Scientific and Methodological Approaches for the Creation of Complex Diagnostic and Prognostics Systems of the Technical Condition of Units, Functional Systems and Power Structures of Helicopters

Alexander Belskiy[1,2,3,*], *Anton* Dergachev[1,2,†] and *Olga* Esipovich[1,2‡]

[1]JSC "NHC Mil Kamov", Moscow Aviation Institute (National Research University), RARAN, Moscow, Russia
[2]Moscow Aviation Institute (National Research University)
[3]RARAN, Moscow, Russia

Abstract. This article discusses the approaches and requirements for creating a comprehensive system of diagnostics and prognostics of the technical condition (CSDP TC) of the helicopter units and prerequisites for its further integration into the after-sales service system. The systems of monitoring and diagnostics of the technical condition of aircraft (HUMS) being used on helicopters, allow the determining of the operation parameters of the power plant and transmission units within the framework of the flight, as well as during operational maintenance. First of all, the HUMS systems were created for the purpose of servicing the helicopter units according to their technical condition (servicing «on condition»), but it is not possible to determine the residual resources of the units using these systems. The proposed system for predicting the technical condition of aggregates and functional systems permits the use of recorded helicopter flight parameters and parameters recorded by the HUMS system, and allows you to analyse the causes of defects and predict the residual life of aggregates, taking into account the dynamics of the development of defects before reaching the pre-failure state. Aggregation of the received information about the state of the units into the analytical - information system will optimize the material and technical support of operating organizations and provide developers of aviation equipment with information about the results of operation and use it as input data to improve the characteristics of the helicopter and its aggregates and the gradual transition to the creation of integrated systems of the CSDP TC.

1 Introduction

* Corresponding author: alboricovich@yandex.ru
† Corresponding author: banderos1225@mail.ru
‡ Corresponding author: olga544@bk.ru

HUMS (Health and usage monitoring system) monitoring and diagnostics systems are increasingly being implemented on modern helicopters in various countries, which have shown their effectiveness in the field of helicopter maintenance, as well as in improving flight safety and cost-effectiveness associated with simplifying maintenance procedures for helicopter systems and assemblies. The use of HUMS has also allowed many operating organizations to save costs significantly by minimizing the early replacement of units.

The standard composition of HUMS systems provides for monitoring the technical condition of the power plant and transmission units, as well as the canonicity and weight balancing of the main rotor blades [1].

Of course, the technical condition of the power plant and transmission units hams a significant impact on flight safety, but from the point of view of full-fledged technical operation of helicopters, according to the state of automated control of the technical condition of these units, it is not enough. The nomenclature of controlled units in terms of technical condition should also include: power supply system units (batteries, generators), chassis, auxiliary power plant, fuel and hydraulic system units, etc. The main criteria for assessing the technical condition of these units can be: operating time in normal and limit operating modes, the magnitude, duration and nature of changes in the operating parameters of individual units or systems from nominal values.

In addition to monitoring and analysing of the current technical condition of the helicopter units, the issues of forecasting the appearance and development of malfunctions of systems and units leading to failures are relevant. A set of techniques and technical means for analysing the technical condition of aggregates and predicting the appearance and development of defects will allow improving technical operation according to the condition, as well as optimizing the material and technical supply of operating organizations.

It is worth noting that the mechanisms for diagnosing and predicting the technical condition of helicopters as a whole and their individual functional systems and its aggregates is a fairly high-tech process. The following procedures should be attributed to this process:

-Carrying out various tests (resource, on the impact of static and dynamic loads, on the impact of external influencing factors, etc.).
-Analysis of the results of operation (in terms of failures / damages, taking into account the operating conditions).
-Assessment of the technical condition of the units and making a decision on the possibility of further operation.
-Analysis of reliability of systems and aggregates.
-Calculation of the strength of aggregates.
-Improvement of methods and means of diagnostics and non-destructive testing.
-Development and development of methods for diagnosing the occurrence and development of defects leading to failures.

The variety of technologies and materials used, as well as differences in the purposes and principles of operation of individual units require individual approaches, which significantly increases the amount of research required. The issues of monitoring the technical condition of units and predicting the development of malfunctions are relevant not only in the field of helicopter construction, but also in other industries, which requires using the results achieved in the research, improving computational and experimental methods with further adaptation in relation to helicopter units and the selection of measuring and control tools taking into account functional and dimensional-mass characteristics.

The urgency of creating a system for predicting the technical condition of aggregates lies in the need to determine in advance the residual resources of aggregates in the presence of prerequisites for the appearance of defects or their appearance before the failure of the

unit. The use of the data obtained will allow to perform the most efficient planning of the flight task (for example, to exclude the operation of systems at extreme modes and increased overloads), as well as maintenance and logistical support.

2 Results

The scientific and methodological approaches used in the development of a CSDP TC system for predicting the technical condition of helicopter units are to create a unified integrated complex that includes a measurement system, a data processing complex and an information analytical system. The detailed structure of the integrated CSDP TC system is shown in Fig. 1.

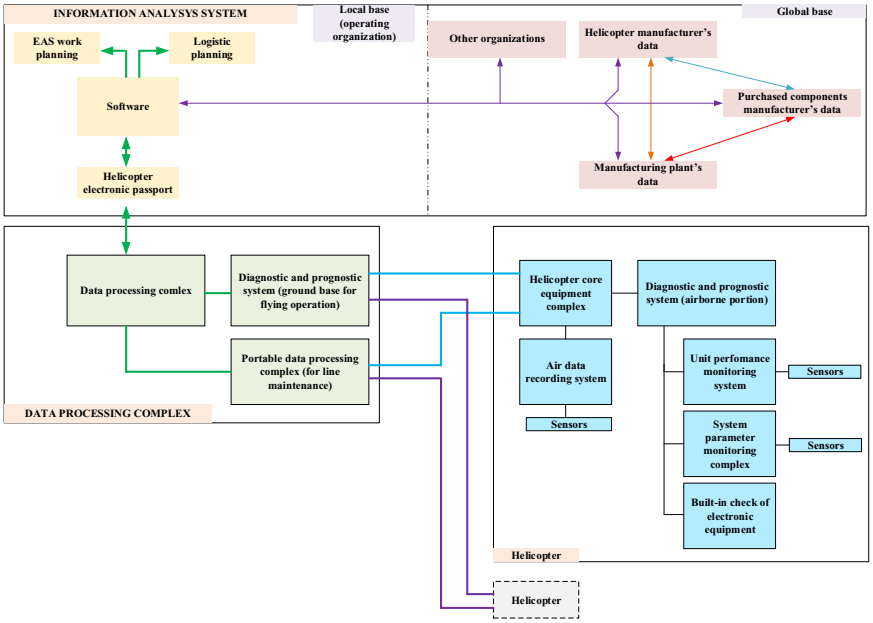

Fig. 1. Structure of the prognostics integrated system.

The controlled parameters during the operation of the helicopter are measured using sensors. Some of the sensors are included in the complex of basic equipment and their data are being registered by the flight data registration system. The remaining parameters are controlled by the diagnostic system (HUMS).

The basic equipment complex includes systems and sensors that provide measurement, registration and indication of flight parameters, operation of the main units required in flight, as well as one-time commands. The measured data is fed into the flight data registration system. Monitoring of the main parameters of the operation of the units during the flight can significantly simplify the installed diagnostic system by using the implemented control of individual parameters. The diagnostic system includes various sensors for monitoring the operation and condition of units that are not controlled by the complex of basic equipment. The nomenclature of additionally controlled parameters is determined taking into account the results of the analysis of the main causes of failures of systems and units, methods of their detection and design features of controlled units. In addition to the control parameters of a separate unit, the parameters of the operation of adjacent units and systems are also taken into account, which make it possible to determine with greater accuracy the causes of defects in the units or phenomena, for example,

increased vibration of a helicopter. A set of parameters entering the flight data registration system and recorded by the diagnostic system to ensure control of the technical condition of particularly critical units and systems of the helicopter. registration system.

The diagnostic system is being developed in a modular version, which allows taking into account the design features of the operated helicopters, their purpose and the use of a certain range of removable equipment.

In the system of registration of controlled parameters, algorithms are provided for accounting for the operating time of aggregates using parametric information, as well as registration and analysis of the dynamics of changes in the parameters of controlled aggregates and related systems during operation, the results of which are used in methods for determining the pre-failure state of the unit.

Detailed processing and analysis of the recorded parameters is carried out in the data processing complex. The complex includes a portable data processing complex and a stationary complex. The portable complex is designed to read, process and analyze the recorded parameters during operational maintenance of the helicopter, and the stationary complex is designed to conduct a deeper assessment of the technical condition of aggregates, functional systems and power structures. The use of a stationary complex makes it possible to simplify the on-board part of the diagnostic system, thereby reducing its weight. A stationary complex is provided for performing checks at a certain helicopter raid, as well as in the case of information being issued by the diagnostic and prognostic system about the achievement of a pre-failure state by the unit. The specialized software of the data processing complex provides for an electronic form of the helicopter indicating data on systems and aggregates, maintenance work carried out and electronic forms of aggregates. Electronic forms of the units provide not only general information, such as manufacturer's data, operating time, etc., but also reference characteristics of normal operation in various modes. The reference characteristics laid down in the electronic forms of aggregates are used in the algorithm for detecting defects of aggregates and their causes. All recorded and processed data are summarized in an information and analytical system.

As diagnostic and prognostic systems are being installed on various types of helicopters within the same operating organization, the data of the information and analytical system will allow summarizing and analyzing the results of the operation of the aircraft fleet, as well as planning logistics and maintenance work on the helicopter. The algorithms embedded in the information and analytical system will optimize the maintenance of the helicopter and the replacement of aggregates, taking into account their condition, ensuring minimal downtime of the helicopter during maintenance and a minimum number of simultaneously serviced helicopters. Hierarchical structure of the comprehensive system of diagnostics and prognostics of technical condition (CSDP TC) is shown in Fig. 2.

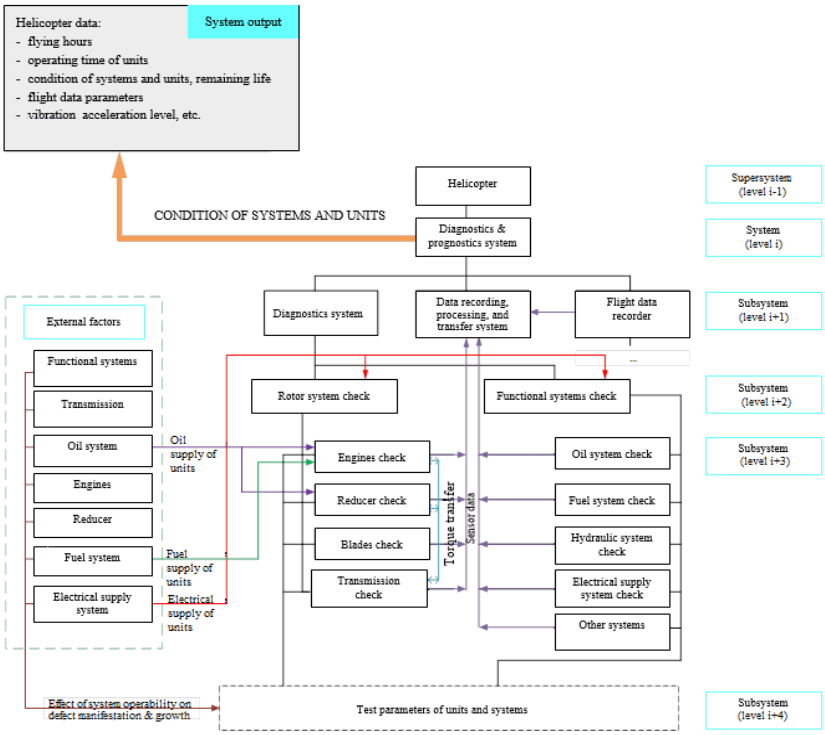

Fig. 2. Hierarchical structure of the comprehensive system of diagnostics and prognostics of technical condition (CSDP TC).

The use of diagnostic and prognostic systems in various operating organizations requires the expansion of the functionality of the information and analytical system. First of all, this will allow you to summarize information in organizations that have several operating units located in different regions. In addition to the most effective planning of the use of helicopters and logistics for each of the operating organizations, the expansion of the functionality of the information and analytical system will allow the exchange of necessary information between the operating organization, the developer and manufacturer of the helicopter, as well as suppliers of spare parts. First of all, information about the results of helicopter operation will allow the developer and manufacturer to improve the design and improve the characteristics, and suppliers of spare parts to ensure their timely delivery in the required volumes.

The database of the results of various studies and experiments of computational and theoretical methods in the field of diagnostics of the technical condition of units and systems, which are implemented in HUMS-type systems based on the accuracy and reliability of measuring signals with elements of forecasting the development of defects in power structures and functional units of the helicopter, also serves as confirmation of the feasibility and possibility of creating an integrated diagnostic and prognostic system for helicopter equipment, products made of various materials and other information sources in this field of research. As an example, the following works can be cited: research in the field of accuracy of flight data generation [2, 3], prognostics of the remaining service life of units [4] and failure rate [5].

3 Conclusion

The modern scientific and technical level, determined by achievements in the field of research methods for diagnosing the technical condition of units and predicting the technical condition of individual parameters of the unit, allow us to conclude that it is possible to create a comprehensive system for predicting the technical condition of helicopter units. This system will allow you to determine the remaining life of the units before reaching the pre-failure state and optimize the maintenance and logistics of the helicopter. The integration of helicopter operation data into a single information analytical system will significantly improve the operation of the helicopter fleet, as well as generate the necessary statistics on the operation of helicopters in various conditions necessary to improve the design of units, analyse the conditions and causes of defects, as well as the formation of maintenance and repair programs for aviation equipment.

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