

### **Modern aspects of engine diagnostics and the connection between the stages of airworthiness of aircraft**

*The article considers regulatory support and the connection between the stages of airworthiness of aircraft and defines certain aspects of the use of aviation gas turbine engines in the system of continuing airworthiness of aircraft*

The main reasons that led to the need to sign the Convention on International Civil Aviation are the necessity to establish comprehensive principles and rules that ensure [1, 2]:

- a sufficient level of uniformity to regulate relations between states arising during air transportation;
- acceptable conditions for the majority of states to implement these principles and rules;
- safety, efficiency and regularity of air transportation;
- conditions for both sustainable and efficient functioning, as well as effective development and improvement of international aviation transport.

It should be noted that the ICAO regulatory framework (Chicago Convention, standards and recommended practices (SARPs – standards and recommended practices) and nineteen Appendices to the Convention) indicate the existence of two stages of airworthiness of aircraft, as well as: ensuring and maintaining flight worthiness.

The presence of one or another (or two stages together) stage airworthiness in an ICAO member state depends on the development of the aviation industry. The state of Ukraine has two stages of the airworthiness of aircraft because it is the developer, manufacturer and operator of the aircraft.

So, as objects of international and state regulation of aviation activities in Ukraine, there are [1]:

- a) in the system of providing airworthiness of aircraft:
  - developer (Design Bureau, for example SE "Antonov", Ivchenko-Progress, etc.);
  - manufacturer (manufacturing plants of SE "Antonov", Motor Sich JSC, etc.);
  - aircraft type (based on the results of certification of the aircraft design sample).
- b) in airworthiness of aircraft maintenance system:
  - aircraft sample;
  - air carrier (operator);
  - maintenance arrangement of the aircraft and its components;
  - maintenance personnel of the aircraft and its components;
  - staff training arrangement for maintenance of the aircraft.

Of course, according to ICAO standards, the operation of a particular object of aviation activity is allowed only if there is an appropriate document, such as a certificate or license. According to the standards of EASA – the European Aviation

Safety Agency, these objects are approved (certified) according to the following requirements: developer, manufacturer and aircraft with its components-Part – 21; instance of aircraft – Part-M; operator – a series of OPS requirements (depends on what kind of work the operator performs – air transportation or aviation work); arrangement for maintenance of the aircraft and its components – Part-145; personnel for maintenance of the aircraft and its components – Part-66; staff training arrangement for maintenance of the aircraft and its components – 147.

According to Article 11, Part three of Article 42 of the Air Code of Ukraine, the law of Ukraine "National Program on Adaptation of Ukrainian Legislation to the Legislation of the European Union" and for the purpose of implementing the regulation of the European Commission dated of November 26, 2014 (EU) No. 1321/2014 (as amended, taking into account the regulation of the European Commission dated of September 16, 2015 (EU) No. 2015/1536) in the composition of the National Aviation Regulations of Ukraine added according to the Order of the State Aviation Service No. 286 dated of 06.03.2019. On approval of the aviation rules of Ukraine "maintenance of airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organizations and personnel involved in these tasks".

Based on the requirements of ICAO and long-term experience in the functioning of the aviation transport system, there is a close connection between the airworthiness support and maintenance systems, because [1-5].

- first, the developer cannot provide for everything possible in such a characteristic as the airworthiness, taking into account the conditions and operating modes of the aircraft, because it is the period of operation that can indicate existing shortcomings in the design, in the flight operation manual and maintenance manual, and the operator must provide statistical data on malfunctions and failures to the developer;

- secondly, it is the developer who can make a decision on making changes in the design or acoustic or emission characteristics of the aircraft as a whole (modification), and all this is possible only according to data from enterprises operating a particular type of aircraft.

If we consider the process of ensuring flight safety (FS) on the part of airworthiness, then it is characterized by an integrated approach – the continuity of both stages of airworthiness.

Based on it, we can conclude that ensuring the FS primarily depends on the flight suitability of each instance of the aircraft that is entered in the operator's certificate, that is, the operator is directly responsible for the serviceable condition of the aircraft [1, 2, 5].

There is a so-called list of minimum responsibility of the operator when maintaining the airworthiness of the aircraft, first of all, it is the development and approval of the maintenance program, the assignment of types of work, the calendar time of maintenance, etc.

Therefore, maintaining the aircraft in good condition depends on many factors when performing maintenance, and first of all on such a complex property of the aircraft as reliability.

The main goal that each airline pursues is to maximize the profit from performing air transportation or performing aviation work with the undisputed dominance of the FS requirement. Solving this problem against the background of

the ever-increasing complexity of the aircraft and rather high requirements for safety and regularity of flights will require constant monitoring of the performance indicators of the aircraft maintenance system. Compliance with the high level of aircraft FS is ensured at all stages of their life cycle, which requires rapid exchange of information between objects and subjects of Aviation Regulation [6-8].

The formation of the aircraft maintenance system begins at the earliest stages of its design and is gradually improved at the stages of factory and state tests. Thus, with the beginning of the operational period, the aircraft has a fully formed and proven maintenance system.

But in practice, as mentioned above, the aircraft is constantly being improved, new methods and means of its maintenance are being developed, and the general requirements for aircraft maintenance change depending on the operating modes and external conditions. All this leads to the need for scientifically based adjustment of maintenance programs both for the aircraft as a whole and for its individual components, deadlines and volumes of work, the composition of performers and maintenance facilities aimed at maintaining the airworthiness of the aircraft sample.

Therefore, the priority task for the specialists of the Central Asia of Ukraine will be:

- development of methods for building effective aircraft maintenance systems and adjusting them in operation depending on the situation that develops in a particular airline, taking into account, first of all, the improvement of methods and means of vehicle control of their components, including engines, as a first-class component and components;

- adjustment of the volume and frequency of maintenance work on aircraft, their functional systems and components (adaptation of the maintenance program), taking into account the specifics of their operation in a particular airline [6-8].

The main role in solving the problems of technical state control of a new generation of aircraft is given to the onboard automated control system. This system, taking into account the analysis on the ground device of processing flight information accumulated in the onboard registration device, will allow monitoring, for example, the operational state of the engine and maximize the possibility of quickly making a decision on the departure of the aircraft on the next flight [9].

But it should be noted that the development of new and improvement of existing mathematical, software and algorithmic support for such systems remains relevant to this day. The relevance is emphasized by the need to introduce artificial intelligence methods and tools into the conditions of real operation as a tool for these systems.

Regarding the disadvantages and advantages of using artificial intelligence in the diagnosis of aircraft turbojet dual-circuit engines, many experiments have already been conducted by both domestic and foreign scientists. Most of these experiments were carried out in a theoretical nature or based only on the results of computer modeling, and little attention is paid to research related to the use of data recorded in the conditions of real operation of engines as input parameters.

The scheme of automated assessment of the technical state of a gas turbine engine (GTE) in real operation conditions may look like this (Fig. 1).

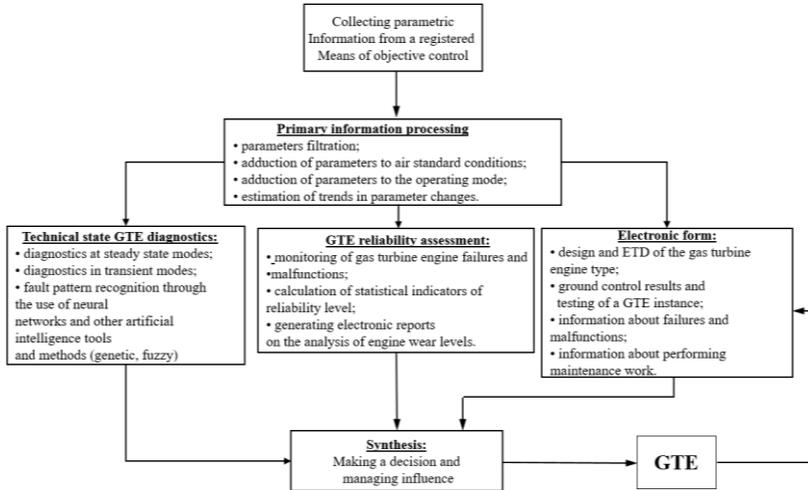


Fig. 1. Automated vehicle assessment scheme for a gas turbine engine

The development of diagnostic procedures, principles of forming rules for making decisions based on the results of engine diagnostics based on flight information determine the priority task when solving issues of after-sales support of the engine.

Clear interaction between the engine developer and the operator still requires improvements in regulatory aspects. The introduction of automated engine monitoring and diagnostics systems into the airworthiness maintenance system at the current stage of aircraft operation to ensure flight safety and efficiency of aircraft operation is impossible without the use of artificial intelligence.

## References

1. Энциклопедия безопасности авиации / Н.С. Кулик, В.П. Харченко, М.Г. Луцкий, А.Г. Кучер и др.; под ред. Н.С. Кулика. – К.: Техніка, – 2008. – 1000 с.
2. Конвенция о международной ГА, Doc. 7300/9, 2006 г. – 51 с.
3. Дмитриев С.А., Бурлаков В.И., Попов А.В., Попов Д.В. Формирование программ технического обслуживания авиационных двигателей // *Авиційно-космічна техніка і технологія*. – Х.: – 2013. – № 7/104. – С. 190 - 194.
4. Пучков Ю.П., Молодцов М.Ф., Бурлаков В.І., Попов О.В., Попов Д.В. Удосконалення системи технічного обслуговування повітряних суден України // *Вісник Інженерної академії України*. – Миколаїв, 2014. – №1. – С. 37-39.
5. *Повітряний кодекс України: Закон України від 19 травня 2011 р. №3393-VI // Відомості Верховної Ради України*. – 2011.
6. Тамаргазін О.А. Розробка методів оцінки ефективності і вдосконалення керування системою технічного обслуговування пасажирських літаків: автореф. дис. на здобуття наук. ступеня д-ра техн. наук: спец. 05.22.20

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7. Орловський М.М., Приймак А.В., Височанська Ю.Ю., К.А Гальчинський. Дослідження стану льотної придатності та перспективи розвитку цивільного авіаційного парку України // Открытые информационные и компьютерные интегрированные технологии, 2019. – № 83. – с. 42-58.

8. Машошин О.Ф. Диагностика авиационных газотурбинных двигателей с использованием информационного потенциала контролируемых параметров: автореф. дис. на здобуття наук. ступеня д-ра техн. наук: спец. 05.22.14 «Експлуатація повітряного транспорту» / Машошин Олег Федорович; Московський державний технічний університет громадянської авіації. – М., 2003. – 30 с.

9. Дмитриев С.А., Кучер А.Г., Журавлєва Л.А., Камышин В.В. Особенности использования FU-GE-NE-SYS алгоритмов в процессе синтеза нейронной модели состояния авиационного двигателя // Авиационно-космическая техника и технология. – Х.: НАУ "ХАИ". – 2000. – Вып.19. – С. 372-376.