Aircraft outer contour in flight mode diagnostic system

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Abstract **Method of diagnosis of the external contour of the aircraft using the introduction of composite materials in the optical fiber, an automatic optical fiber identification system is proposed.**

Keywords: **Reconfiguration, Aircraft contour, Damage identification, Wing outer contour**

1. INTRODUCTION

Many incidents in civil aviation are associated with damage to the outer contours of the aircraft. Changing circuit wing or fuselage damage due to respective surfaces results in a change of aerodynamics, roll and thus loss of control. Thus, the definition of the moment of location and extent of damage to the skin of the aircraft makes it possible to assess the damage and help fend off the reconfiguration control perturbation and return the aircraft controllability.

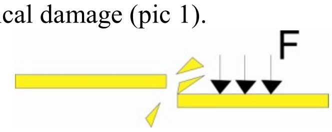
2. RESEARCH BACKGROUND

November 22, 2003, just after taking off from Baghdad airport cargo plane Airbus A300 DHL's zenith was struck by a missile fired from MANPADS. Damaged console and mechanization of the wing, causing leakage of fuel, hydraulics and loss as a result of management. Aircraft, planted by changing the engines traction.[1].

With the help of standard instruments, pilots can see only the loss of hydraulic fluid and the appearance of bias. The decision to move to the control using only engines only saved the situation, but the control was carried out actually in blind.

3. DIAGNOSTIC SYSTEM STRUCTURE

The diagnostics system based on the network of longitudinal and transverse fibers and sensors, captures the light output in the fibers and transmits information to the classifier typical damage (pic 1).

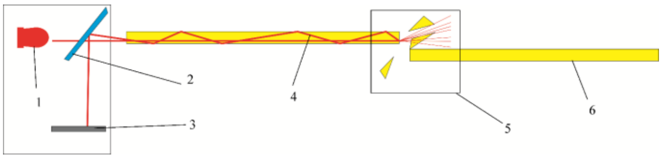


Pic 1. Breaking optical fiber

Considering the disadvantages of composite materials associated with resistance to damage, there is a need for surveillance strength designs with built-in diagnostic systems. Fiber technology for these tasks has several advantages over other means of non-destructive testing and diagnostics, including light weight and comfortable layout, completely passive circuit using low power, immunity to electromagnetic interference, high sensitivity and wide bandwidth, compatibility with optical transmission and data processing, long life and low cost....

Fiber optic measuring system can be easily and conveniently combined due to their usual small size. In particular, in the case of fiber sensors, area measurement is limited by the fiber, a fiber material can be embedded in any element of the external outline of the aircraft.

Optical fiber is bent freely, but any bias on the horizontal axis is scrapped. Integrating it into the structure of composite material properties its properties are not worse, but only adds the ability to track the integrity of the surface of the aircraft.



Pic.2. Specify where breaking optical fibers

1 - light generator, 2 - semitransparent mirror 3 - photodetector 4 - light beam 5 - place of fracture, 6 - optical Fiber

This optical fiber - is, in fact, a glass tube with a close to 100% reflecting ability, which makes it possible to freely transmit light signal. At the point where the optical fiber ends bent or zlamuyetsya, reflecting the ability to change, and part of the back light.

The optical pulse is introduced in the fiber through the directional coupler or semitransparent mirror. This pulse propagates through the fiber and is attenuated according to the coefficient of attenuation fiber. A small portion of optical power dissipation, resulting scattered radiation through the directional coupler reaches the photodetector is converted into an electrical signal, amplified, processed and the result is displayed.

Measurement of attenuation is based on the assumption that the backscattering coefficient is constant for a given fiber, ie the fiber at each point scatters back the same amount of optical power, but because of the attenuation of the fiber to the photodiode or resistor reflectometer falls linearly reduced optical power. Fiber attenuation between points 1 and 2 is defined as half the difference between the respective power levels P1 and P2: $A = (-0{,}5) \cdot (P1-P2)$ (dB) - a factor -0.5 appears because the light has passed dual path from the source to the point of reflection and back [2]. In case of defect or joints is a sharp increase in reverse radiation and time of this radiation is calculated point defect junction and fiber breakage.

1) Light source

The laser sends pulses of light at the command controller. Under different measurement selects different pulse duration. Light passes through the splitter and is part

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of the test fiber. Some optical reflectometer have two lasers, with which you can test fibers at two different wavelengths. Use both lasers simultaneously is impossible.

2) Splitter

Splitter has three ports - one for lights, one for the test fiber, and one for the meter. Splitter - a device that allows light to propagate only in certain directions from the laser source to the test fiber and the fiber under test to the meter. Light can not go directly from the source to the meter. Thus, the pulses of light source directed at the tested fiber, and reflected light energy - frenelevske backscattering and reflection - is sent to the meter.

3) Optical meter block

Optical meter - a photodetector that measures the amount of light coming from the tested fiber. It converts optical radiation into electrical signals corresponding level - the more power optical radiation, the higher the level of electrical signals. Measuring optical reflectometer specifically designed for measuring extremely low levels of backscattering of light energy. The structure includes meter and electric power, is designed to further improve the electrical signal.

Frenel display about 40 000 times stronger backscattering. Measure the size of a meter is not in a position - it causes it to overload and saturation. Therefore, the output electrical signal is "clipped" when reaching the maximum level of output power meter. So every time testing impulse reaches the end of the fiber - is still near the mechanical connection (junction) or at the end of all fiber - this leads to the fact that the meter "blind" to the end of the pulse. This period of "blindness" is called a dead zone.

4) Controller Block

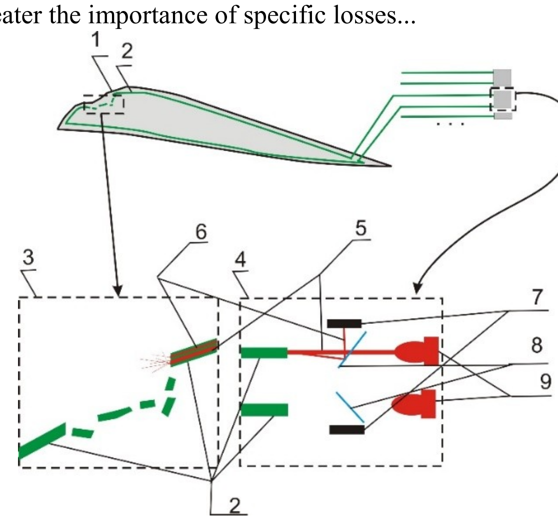
Controller - a brain optical reflectometer. He tells the laser when to send a pulse; receives meter data about power levels; calculates the distances to the points of reflection and scattering in the fiber; there remain some points of measurement; it sends the information to the display.

One of the important components of the block diagram of the synchronization controller is used to accurately measure the time difference between sending a pulse laser and detecting the reflected light meter. Multiplying this time pulse propagation in both directions (back and forth) at the speed of light in fiber (which is the speed of light in vacuum, adjusted introduction of the refractive index), and dividing it in half, we can calculate the distance from the optical reflectometer to the desired point.

Since the inverse scattering occurs along the entire length of fiber, then back to the reflectometer, there is a continuous flow of light. Controller at regular intervals fixing level identified by meter, and thus gains a point measurements. Each point of measurement is characterized by its corresponding time (which is related to the distance from the reflectometer) and power level. As the initial momentum as its distribution in the fiber becomes weaker (because of losses caused by releyevskym scattering), the more it is passed by fiber length, the lower level of the corresponding backscattering. But when there is frenelivske display, the power level in the corresponding point rises sharply to a maximum - much higher than the backscatter, which was directly in front of it.

When the controller has collected all measurements data, it displays the collected information to the display screen. The first point of measurement results displayed on the left edge of the graph as a start point fiber. Its position on the vertical axis depends on the power level of the reflected signal: the higher the power, the higher is the point.

Subsequent measurement points are right. As a result, the trace is a sloping line that goes from the top left corner to the lower right. Reflectography slope indicates the specific loss (in dB / km). The greater the slope, the greater the importance of specific losses...



Pic 3. Functional diagram of diagnosing

1 - profile wings, 2 - fiber, 3 - damage to the wing leading edge, 4 - device adoption / transfer of the light signal, 5 - input light signal, 6 - light signal that returns 7 - photoresistor 8 - splitter, 9 - LED or laser

The line is formed from measurement points, respectively, equal to the inverse scattering. Frenelevske display appears on the trace in the form of bursts that are coming up from the level of backscattering. The dramatic shift level backscattering indicates "point loss," which could mean the presence of the weld (fiber junction) or in terms of mechanical stress through which the world comes from the fiber.

5) Display

Display - a screen on the CRT or liquid crystal, which are derived in terms of measurement, forming reflektohramy fibers and parameters settings reflectometer and measurement results. Most displays reflectometer measurement points for greater clarity connected with each line. With on-screen cursors on the trace, you can select any point measurements. When the cursor is on any point displays the distance to that point. In reflectometer with two cursors on the screen will be displayed distance to each of them, and the difference between backscattering in both locations. Using cursors can be measured by different parameters: the loss of two points, specific losses, losses on the joints and loss of reflection. The results of these measurements are displayed....

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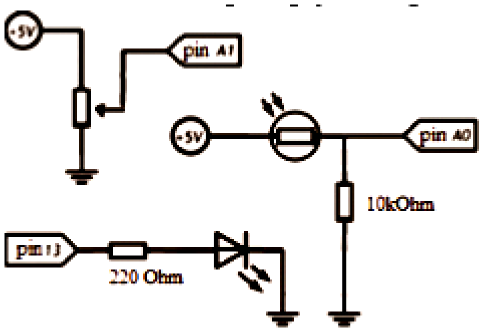
In addition to output reflektohram display data on a bend or kink optical fiber processed is determined by location and degree of damage. This information is transmitted to the system reconfiguration of aircraft, and, if necessary, to display pilot.

Measuring with a reflectometer usually held at a wavelength of light is equal to 1.31 or 1.55 microns.

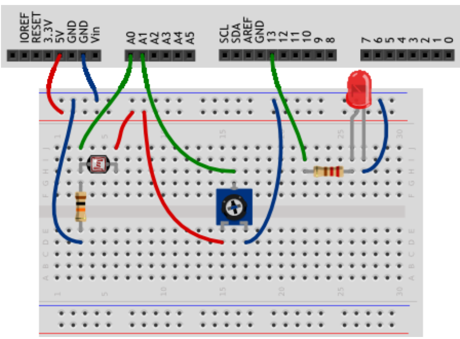
According to the data, forming characteristics, the so-called trace. Movement adopted pulses to determine the length of the fiber optic line attenuation in it, including losses on the connector, distance to places inhomogeneities fibers that may be associated with breakage or change in its structure.

As LED brightness varies according to the supplied voltage to adjust the brightness we shall add resistive sensor based on the potentiometer. The result is a schematic diagram of reflectometer diagnosing system (Pic 3).



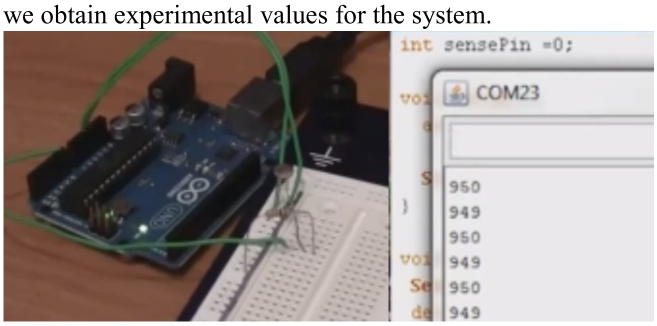
Pic. 3. Schematic diagram of the reflectometer diagnostic system

To test, draw on the breadboard circuit reflectometer (Pic .4).



Pic 4. Test circuit diagnostic system

For performance testing, breadboard should be placed in a dark environment to simulate shell system diagnostics. As a result of semi natural experiment we obtain data on a scale 0-1023that corresponds to voltage 0 ... 5V. Based on the performance of experiments (Pic 5), we obtain experimental values for the system.



Pic 5 The experiment on the reaction rate.

In table 1 there are results obtained within 10 seconds of the experiment.

Table 1.

Results of semi natural experiment

normal environment		dark environment without LED		dark environment with 50% of the voltage across the LED		full voltage for the LED	
950	949	188	190	220	214	549	549
949	949	190	190	221	221	550	550
950	950	187	189	220	219	549	550
949	949	189	188	219	219	549	549
950	950	190	191	219	221	549	550
949	949	188	190	220	219	549	550
950	950	190	191	222	220	550	549
950	950	189	190	220	220	549	549
949	950	190	190	222	220	548	548

While fiber fracture occurs subsidence signal, i.e. change in the amount of reflected light is 6-18%, so the error of the results obtained in different conditions should not exceed 75% of this value that should not be greater than 4% of the maximum value of the sample. 4% of 950 = 3,8 ≈ 4 In a normal environment values vary from 949 to 950. 950-949 = 1 <4, in a dark environment without LED 191-188 = 3 <4, in a dark environment with 50% of the voltage across the LED is 221-219 = 2 <4, and at full voltage for the LED 550- 548 = 2 <4. Thus, we can conclude that the proposed system provides the necessary accuracy.

As a result of these experiments it can be concluded that the use of refractometric method in composite materials - justified. Also, it can be seen that the required accuracy of the scattering light power is observed.

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