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FIBER-OPTIC INTELLIGENCE STRUCTURES FOR THE TECHNICAL CONDITIONS DIAGNOSIS OF THE OUTSIDE OF THE AIRPLANE

Article is devoted to the possibilities of usage of the fiber-optic intelligence structure for the diagnosis of the technical conditions of the outside of the airplane.

Розглянуто можливість використання волоконно-оптичних інтелектуальних структур для діагностування технічного стану зовнішніх обводів літака.

aiber-optic intelligence structure, fiber-optic sensors, pulse neuron network

Introduction

While operating, plane is being under the influence of a lot of mechanical, biological and electrical factors that reduce to the flight configuration changes as well as accident. Therefore airplane construction as very serious, complex and critical technical system needs regular, thorough, numerous checking both with the on ground maintenance and during the execution of the flight. Under the conditions for the contemporary intensive introduction of polymeric composites as the new materials for creating the airplane trimming appears the need for the appearance of new methods of evaluating its stress-strained state on the basis of fiber-optic intellectual structures.

Goal of the article

Development of the system of diagnostics of the aerodynamic state of external airplane bypass with the use of fiber-optic intellectual structures, for the fixation of place, degree and the time of the suddenly emergent damages and their subsequent classification, and also guarantee of integrity of structure.

Main part

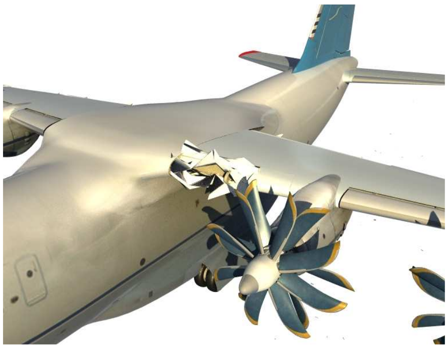
Nowadays composite materials are widely used in the aerospace field. This is caused, from one side, by high strength and hardness, characteristic of composites, and, from the other side, with small mass relative to the mass of metallic materials [1].

In foremost aviation and space equipment the technologies of measurements are necessary both for the classification of a change in the technical state of the external be pass of aircraft (plane) and for evaluating the design integrity (fig.1). Size, weight, insensitivity to the electromagnetic interferences, the increased strength and protection from the environment influence is the basic factors, which influence the technologies selection.

Fiber technology for the diagnosis of external bypass of airplane, has a number of advantages in comparison with the electronic technology [2-7], including low weight and convenient layout, completely passive network, the use of small power, insensitivity to the electro-magnetic interferences, high sensitivity and the broad band of transmission, compatibility with optical transfer and data processing, the prolonged period of operation and low cost.

Fiber-optical intellectual technologies can be lungs and it is convenient to be arranged because of the small sizes inherent in them.

a



b

Fig. 1. Typical damage of the stabilizer (*a*) and of the wing of the aircraft (*b*)

The use of small power is substantial for the plane, in which it is necessary to introduce the large number of sensors. Insensitivity to the electromagnetic interferences is important also from the point of view of weight and sizes. In many electrical systems the screening of the weak electrical signals, which go from the sensors, is the difficult-to-solve problem. To solve this, usually it is necessary to lay volumetric and heavy cables. For fiber optics this problem does not exist.

The last advantage becomes more influential, when the large number of sensors is united into the massif. If these sensors have high sensitivity and large dynamic range, the required pass band of massif will prove to be sufficiently wide. Since multiplexing of these sensors is possible with the use of a wide-band optical fiber, potentially capable of supporting the transfer of signals of hundreds of sensors, problems do not appear with the diagnosis of external bypass of the aircraft. For guaranteeing the effective band width electrical cable must have a thickness several centimeters. Fiber-optic sensors in the intellectual structures ensure the following basic functions [8]:

– functioning in the composition of the fiber-optic networks, which consist of the multiplexed fiber-optic sensors and the channels of transmission of the given and ensuring observation of the technical state external bypass of aircraft;

– the classification of the standard damages of the external bypass of aircraft in flight;

– control of the effectiveness of the work of intellectual system, and also the reconfiguration of control under the conditions of the appearance of special situation in flight.

The composite panel of the plane , that is build it fiber-optic sensors, can undergo different actions of environment, such as the deforming load, temperature, pressure and so forth sensors are optically multiplexed, only glass fibers so that are incorporated in the panel or are fastened to it, and the obtained signals are sent directly for the block of processing signals. As the block of processing signals it is proposed to use pulse neuron networks (PNN). Pulse neuron possesses such functional properties [9]:

– the increased accuracy of the classification of standard damages to aerodynamic surface of aircraft, due to the absence of the losses of information with the isolation of the static signs of dynamic signals, and also due to the use of a noise immunity of the pulse-frequency idea of information;

– the increased speed, since the result of classification can be obtained even to the end of the measurement of the signals of fiber-optic sensors on most intensive pulsation on one of the output neurons;

– an improvement in the technological-design parameters of the system of diagnostics of external bypass of aircraft due to the use of optical, but not electrical signals for organizing the huge amount of connections between the neurons of network.

Pulse neuron works as follows [by 10, 11], fig. 2: the first photodiode VD1 picks all exciting input optical signals (continuous or pulse), and the second photodiode VD2 picks up all braking signals.

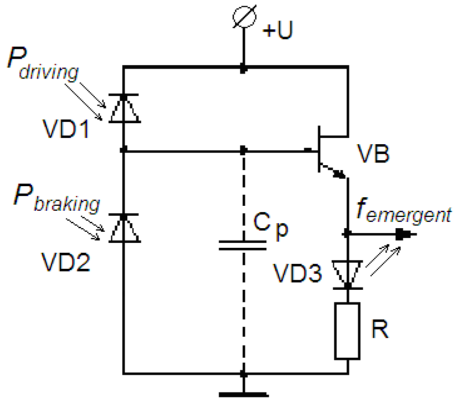


Fig. 2. Functional diagram of the impact neuron

With the condition of continuous input signals the sum of all driving signals causes the photocurrent through the first photodiode VD1 proportional to them, which charges the capacity Cp of the base layer of bispin-device B. The sum of all braking signals causes the photocurrent through the second photodiode VD2 proportional to them, which escapes from the base layer of bispin-device VB to the common bus, discharging the capacity Cp of the base layer of bispin-device VB. With the reaching by potential on the base layer of the bispin-device B of threshold quantity, the locking passage of bispin-device is opened and the charge, accumulated in the base layer, begins through it to emerge, shaping output impulse on the resistor of load R and light diode VD3.

Pulse frequency on the resistor of load R will be directly proportional to the algebraic sum of the photocurrents through first VD1 and second VD2 photodiodes. In case of pulse input signals, the driving pulses, which enter the first photodiode VD1, cause the pulses of the photocurrent through it, that charge the capacity Cp by portions of the base layer of bispin-device VB. But retarding impulses discharge the capacity of the base layer of bispin-device VB by portions.

Output pulse on the resistor of load R and the light diode VD3 will be formed, when the potential of the base layer of bispin-device VB reaches the threshold value as a result of the algebraic time-spatial summing up of energies of the input pulses that entered to the exciting and braking entrances. Pulse neuron element has a threshold, whose value can be assigned optically (changing the value of the permanent luminous flux on the n-layer of bispin-device) or electrically (changing the value of the bias current that inflow or outflow from the base layer of bispin-device).Neuron element generates the sequences of pulses with the frequency that is proportional to the algebraic spatio-temporal sum of the exciting and braking signals; the pulse amplitude with the specific supply voltage is constant. The most important principles of the functioning of pulse neuron are: frequency output - initial information about the excited level is coded in a series of nerve impulses with the appropriate frequency; amplitude and duration of the separate nerve impulses, which are passed on one and therefore to fiber, constant, and frequency and a quantity of nerve impulses in the sequence depend on the intensity of excitation.

The example of diagnostics system of the realizations of the aircraft wing conditions on the basis of fiber-optic intellectual structures is represented in fig. 3.

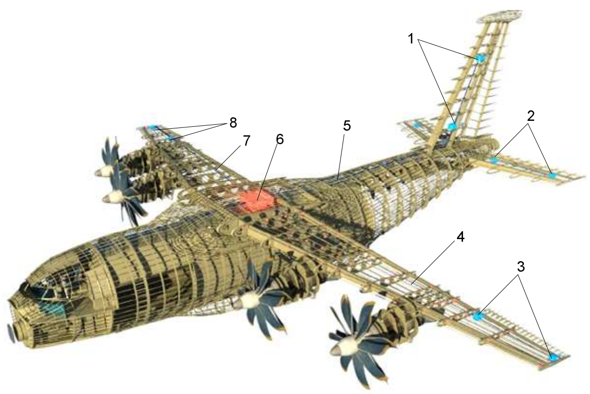


Fig. 3. System of diagnostics of external bypass of the aircraft in flight based on fiber-optic intellectual structures:
1, 2, 3, 8 are fiber-optic sensors (FOS);
4, 5, 7 are the optical plait, that connects several FOS;
6 is pulse neuron network, for the classification of the standard damages of external aircraft outlines

You can see that for the reliable recognition of the specific place of damage they adapt the distributed systems of optical fibers with different radiation spectrum. Moreover as positive property is noted the presence of the threshold nature of the dependence of luminous intensity on the applied mechanical load.

This circumstance ensures the insensitivity of sensors to the insignificant loads and the vibrations in process of operating the aircraft. The integration of function in the limits of one construction makes it possible to create the built-in sensors, which possess the ability to selectively determine the degree of damage to plane during the flight, and with help of PNN it is possible to relate them to the standard classes.

The comparative analysis of the existing sensors of the measurement of the mechanical load of plane makes it possible to isolate the following advantages:

– the primary data carrier - the flow of photons is its own product of the process of a change of state of substance, i.e., they do not require special actions and straight contact with the material for obtaining information;

– information will be transmitted to the photo receiver, registering gear with velocity of light − it is almost accelerative -free, which makes it possible to record the damages in real time, that appear during the flight (dent, breaks, chippings, the breaks of edging, so forth);

– information about the damages can be obtained both integrally and locally, i.e., it is possible to determine position, degree and time of the appearance of the damage of the plane which will make it possible to reconfigure flight control and to avoid accident during the flight.

Conclusion

That is why, for the solution of the problem of the diagnosis of the technical state of the wing of the plane during the flight, it is necessary to inject the new systems of control and diagnostics based on the fiber-optic intellectual structures, which will make possible to develop in proper time and objectively estimate the development of possible accident and to take necessary actions that are directed toward averting its development, by the reconfiguration of flight control or change the regime of flight. For recording of place, degree and time of the suddenly emergent damage to plane during the flight it is proposed to use fiber-optic sensors, and as the classifier of standard damages a pulse neuron network, which will increase accuracy, speed and authenticity of the recognition of standard damages and will make possible to preserve the necessary stability parameters and aircraft controllability.

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