DEVELOPMENT OF LEAKAGE CONTROL TECHNOLOGY OF UNCLOSED CONSTRUCTIONS IN AVIATION

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Abstract. Research is devoted to the study of prospects for applying the method of penetrating substances during for the leakage control of unclosed constructions in aviation.

Maintenance of tightness is a prerequisite for the operation of aircraft components and systems, responsible for safety. However in some cases in the course of control during the production significant difficulties arise, which dramatically increase the time and the cost of leak testing. To a large extent these problems are related to the control of the so-called unclosed designs which can't be pressurized by test medium. In practice, the leak control of unclosed designs performs by capillary penetrant testing (PT).

Unique PT capabilities are achieved through the selection of hypersensitive recipes of defectoscopic materials (penetrant, developers, etc.). However, to date, the potential of the traditional ways for improvement of characteristics is almost exhausted. The further development of the method is possible only through a fundamentally new approach. So as one of the most promising areas of the NDT penetrant method we studied the use of ultrasonic capillary effect (USCE). Ultrasonic capillary effect is an abnormal increase in the lifting height of the liquid in the capillaries by the direct effects of ultrasound. Active version of ultrasound tightness control significantly increases possibilities of leak testing of unclosed aircraft constructions.

On our point of view prospects of broad development of PT method of unclosed constructions can be occupied with using of electromagnetic fields as penetrants. By using the terahertz radiation source and spectroscopic methods of registration (EPR, NMR), physic-chemical properties of impurities and defects can be effectively determined with high accuracy.

Thus, as a result of the application of modern physical and chemical methods of research, new opportunities for the development of complex technology of non-destructive penetrant testing can be received.

The report describes the results of investigations, conducted in the testing laboratory of SE "KOLORAN" NAS of Ukraine on specimens, produced by SE "ANTONOV".

Introduction

Ensuring the requirements of tightness is a necessary condition for the functioning of assemblies and systems, responsible for safety of aviation flights. These include fuel tanks and pipes, hydraulic systems, the fuselage and other elements of the aircraft. From the very beginning our efforts were concentrate on the development of NDT by penetrating substances [1].

Fig. 1. Example of “unclosed” aircraft construction

Among other’s NDT directions this method differs on principle, because is based on application of special substances - “penetrants”. Such gases or liquids are used to indicate defects by means of different physic and chemical methodise. Today every NDT specialist knows a lot of “penetrants” for realization of LT and PT [2,3]. But our experience prompts, that the method of penetrating substances has more large possibilities, which allow solving a lot of non-usual technical questions. The current tightness testing technology provides the necessary level of sensitivity of leak detection [4,5]. However in some cases during the monitoring there are significant difficulties, which dramatically increase the time and cost of leaks finding. To a large extent these problems are related to the control of so-called “unclosed" structures (Fig. 1). This term refers to aircraft elements, which can’t be pressurized by means of test medium.

Control of “unclosed” aircraft structures

In practice leak testing of “unclosed” aircraft elements performs by penetrants. Figure 2 shows the leak detection by means air as the penetrant.

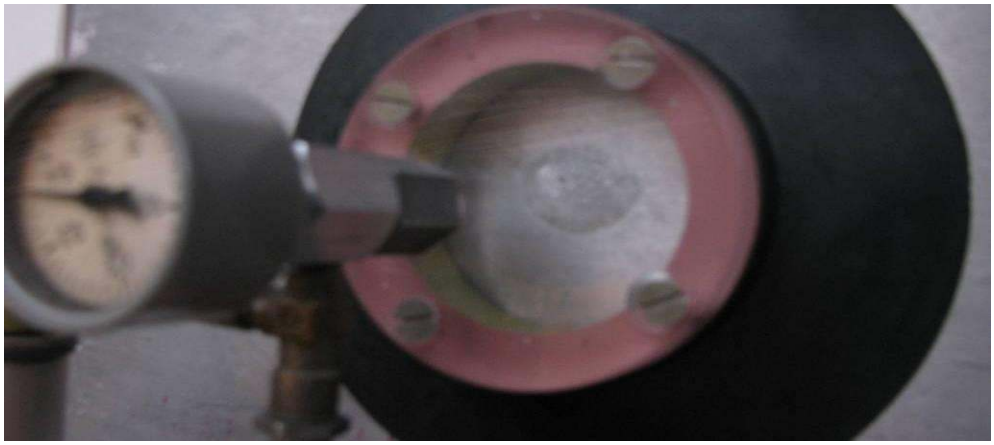

Fig. 2. Detecting of leakage by means air as penetrant

It is the most convenient form of penetrant testing, because the air is not dangerous and available for use and therefore has long time been used in the control of tightness. Unfortunately, a disadvantage of its use is the low sensitivity of control. At present we are working to eliminate this drawback. Now the most widespread for leak testing of unclosed constructions is capillary method, for example, by use of fluorescent penetrants [6].

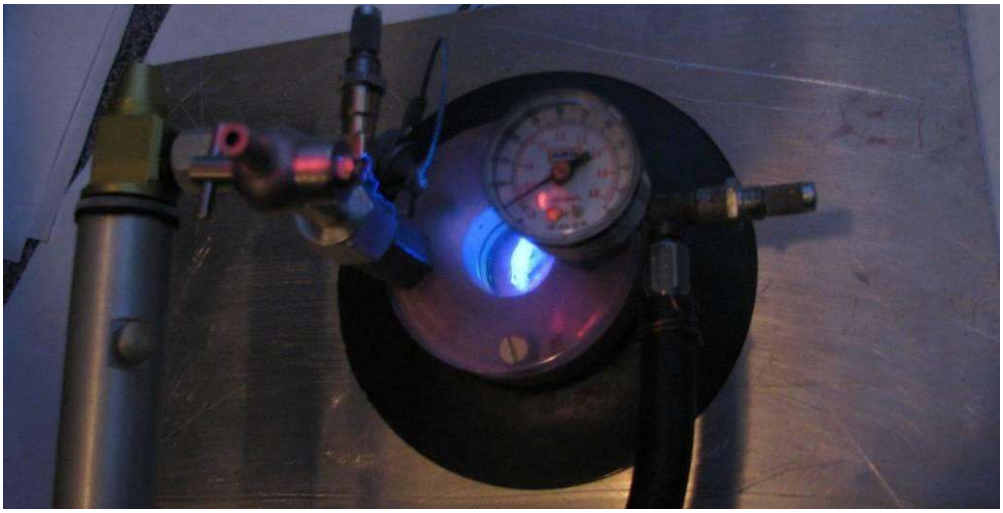

Fig.3. Fluorescent penetrant testing of unclosed aircraft constructions

The method of non-destructive testing with liquid penetrant is one of the oldest and most widely used diagnostic methods of responsible technical object's control. It is enough to mention a well-known kerosene-chalk testing. Unique features of fluorescent capillary control allow detecting defects with the opening width less, than a micron. This can be achieved through the selection of hypersensitive recipes of penetrant materials. Today, however, the capabilities of traditional options to improve the characteristics of non-destructive penetrant testing are almost exhausted. And further development of penetrant testing may be possible only by new approaches. So as one of the most promising areas of the NDT penetrant method we studied the use of ultrasonic capillary effect (USCE).

Outdoor by E.G. Konovalov [7] ultrasonic capillary effect (USCE) consists in an abnormal increase in the lifting height of the liquid in the capillaries by the direct effects of ultrasound. As a result, due to the energy of the sound field efficiency the rising of substances in capillaries can increase by 2 - 3 orders of magnitude.

It was experimentally proved, that in this case the liquid is not pushed up by the radiation pressure and capillary forces, but by standing ultrasonic waves. The main initiator of the physical and chemical processes occurring in the liquid under the influence of ultrasound - is ultrasonic cavitation.

Cavitation is the formation of pulsing bubbles in the liquid, which dramatically slam after the transition to high pressure field, generating strong hydrodynamic disturbances in fluid and intense radiation of acoustic waves.

The gas-vapor mixture in the bubbles heats up to 8000 - 120000K and its pressure exceed 10 000 atm. And the main contribution to the implementation of the following technological processes, intensified by pressure fluctuations, makes by collapsing cavitation's bubbles. Thus, due to the energy of the sound field efficiency penetration of substances into the capillaries increases. The dependence of the effect on the nature of the penetrant and the experimental conditions was investigated.

A possibility of through defects search in the unclosed aerostructures significantly expands by the active version of the ultrasonic leak monitoring. For this aim we have developed a generator of ultrasonic vibrations in the low frequency range and a device for scanning (leak tester) (Fig. 4).

Shotgun source of ultrasonic vibrations allows scanning the inner surface of unclosed construction. The outer surface of the structure examined by the help of our new portable ultrasonic leak detector "Koloran" in order to detect through defects in walls.

Fig.4 The ultrasonic leak tester "Koloran"

Extensive opportunities of (PT) testing of unclosed structures arise, when as a penetrant somebody uses electromagnetic fields. As an example we can point the well-known spark method of nondestructive testing. This method is based on detection of penetration of the electromagnetic field in the defect (occurrence of electrical breakdown). The method allows identifying through defects in nonmetallic coatings with thickness till 10 mm. Defect with diameter at least 0.3 mm can be found by such technology, if an electrode moving speed is not more than 0.35 mm/sec. (Fig. 5). Comparing of penetrating roperties of electromagnetic fields, we confirms promising possibilities of their use for the realization of (PT) method.

Fig.5. Electric spark defectoscope

The greatest prospect for the control of non-metals currently has the field inspection, which use radiation in the terahertz (THz) range of the frequency spectrum [8]. It is located between the infrared region of electromagnetic waves and microwaves.

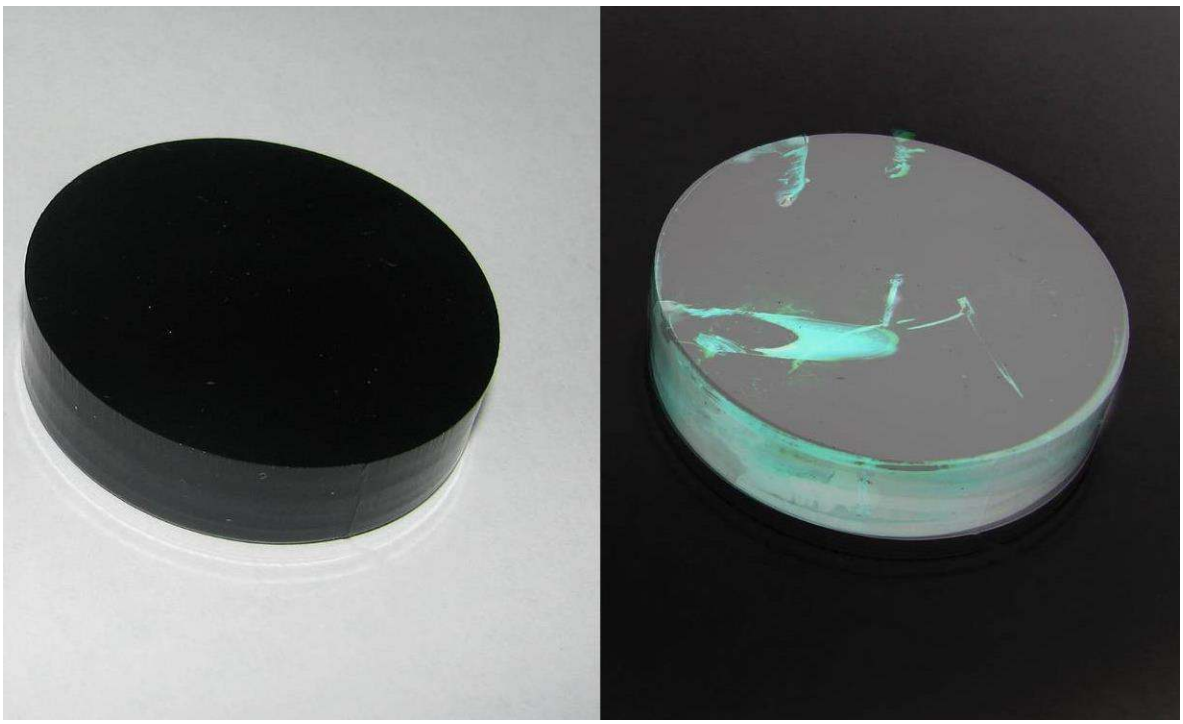

Fig. 6. The results of comparative PT testing of samples by visible (1) and THz (2) wave's regions of radiation

Terahertz waves – is non ionizing radiation, which passes easily through the dielectric, but is strongly absorbed by conductive materials (metals and alloys) and water. Unlike x-rays and Ɣ-radiation it is not harmful for living organisms and the contrast of the image in this wavelength is much higher. In this region of spectrum a lot of penetrants have different informative spectral characteristics.

As a result, by using the THz - illumination and spectral analysis techniques, you can effectively identify the physic-chemical composition of the penetrant and find foreign impurities and defects. Fig. 6 shows the results of comparative testing of samples with the use of electromagnetic radiation in the visible region of the spectrum (left-1) and THz - radiation (right-2).

Conclusions

The investigations continue to improve the technology of tightness control of aviation equipment [9, 10]. As a result of the application of modern physical and chemical methods of research appear new possibilities for creating of complex technology of nondestructive penetrant testing which has delighted advantages for carrying out the express control of the tightness of "unclosed" aircraft structures:

- the possibility of increasing of penetrant properties and hence the sensitivity of control;
- carrying out leak testing of "unclosed" structures with a sensitivity, required to control aircraft systems without creating excessive pressure in them;
- due to the feedback of the ultrasonic leak tester and the generator defects, that violate the integrity, can be find out in an automatic regime, which provides high performance and objective of control.

And finally, thanks to the phenomenon of ultrasound and electrochemical polishing of the surface, the proposed control schemes eliminates skipping of closed undetectable defects and improve the reliability of leak detection.

The report describes the results of investigations, conducted in the test laboratory of SE "KOLORAN" IPC named by L. V. Pisarzhevskiy NAS of Ukraine on specimens of SE "Antonov".

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