

Acoustic emission method of diagnostic of elevating rudder covering in places of lightning strikes impact

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Abstract: Acoustic emission (AE) is the process of emission of mechanical waves by materials caused by dynamic local restructuring of its internal structure under the influence of stresses of any kind. The source of AE is plastic deformation, the formation and growth of cracks, the outflow of a working fluid (liquid or gas) through holes. The AE method, unlike other methods of non-destructive testing (NDT), is passive, i.e. using the physical field of emission generated by the defects themselves. The acoustic emission (AE) method is based on the registration and analysis of acoustic waves arising in the process of plastic deformation and fracture (crack growth) of diagnostic objects. It makes possible to determine the places where the structure of the material changes when lightning strikes the covering of the elevating rudder for the composite laminate from which the elevating rudder of the RRJ aircraft is made.

KEYWORDS: acoustic emission; diagnostics, elevating rudder; composite laminate; lightning stroke.

Introduction

The acoustic emission (AE) method is based on the registration and analysis of acoustic waves arising in the process of plastic deformation and fracture (crack growth) of diagnostic objects. It makes possible to determine the places where the structure of the material changes when lightning strikes the covering of the elevating rudder for the composite laminate from which the elevating rudder of the RRJ aircraft is made.

When lightning acts on the elevating rudder, the covering of which is made of two panels of 7-layer carbon composite, it becomes necessary to diagnose the material in places close to the visual destruction of the covering of the elevating rudder. A potential change in the structure of the layers of the composite material can occupy much larger areas than the zones of visual surface damage to the composite covering.[1]

The object of diagnostic

The object of diagnostic is the RRJ aircraft elevating rudder made of composite materials, which is a three-component honeycomb core construction of two 7-layer panels and a honeycomb core.[2] The elevating rudder passed certified tests for lightning stroke in accordance with the program before the trials. The value of the rupture load of the elevating rudder after lightning stroke was determined, which made up to 110% of the rupture load as a result of the trials.

The appearance of the elevating rudder after static crushing tests is shown in Fig.1.



Fig.1. The elevating ruder after lightning strikes impact by the end of crushing tests.

The zones of lightning impact on the elevating rudder in the area of the root and end parts are shown in Fig. 2, from which it can be seen that there is one in the root part, and two places of lightning impact in the end part.



a) The root part of elevating rudder.



b) The end part of elevating rudder.

Fig.2. The zones of lightning impact on the elevating rudder.

Device for Elevating rudder Diagnostics by Acoustic Emission Method.

For the diagnostic was used a portable two-channel acoustic emission device POCKET AE-2 under the control of the AEWin package to which piezoelectric converter were connected. [5]

Device settings during diagnostics are shown in the Table below.

Threshold	HFF	LPF	Preamplifiers	Sampling frequency
30 dB	5 kHz	1000 kHz	inside 26 dB	2 MSPS

Tab.1. Conduction of diagnostics by the AE method is shown in the photo Fig.3.

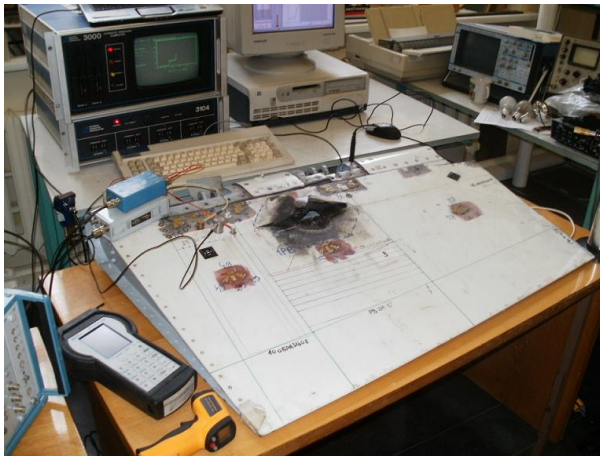


Fig.3. The diagnostic of the elevating rudder's part by AE method.

Piezo sensors attachment on the construction of the skin of the elevating rudder is shown in Fig.4. Triple reservation of AE measurements was carried out (three independent sensors and measuring devices) to strengthen reliability of diagnostics.

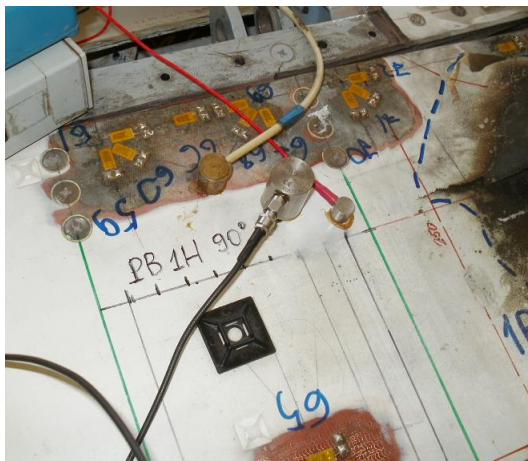
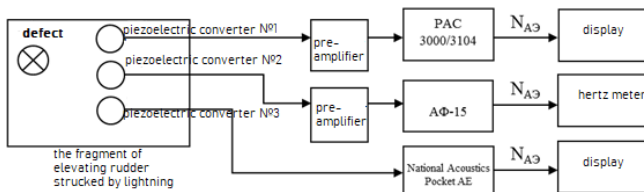


Fig.4. Piezo sensors attachment on the construction of the skin of the elevating rudder.

The block diagram of acoustic emission measurements for the elevating rudder's notch zones, from where the triple reservation of the acoustic signal measurement can be seen, is shown in Fig.5.



1,5 см Block diagram of acoustic emission measurements for elevating rudder's notch zones.

The results of diagnostics of the elevating rudder covering in places affected by lightning.

The object of research was the root and end parts of the elevating rudder after lightning strikes, on which acoustic sensors were glued. In the places of diagnostics (impact by lightning), the object was locally heated up to 80°C. At the same time, the probe scanned the area from the center of lightning impact to the periphery. As a result, two zones of emission variation were observed: a weak one along the periphery and a strong one closer to the center. The attached Figs. 6 - 8 show the damage zones in zones

PB1, PB2 and PB3: blue - hammering, red - intensive crushing (acoustic emission method) and green - initial damage (acoustic emission method).[6]

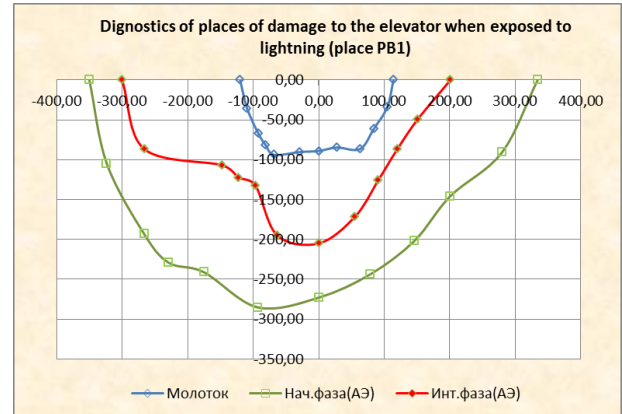


Fig.6. Dignostics of PB1 zones in the root part of the elevating rudder. Blue - hammering, red - intensive crushing (acoustic emission method) and green - initial damage (acoustic emission method).

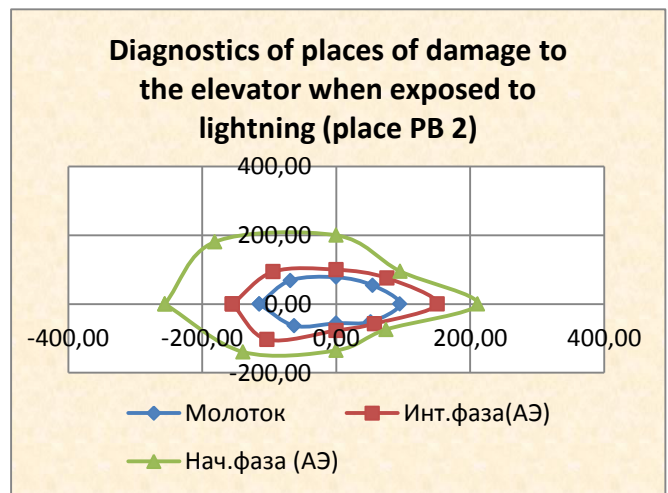


Fig.7. Dignostics of PB2 zones in the root part of the elevating rudder. Blue - hammering, red - intensive crushing (acoustic emission method) and green - initial damage (acoustic emission method).

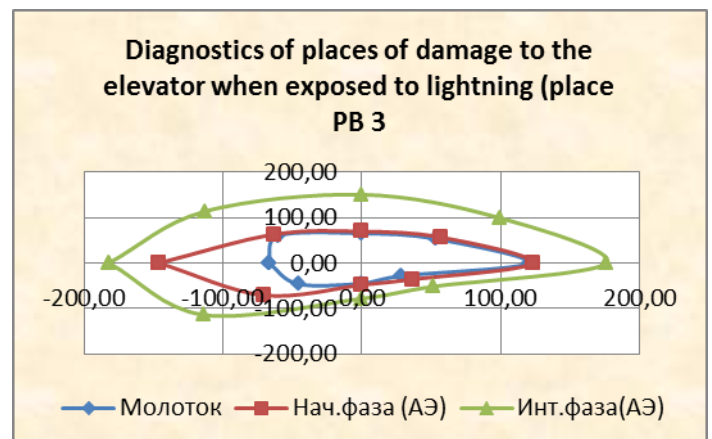


Fig.8. Dignostics of PB3 zones in the root part of the elevating rudder. Blue - hammering, red - intensive crushing (acoustic emission method) and green - initial damage (acoustic emission method).

On Fig.9. Zones of diagnostics of the elevating rudder PB1 are applied the object of diagnostics (the root part of the elevating rudder): central unpainted - material delamination by taping; middle orange - intensive phase of AE and extreme blue - initial phase of AE.

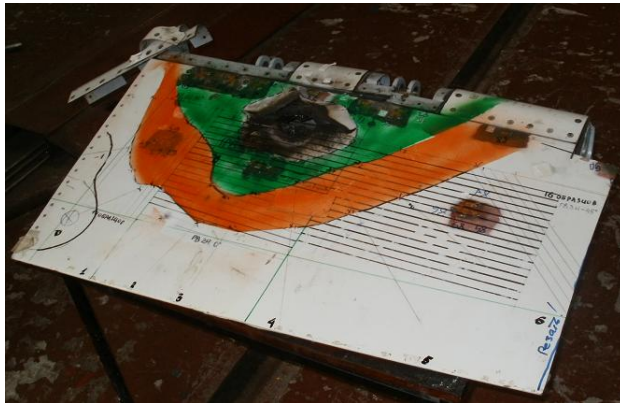


Fig.9. Zones of diagnostic of the elevating rudder.

The following results were obtained investigating the covering of the elevating rudder in places affected by lightning by acoustic emission method:

- ✓ the diagnostic of changes in the structure of the composite material of the elevating rudder in places affected by lightning PB1, PB2 and PB3 was conducted;
- ✓ the zones of change in the structure of the composite material near the places of lightning impact were determined;
- ✓ the zone of a strong change in the structure of the material was found by manually tapping the covering directly near the destruction zone and is an ellipse for the PB1 zone with dimensions of 100x200 mm
- ✓ the zone of intense and initial changes in the structure of the composite was determined by the acoustic emission method (intense - 350x500 mm);
- ✓ it is necessary to conduct strength tests of the samples of the elevating rudder covering in the zones PB1, PB2 and PB3 and compare the obtained characteristics with the characteristics of samples from undamaged covering to confirm the diagnostic results. [3;4]

Conclusion.

The diagnostics of the elevating rudder covering zones near the places of lightning impact was performed by the acoustic emission method. The zones of intensive and initial changes in the strength characteristics of the elevating rudder covering in places affected by lightning were determined. The zone of a strong change in the structure of the material was found by manually tapping the covering directly near the destruction zone and is an ellipse for the PB1 zone with dimensions of 100x200 mm. The zone of intense and initial changes in the structure of the composite was determined by the acoustic emission method (intense - 350x500 mm).

There is a good agreement of zones of change in the strength characteristics of the elevating rudder in the area of lightning impact, obtained by acoustic emission methods and strength tests of samples.

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