The remote technical equipment monitoring system for light aircraft

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Abstract. The concept of monitoring the technical parameters of light aircraft equipment (less than 5700 kg) are considered, which is based on the principles of building automated telemetry systems. The proposed monitoring concept will allow to test the condition of aircraft both in the aircraft repair plant and during operation. Decision support will be provided for repair planning based on the current parameters of the controlled equipment of light aircraft. The features of the implementation and functioning of the system for monitoring the technical parameters of equipment are considered.

1. Introduction

Most commercial flights in the post-Soviet space are carried out by Western-made aircraft (aircraft) weighing more than 5700 kg, while light aircraft were able to maintain their niche in aviation market [1]. Traditionally, "heavy" aircraft focused on ensuring flight safety due to large number of passengers carried. Currently, power plants and equipment of such aircraft types as Airbus, Boeing, Embraer, etc., are provided with a remote monitoring system like ETM (Engine Trend Monitoring) via satellite systems SATCOM (Satellite Communications Center) and communication systems CPDLS (Controller – Pilot Data Link Communications). The organization of airworthiness maintenance of these types of aircraft is carried out through various software products, such as CAMP (Computerized Aircraft Maintenance Program) or AMASIS (Aircraft Maintenance and Spares Information System).

The existing fleet light aircraft in CIS is large enough and has a wide geography of use in aircraft operations, commercial transportation, etc. Companies using these airplanes independently decide on airworthiness maintenance, but not always successfully, as evidenced by annual "Safe Flight Status Reports by Interstate Aviation Committee".

Maintaining airworthiness of aircraft is not only implementation of maintenance directives and routine maintenance, it also includes capital repairs at aircraft repair plants (ARP). Currently, when aircraft arrives for repair, ARP does not always have information about technical condition facility, which requires additional time and costs. The possibility of timely assessment current state aircraft through control and monitoring systems would provide ARP with better planning and organization of maintenance and repair processes [2]. In addition, if such a condition assessment system is in place, company operating the aircraft (hereinafter referred to as the operator) will receive a decision support tool for further operation path.
In this regard, it becomes urgent to develop monitoring and analysis tools for technical parameters of aircraft equipment during their operation, with aim of improving principles organizing maintenance and repair processes at ARP.

Information transfer at moment can provide both Internet and fiber-optic communication [3]. Since 1976, Western-made aircraft have been equipped with ACARS (Aircraft Communications Addressing and Reporting System) system, which is an address-reporting aviation communications system that allows you to exchange flight information about status of current flight data via ground-based transponders with airports and airline’s office. System includes not only on-board equipment, but also a ground-based complex, which is a wide network of transceiver stations. The advantages above used systems, programs and methods are quite high accuracy and reliability. This is all justified by ensuring flight safety, but same time they have their own characteristics, both technical and economic, expressed using additional ground-based embedded complex systems and control elements.

Light aircraft used, such as An-2, Mi-2, Mi-8, L-410, etc., as well as local airlines do not have such equipment and appropriate ground infrastructure, which leads search new solutions.

Proposed system for monitoring technical parameters does not require complex additional equipment and use network of ground-based radio stations, while it can allow ground-based inter-flight diagnostics thousands of kilometers from ARP, accumulate current data and plan maintenance and repair processes.

2. Structure monitoring technical parameters equipment light aircraft

Modern automated systems are characterized use industrial technologies on basis mass-produced industrial controllers compatible with personal computers and powerful software and hardware systems for programming support, as well development and standardization of network technologies. Under the structure understand human-machine system, which provides automated collection and processing of information necessary to optimize management technological object in accordance with accepted criterion [4].

Solution problem technical control state equipment aircraft for ARP is possible using a monitoring system technical parameter. Monitoring system technical parameters consists a set of measuring transducers: sensors (D) - carrying out measurement parameters elements control state aircraft, programmable logic controller (PLC) - which processes information and means communication and transmission processed information to ARP for evaluate monitoring results in real time. It is proposed to use standard sensors placed on board aircraft as monitoring sensors to take main parameters: vibration, temperature, pressure, revolutions, deviation and movement, flow rate, etc. In order to obtain accurate data, signals sensors installed on aircraft are pre-calibrated with signals of reference sensors submitted by ARP, with preliminary determination error coefficient.

For example, to obtain power system parameters (voltage, current, frequency) can be performed from terminals of generators, batteries, from busbars of AC and DC electrical systems, shunts, differential-minimum relays, etc. The use such a system will make it possible to forecast complex defects, and based on statistics, forecast the receipt aircraft for repair and optimize maintenance and repair processes [5]. For width and depth diagnosis, it is possible to use additional diagnostic equipment depending on nature and dynamics parameter diagnosed object.

Internal composition system will be a chain sequentially performed functions, where outputs of one object will be the inputs following (figure 1). As a dynamic system, sequential communications terminate in negative feedback. The output “adder solution”, there is a database current aircraft state data with deviations from technical requirements for maintaining airworthiness aircraft established by plant developer. Totality of this data is an operator’s decision support tool for sending aircraft for repair, and for ARZ, information for analyzing and planning organization upcoming repairs. The adder will be Information and Computing Center system that evaluates according to software algorithms and established restrictions.
3. Mathematical description system
To formalize system monitoring technical parameters equipment light aircraft, we will represent it as a set of different elements having different functional relationships with each other, forming a single common organism, which can be an ordered pair $Z = (X, Y)$, $X$ — many elements located aircraft; $Y$ — many functions between $X$. Moreover, $X$ represents a set of subject and accessible to control properties $I_n$ these elements.

Then, each property control $I_n$ inherent in a certain variable $K_i$, with the help of which the change in properties in the form of parameters is summarized.

$S: I_n = \{I_{n,j}, j=\{1,N\}\} \rightarrow K_i = \{K_{i,j}, j=\{1,N\}\}$,

$I_n$ — $n$ property (physical property an element),
$K_i$ — variable (controlled parameter).

In order to streamline system, we reflect it in form a set:

$Z = (X_i, K_i, Y_j, R_l)$,

where $X$ — many elements,
$K$ — many parameters,
$Y_m$ — many functions appeal to $X_i$ and $K_i$,
$R_l$ — output data exceeding operational limits for decision making.

Figure 1. Structure monitoring technical parameters equipment light aircraft (MTPELA)
AL — airline, TP — technical personnel, A — Aircraft, ICC — Information and Computing Center, PDA — Plant Developer Aircraft, TR MAA — technical requirements maintaining airworthiness aircraft, CTS — communication and transmission system, S — sensors.

For all variety available alternatives $\{\chi\}$ and logic decision making $L$ according to theory of system analysis, as a result, should be only two (fit-unfit) conclusions based on a clearly structured decision-making algorithm. In this case, quality decision-making will be based on degree accuracy $P$ and the conditions for ensuring the reliability of $D$ input information.
in this case, right decision for set all alternatives $\chi$ adopted on the basis of the received data $Z$, will depend on degree conformity aircraft to technical requirements $TR$ for maintaining airworthiness aircraft, provided that necessary accuracy $P$ and reliability $D$ measurements are ensured, $Z \in (\chi \mid \Phi(\chi)) \cap TR \Leftrightarrow (P \land D)$.

4. Technical implementation of monitoring system

In proposed structure, ARP should have a server with a central processor for receiving, storing, analyzing and processing data base. System monitoring technical parameters of equipment light aircraft consists of a control object, which is an aircraft, various sensors for measuring state of equipment and PLCs that process data. In addition, system includes means for outputting data monitoring results and means for transmitting data over a distance. The processed data can be transferred to ARP, which organizes a system for receiving, analyzing and processing data, as well as storing archived data.

Construction of monitoring system is carried out according to principle of an automatic control system. In Figure 1, direction of information flows is shown by arrows that move in direction from object to the end user at ARP. Monitoring system can be divided into two parts. One of parts is located at location of object (aircraft), and other part is integrated into remote system, which is located at RP. Exchange of data between them can be organized using known protocols and data transmission networks, depending on distances.

Technical personnel (aircraft technician, engineer) servicing aircraft connects output of sensor group of diagnosed objects to PLC through built-in signal converter and synchronizes with ARP server, which receives real-time aircraft data.

In order to eliminate disputes about monitoring results and need for constant access to primary information about state of aircraft, all measured information can be archived. If it is impossible to evaluate monitoring in real time, archive with results can be transferred to ARP for consideration and study.

5. Conclusion

Presented concept of improving principles of organizing maintenance and repair processes at ARP will allow us to move to a new level of forecasting and implementation of production activities through introduction of a real-time monitoring system for the technical parameters of light aircraft equipment. Use of such modern information technology solutions in field of forecasting the prospective production load significantly increases level of organization of maintenance and repair processes, which leads to an increase in quality level of functioning of objects under consideration.

Implementation of a system for monitoring technical parameters of equipment light aircraft will contribute to achievement of following positive results:

- reducing time processes of servicing and repairing aircraft at ARP;
- reduction resource consumption due to timely planning;
- improving quality repairs based on forecasting and accumulated failure statistics;
- ability to conduct diagnostics at any necessary time;
- a possible increase in ARP load volumes due to improved service and pricing policy being formed.

On its basis, a system of mass dispatch control and diagnostics can be implemented. In addition to listed advantages, a system monitoring technical parameters equipment light aircraft will increase flight safety due to implementation of an objective assessment by technical means compliance an aircraft instance with requirements of technical regulation.
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