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PROBLEMS OF TECHNICAL CONDITION ESTIMATION OF COMPLEX AVIATION SYSTEMS COMPONENTS

There is a problem of aircraft components condition change forecasting, which is the lack of admissible approaches and methods. The solution of the problem - the development of models that allow: to take account of unit condition change, caused by either operating time, or service period, to determine requirements to aircraft maintenance work volume and content, and also.

Aircraft construction should make impossible failures to appear or provide conditions for failure consequences not to have influences on safety (failures possible to foresee are meant).

Failure consequences are considered as basic factor either for maintenance program creation or for pilot reaction speed to failure information. Aircraft operators are responsible for construction safety preservation and dangerous failures prevention. It should be achieved by maintenance program.

Modern maintenance program formation principals provide four basic maintenance types in order to keep reliability and safety.

- units condition control through fixed intervals in order to find and remove potential failures for functional failures frequency preservation and reduction;
- article standard indexes resumption through the fixed service terms in order to reduce functional failures frequency;
- removal of an article or one or more elements in fixed service terms in order to reduce functional failures numbers and frequencies;
- periodical checks in order to find and remove hidden functional failures, which have already appeared.

First three work types are directed on failure prevention, and the fourth one on hidden functional failures consequences, which may take place on the basis of other failures.

During maintenance program development the following conditions should be kept:

- analysis should be realized only for articles important in frames of failure consequences or economic loss, and for "hidden functions" articles;
- failure consequences exact evaluation should be realized for every important article including probable secondary damage consequences;
- following criteria works effectiveness evaluation should be realized by following criteria: failure probability shortening up to allowably small value, in case of probable serious failure consequences in a safety frames; economic effectiveness of works, non-connected with "hidden functions" and safety influences;

- work applicability evaluation, based on failure characteristics, should be realized. Work intervals should be established.

If the failures have any impact on safety, failures intensity reduction works are recommended only in case of economically effective works. If these works are economically ineffective, they should not be performed, and the residual failure intensity should be considered as an intrinsic article reliability characteristic.

Decision-making process of works insertion into the maintenance program lies in answering the line of questions. Maintenance works, selected in such way, flow out of article reliability characteristics. Maintenance program, created under those principals, is adaptable and figured on correction taking into account article exploitation work information receipt.

Western airlines program work experience allowed making a number of consequences.

Technique reconstruction planning works are inoperative for complicated systems, if there is no dominant failure type. They are also ineffective in case of failure influences on safety.

Any way failure data necessary for such works applicability evaluation may be received after temporary aircraft exploitation.

The similar is the situation with rejection works. They cannot be kept until safe works intervals by testing materials at reduction or working out point, which is modeling exploitation conditions, are determined.

Sometimes failure meant to be evident turns out the hidden one. Information collection process is the service period influence investigation, since the available information volume is the direct function of component servicing term, and a part of this information concerns servicing terms of the article. Information search and storage system should be established. In order to avoid useless maintenance expenses and to increase the work volume if necessary, opportune maintenance information use is very important.

Aircraft units' failure information is extremely important for effective maintenance works planning. But in real airline activity conditions there are some problems with current aircraft units condition evaluation, namely: limited failure diagnosis time, lack of equipment necessary for effective separate unit condition evaluation [1], human factor influence on failure detection work results [2].

That is why there is a necessity to know units technical condition peculiarities beforehand in order to make corresponding equalizing measures to detect failures and resumption of their work state or deduction.

Available sources analysis shows that nowadays applying to aircraft units and other complex systems, following items are absent:

- common universal condition evaluation methodology during normal and extreme exploitation for the whole life-cycle interval;

- specific units real technical condition prognosis model during maximal time interval and to maximal exploitation conditions range, corresponding to real life-cycle interval;

- separate articles degradation processes model in general and in parts;

- general methodologies of aircraft unit current wear degree evaluation in real or close to real time;

Modern scientific approaches of wear and aging evolution processes description, taking place in complex technical systems, are based on observations and experiments results generalization, empirical and semi-empirical models construction, formalized in accordance to experimental investigation results, and on the analysis of these models with the aim of internal and external factors influence detection on complex technical systems technical condition parameters.

The totality of those models may be divided on:

- semi-empirical wear and aging models [3-6],
- empirical models of mechanic wear [3],
- structural models of damage accumulation [3],
- stochastic wear and failure models [7],
- economic loss and expenditure models during complex technical systems exploitation [3].

These models are sufficiently common and are the result of experimental data generalization and are more adapted for experimental data processing and analytical results presentation. Their passive and fragmental character, inability to show the most general, fundamental technical system condition condition change pattern in general, in connections with storage, exploitation and functional article application modes are the disadvantages of these models [7].

That is why for in order to solve the evaluation and forecasting task of aircraft units technical condition change it is necessary to use models, based on other approaches.

Any complicated technical system with energy (power) flow during long-term exploitation "during its free movement tends either to balance, or to conservative system movement with the lesser number of degrees of freedom" [8]. The loss of the degrees of freedom characterizes the change of constructive system degradation to its functional degradation. Consequently the amount of energy, passing through the system, determines its technical condition.

It is well known that any physical system properties may be introduced with the help of equation system, establishing correlation between energy and power flows, taking place between system and environment. The best way to describe such dependencies is to use Hamilton differential equation system, which may be easily reduced to canonical Cauchies form. That is the common second order differential system. In general case the input coefficients are the dependences of kinetic, dissipative and potential energy correspondently. At the same time these coefficients are the functions of complicated technical system components parameters, i.e. Hamilton equations allow connecting energetic and parametric (informational) evolution processes characteristics, taking place in complex technical systems [9].

So, integrated dynamic model of complex technical systems may be subdivided in two parts - energetic and informational. Such integrated model should include:

- submodels of complex technical systems component, which are in general an ordered hierarchical structure;
- submodel of energy flow through complex technical systems components;

- submodels of virtual parameters removal of complex technical systems component, provided by flowing through it energy flows.

Conclusions

Nowadays in aviation with the aim of maintenance effective planning, there is a problem of aircraft components condition change forecasting, which is the lack of admissible approaches and methods.

The legacy models are applicable only for common systems, they are mostly directed on experimental data processing and do not consider separate article exploitation conditions peculiarities.

The solution ofthe problem - the development of models that allow:

- to take account of unit condition change, caused by either operating time, or service period (operation and storage peculiarities);

- to determine requirements to aircraft maintenance work volume and content, and also.

References

1. *О.О. Тризна, В.М. Лужбін, П.П. Міненок* Межі практичного застосування методів та засобів технічного діагностування авіоніки // Матеріали X міжнародної науково-технічної конференції «АВІА-2011». - Т.2. -К.:НАУ, 2011. - С. 9.56 - 9.59.

2. *Тризна О.О.* Інженерно-психологічний аналіз якості візуальних оглядів авіоніки старого та нового покоління // Електроніка та системи управління.-К.: НАУ, 2010. - Вип. № 1(23). - С.82-86

3. *Александровская Л.Н.* Современные методы обеспечения безотказности сложных технических систем / Л.Н. Александровска, А.П. Афанасьев, А.А. Лисов // М., Логос, 2001.-208 с.

4. *Соловйов В.І.* Організація експлуатації авіаційної техники / В.І. Соловйов // Киев, НАОУ, 2005. - 232 с.

5. *Шехватов Д.* Эволюция систем управления техобслуживанием и ремонтами. Журнал "Оборудование" (приложение к журналу "Эксперт") №2, 2004 - С. 18-24.

6. *Барзилович Е.Ю.* Эксплуатация авиационных систем по состоянию (элементы теории) /Е.Ю. Барзилович, В.Ф. Воскобоев // М., Транспорт, 1981. — 197 с.

7. *Чепиженко В.И.* Математическая модель динамики функционального состояния управляемой системы на всем эксплуатационном интервале жизненного цикла / В.И. Чепиженко, В.В. Павлов // Кибернетика и вычислительная техника. — 2010. - №162.-С. 38–45..

8. *Павлов В.В.* Концепция моделирования и анализа эволюции технического состояния сложных технических систем на максимально возможном интервале их жизненного цикла / В.В. Павлов, В.И. Чепиженко// Кибернетика и вычислительная техника. — 2009. — № 157. — С. 3 — 16.

9. *Чепіженко В.І.* Енергетична концепція ядра для моделювання CALS-процесів у складних технічних системах / В.І. Чепіженко // ВІСНИК НАУ. - 2009. - № 3. - С. 76-82.