THE DATABASE OF AIRCRAFT PERFORMANCE CHARACTERISTICS

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Abstract—In this article we describe the main aspects of implementation of a database for flight control of the aircraft. Ways of increasing the accuracy of the initial data are describing there. We also describe a method of interpolation of aircraft performance characteristics. These performance characteristics are used to calculate the desired vertical flight path. In addition, the article describes an adaptive algorithm for the prediction of vertical flight path, which is based on the substitution of the parameters from the database.

Index terms—Aircraft performance characteristics; database; flight control; optimum path; interpolation.

I. INTRODUCTION

Nowadays the system of flight control of the aircraft in the vertical plane must be able to construct a path to perform the following functions [1]:

− formation of the flight plan in the vertical plane;
− generation of control signals for performing piloting in the vertical plane in accordance with a predetermined flight plan at all stages: takeoff, climb, cruising, descent, approach to landing, missed approach;
− change in the flight plan in the vertical plane;
− select the recommended departure procedures;
− calculation of the remaining time and distance to the beginning of descent in the set point;
− calculation of the profile of the climb when you set the mode dial;
− calculation of the parameters of the flight plan;
− control and signaling deviations from the preselected spatial trajectory.

Consider the basic functional modules, solves the problem of forming and keeping the spatial trajectory.

This module consists of a set of procedures for performing the following functions:

− procedure for calculation of the parameters of vertical profile schemes SID / STAR / APPR for a given runway, given departure/landing aerodrome;
− procedure for calculation of the stage os climb / descent, locating points of the vertical profile of TOC (Top of climb), TOD (Top of descend) (the distance to the next nearest check point) in the total flight plan;
− procedure for calculation of the parameters of vertical path for the stage of climb / descent on the route;
− procedure for calculation of the parameters of the flight plan (latitude, longitude specified track angle, magnetic variation, given airspeed / Mach) points to the vertical profile of TOC, TOD;
− procedure for calculation of airspeed for each phase of flight, depending on the mode optimization.

All of these procedures in the calculation based on the information the navigation database and the database of performance characteristics.

II. PROBLEM STATEMENT

The task is the development of the database of aircraft performance characteristics.

Aircraft performance characteristics [2] aircraft are determined by the results of experiment in the wind tunnel and refined during flight testing and presented as nomograms. The typical form of a nomogram is shown in Fig. 1.

This nomogram is used to determine the maximum allowable flight gradient. This gradient is a function of altitude, outdoor temperature or a deviation from the standard atmosphere, gross weight, ratio of airspeed to stall speed ($V / V_{st}$).

In the board computers these data form the electronic database of performance characteristics, which is containing nomograms in table form. The nomogram in table form is arrays points $X_i (i = 1 ... n)$ and $Y_j (j = 1...m)$, called nodes.

III. ANALYSIS OF LAST RESEARCH AND PUBLICATIONS

Determination of aircraft performance characteristics with high accuracy is impotent task.

It is necessary to create the database of the aircraft performance characteristics for performance-based navigation (PBN) [3]. Currently, PBN aims to
harmonise longitudinal and lateral performance requirements (i.e. 2D) for both RNAV and RNP specifications and in the future, a progression is expected to include 4D trajectory-based operations. Although PBN implementations will continue to be based on both RNAV and RNP specifications, future developments will focus on new RNP specifications. As more reliance is placed on GNSS, the development of airspace concepts will increasingly need to ensure the coherent integration of navigation, communication and ATS surveillance enablers.

In the work [2], the authors raise a problem of choosing the optimal way to determine the takeoff and landing characteristics according to the nomograms, which are shown in the tabular form.

**Purpose**

The purpose of this work is to describe development of database of the aircraft performance characteristics.

**IV. DEVELOPMENT OF DATABASE OF AIRCRAFT PERFORMANCE CHARACTERISTICS**

In the [2] author carries out the comparative analysis of the existing methods of interpolation of aircraft performance characteristics from the calculation speed and accuracy point of view and grounds the rightness of selected method usage. All calculations are carried out on the basis of the data provided on Fig. 1. However the calculations which are carried out according to this nomogram are inexact. For increase of accuracy of definition of flight characteristics it is necessary to create a series of the nomograms for all expected flight altitude. The smaller the step altitude in a series of the nomograms, the greater the accuracy of the determination of performance. Consider a specific example of the definition of performance. For example, you must define the descent gradient of aircraft at altitude 12200 m. Let's say in a database of flight technical characteristics there are nomograms of definition of descent gradient with a step on altitude 500 m: \( H = 12500, 1200, \ldots, 0 \). In Fig. 2 are shown the nomogram for flight altitude 12500 m.

For a start we determine a decrease gradient for altitude 12500 m by this nomogram. As can be seen from Fig. 2 it is equal to \(-7.19\%\).

Then we define a decrease gradient for height of 12000 m. As shown in Fig. 3 it is equal to \(-7.88\%\).

For finding of a gradient of decrease on 12200 m it is applicable linear interpolation (Fig. 4).

\[
\theta = \theta_0 + \frac{(H - H_0)}{(H_1 - H_0)}(\theta_1 - \theta_0),
\]

where \( \theta \) is the gradient at altitude equal 12200 m; \( \theta_0 \) is the gradient at altitude equal 12000 m; \( \theta_1 \) is the gradient at altitude equal 12500 m; \( H \) is the altitude 12200 m; \( H_0 \) is the 12000 m altitude; \( H_1 \) is the 12500 m altitude.

Substitute numerical values and obtain:
Fig. 2. The nomogram for determination of the descent gradient of aircraft at altitude 12000 m: 

- **a**: the function of outdoor temperature ($T$); 
- **b**: the function of gross weight ($W$); 
- **c**: the function of ratio of airspeed to stall speed ($r$).

Fig. 3. The nomogram for determination of the descent gradient of aircraft at altitude 12500 m: 

- **a**: the function of outdoor temperature ($T$); 
- **b**: the function of gross weight ($W$); 
- **c**: the function of ratio of airspeed to stall speed ($r$).
\[ \theta = -7.19\% + \frac{(-12200m + 12000m)}{(-12500m + 12000m)}(-7.88\% + 7.19\%) = 7.47\%. \]

Fig. 4. The linear interpolation for determination of the descent gradient of aircraft at the desired flight altitude

**CONCLUSIONS**

In this article we have described the database of the aircraft performance characteristics.

The offered database allows to define aircraft performance characteristics with a high accuracy. The received characteristics are applied to formation of the operating signals (optimum vertical path angle) in the vertical plane. The optimum vertical path angle will vary depending on the type of aircraft, its actual weight, the wind, air temperature, atmospheric pressure, icing conditions, and other dynamic considerations [4]. However, the maximum benefit for an individual flight is achieved by keeping the aircraft as high as possible until it reaches the optimum descent point. This is most readily determined by the onboard FMS, which uses the above database.

**REFERENCES**


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Рассмотрены основные аспекты реализации базы данных для управления полетом самолета. Обсуждались способы повышения точности расчетов на основе исходных данных. Также описаны методы интерполяции летно-технических характеристик самолета. Данные характеристики применяются для расчета заданной вертикальной траектории полета. Кроме того, описан адаптивный алгоритм прогноза вертикальной траектории полета, основанный на подмене параметров из базы данных.

Ключевые слова: лётно-технические характеристики самолёта; база данных; управление полётом; оптимальная траектория; интерполяция.

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