Computer system to predict the state of components operating in a fatigue environment

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Abstract

The system contains two measuring techniques based on termovision and thermocouples. Using two techniques simultaneously enables the distribution of the temperature on the surface of the specimen, as well as inside of the structure, to be determined. The internal temperature distribution in a component subjected to fatigue loads indicates its state. Because of this, the temperature distribution can be used to predict the state of a component under various conditions.

The influence of the ambient temperature field, as well as that due to wearing or other effects, can be introduced in the analysis. This allows the level and frequency of maintenance required by the component to be determine, as well as its normal operating conditions. The results of research allow characterising the structural element using the degradative susceptibility. The procedure, using the system of estimation of the degradation ratio, in conjunction with expert procedures, may be established as a scientific analytical tool for manufacturers as well as users.

Keywords: integrated research computing system, operation-&-maintenance, field of internal temperatures, thermocouples, termovision, prediction, ratio of the degradation, degradative susceptibility, remaining life-time, durability.

1 Introduction

It is impossible in the case of many systems, such as those in aircraft, to be able to predict accurately the residual life of the components. It is not possible to calculate the residual life in a direct way. This is the reason why it is necessary to find indirect ways. In this article one of them is presented.
The degradation process might be described using the degradative susceptibility (degradability). The degradability expresses the hardiness against the degradation process.

The degradability has been considered in indirect way using the set of relative decreases of strength properties as well as increase of operational internal temperatures:

\[ K_{\text{degr}}(t_{e1}, t_{e2}) = \frac{\Delta T_e}{t_{e2} - t_{e1}} \]  

(1)

where \( T_e \) is the temperature of unit and \( t_{e1}, t_{e2} \) - two different operational states (operational times).

The increase of the internal temperature during operational time has been confirmed into the research.

The integrating computing system used to mark the internal temperature distributions consist of two measuring methods (adequately base on termovision and thermocouples) and the testing machine with the temperature chamber has been used into research. The software makes it possible to simulate the fatigue loads of the elements.

The results of the research are functions of distributions of the internal temperature versus the operational time. The gradients of the internal temperature field in operational time are symptoms in the diagnosing process. The gradients express the degradation ratio as well as the operational state.

Making the most of the durability resource as a new approach to the effective management of the reliability has been considered. The condition of the physical...
state of technical object is correlated with the internal temperature of its structure during operation-&-maintenance process.

During the research many conclusions clarifying the problem have been reserved.

The internal temperature is a symptom, which described the technical state of the structure (fig.2).

Figure 2: The temperature changes of the composite shell operating in mechanical fastener versus the operational time.

A behavior of the composite shell operating in the mechanical fastener has been considered. The results of research confirm the influence of temperature both internal and external (environmental) on operating state of the technical object.

2 Research of the composite shell behavior operating into fatigue environment

The mechanical fastener hasn't got any glue joints; this is the advantage of the mechanical fastener; the fastener has been used into research.
Two measuring techniques have been used to research. The first technique based on termovision and the second one based on the thermocouples. The specimen shown on the figure 3 has been used in the research.

Figure 3: The specimen used into research with marked testing points and the way of the documenting results

The finding of the relations between internal temperature of the composite shell and its technical state has been stand as the main goal of research. The research has been conducted in two parts. The first part contained the entrance tests to forming accelerating tests and the second one contained the proper tests which results were helpful to do the figure 4.

The specimens were subjected to the loads changing–in–time loads. There were carrying on tests with different both amplitudes and frequencies. The specimens were both the initially loaded and the initially heated. The environment had got both the constant temperatures and non–constant ones.

For instance on the figure 4 the temperature distributions of the initially–loaded specimens for three levels of amplitude and constant environmental temperature have been presented.

One may noticed that the level of the degradation of the structure is directly connected with the internal temperature.
Above it can be used in diagnostics and the results of research allow to characterize the structural element using the degradative susceptibility. The degradative susceptibility is expressed as the gradients of the thermo-mechanical properties (eqn1).

3 General research remarks

Termovision research gives:
- macroscopically and visually the way of heating process of the fastener elements
- quantitative characteristic of temperature variations on the specimen composite surface versus operational time

Thermocouple research gives:
- qualitative internal temperature variations which produce current operational stage of the technical object as well as described one.

4 Conclusions

The results achieved into the research may be ordered as follows:
- Two measuring techniques based on the termovision and thermocouples have been used to research.
- Using two techniques simultaneously permits the distribution of temperatures on the surface of the specimen as well as the inside of the its structure to be determined
- The distribution of the internal temperatures of the composite shell is correlated with express the ratio of the degradation process of this structure
- The temperature distribution function in operational time is linear
- The linear character of function running allows assess predictions of the life time using degradative susceptibility
- The procedure described above can be applied in diagnostics to determination of the operation–and–maintenance state of technical objects
- The symptom which can be used in diagnostics is the internal temperature field of the composite shell. The temperature is correlated with operation–and–maintenance state
- It can be specified an influence of extraneous (environmental) temperature field and internal (wearing–out) one, on the operation–and–maintenance properties as well as proprieties.
- The results of research allow to characterise the structural element using the degradative susceptibility. The degradative susceptibility is expresed as the gradients of the termo-mechanical properties.
- The proposing procedure of estimation of the degradation ratio in common with expert procedures may be established scientific analytical tool for constructors as well as users