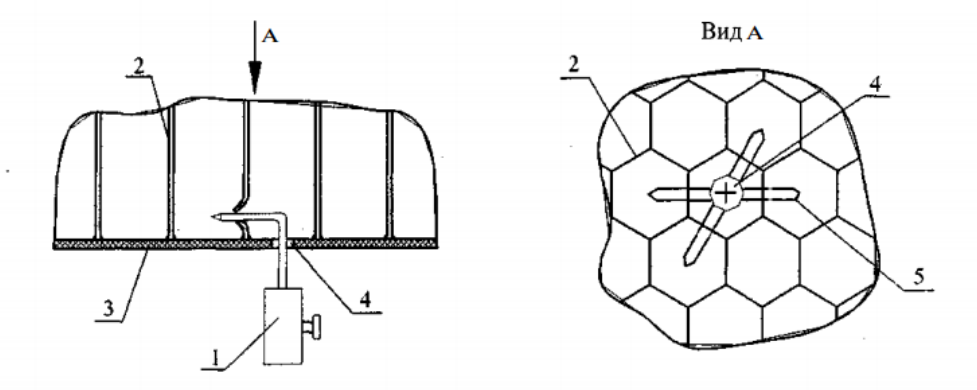

Figure 2. Diagram of cellular filler drainage before gluing:

1 - device for drainage; 2 - cellular filler;

3 - cladding of the unit under repair; 4 - hole; 5 - drainage channels in the honeycomb core.

The plug is prepared for installation in the unit (shortened, degreased) and the adhesive is applied to the hole in the unit. Mostly paste adhesives like BK-9, BK-27 are used for repairs. They are of high viscosity, and special syringes must be used for their injection into the unit. Screw-type syringe which ensures injection of cold pasty adhesives (Fig. 3) is the most widely used. It is filled with freshly prepared adhesive, then the tip of the syringe is inserted into the defect hole, and the adhesive is squeezed out by turning the handle. Cease applying glue when the pressure (force) of the syringe suddenly increases or glue emerges from adjacent holes. After finishing work, the syringe must be rinsed of any adhesive residue.

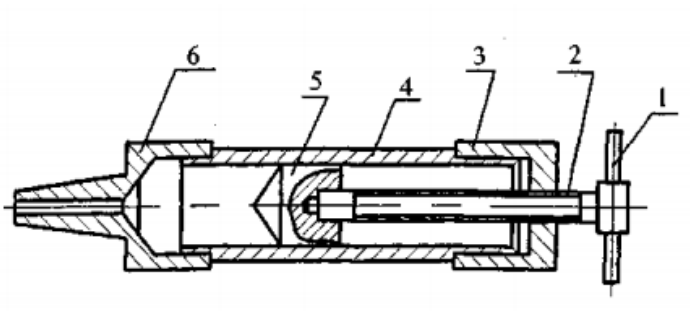

Fig.3. Syringe with screw rod:

1 - handle; 2 - screw rod; 3 - coupling nut; 4 - syringe barrel; 5 - piston; 6 - tip.

Immediately after priming, place a stopper in the hole, making sure it is not tilted. Remove any glue spillage with a cotton cloth soaked in acetone. The heads of the plugs are secured with adhesive tape and the glue is allowed to cure. If heating is required, a heater is placed in the repair area, the process bag and air bag are assembled, ensuring pressure of 0.05...0.1 MPa (0.5...1.0 kg/cm^2), and the glue is cured according to the set regime.

After the curing of the adhesive, the installation of the plugs is checked visually. The presence of delamination and peeling is controlled with a flaw detector or by tapping.

Detachment of skin from honeycomb core on special purpose units (wing mechanization units, tail assembly, landing gear flaps, etc.) must be repaired by removing the skin in the defect area and then forming it with prepregs and film adhesives, and if necessary (e.g. corrosion of metal honeycomb core or damage) the honeycomb core must be replaced.

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