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The simulation model of the system for determining the actual values of the weight of an empty aircraft

This article presents the simulation model of the subsystem for determining the actual values of the weight and centering of the empty aircraft. It also offers its numerical implementation in the SIMULINK visual programming environment.

Our research goal is to develop a decision support system for weight loss and centering. One of the research tasks is to create a model that takes into account the errors that arise when determining the weight and centering of the aircraft. In this paper we present the development of a simulation model of one of the subsystems of simulation of determining the weight and centering of the aircraft in the light of errors.

The calculation and measurement of the weight of an empty aircraft takes place at the enterprises where the aircraft is designed and manufactured. As a result of weight control and centering, fill out the form. Assume that at designing an airplane, the given weight of an empty aircraft G_0 and the tolerance to deviation from it due to the imperfections of the manufacturing technology σ_G are determined. The correlation between these values is determined by the level of development of aircraft and today is:

$$\frac{\sigma_G}{G_0} = 0.01 = \alpha_1 \qquad (1)$$

The mathematical expectation of the deviation of the weight of an empty aircraft from the given weight should be equal to zero [1]. To the form of the airplane with a certain number, the weight of an empty aircraft is added, which is obtained by weighing an aircraft copy with a specific number on special scales. The error of measurement of weight on such scales is a centered random variable, the normalized mean square deviation of which $\bar{\sigma}_P$ does not exceed α_2:

$$\bar{\sigma}_P = \frac{\sigma_P}{P_0} \le \alpha_2 = 0.01 \qquad (2)$$

Of the many literary sources, it is known that aircraft manufacturing errors and weight measurement errors are random variables distributed according to the normal distribution law. So, between the given value of the weight of the empty aircraft and the actual value of this weight P_0, there may be differences as a result of the action of at least these two factors.

The centering of an empty aircraft is determined by the coordinate's x_{T0}, y_{T0} of the center of the mass of the aircraft relative to the wing coordinate system x_0By_0. In the form of the aircraft the following value of the horizontal centering $\bar{x}_{T0}$ is given, which is found by the formula:

$$\bar{x}_{T0} = \frac{x_{T0}}{MAC} \bullet 100 \qquad (3)$$

where MAC is the length of the average aerodynamic wing chord. The MAC and x_{T0} values are determined by additive errors that are random variables with zero mathematical expectations and mean-square deviations σ_M and σ_C that do not exceed the values:

$$\sigma_M \le 0.01MAC^n,\ \sigma_C \le 0.01x_{T0}^n \tag{4}$$

where MAC_n, x_{T0n} - the mean values of the length of the mean aerodynamic wing chord and the coordinates of the center of mass are determined during the design of the aircraft.

Based on the presented considerations, the data on the design and production features of aviation engineering and the principles of modeling random variables with known law of distribution has been developed by the structure of the simulation model of the subsystem of weight characteristics of an empty aircraft (WEA), which is presented in Fig. 1. In the scheme, blocks G_1, G_2, G_3, G_4 are generators of random numbers with a normal distribution law and different dispersions that simulate the occurrence of manufacturing errors or measurement of certain quantities.

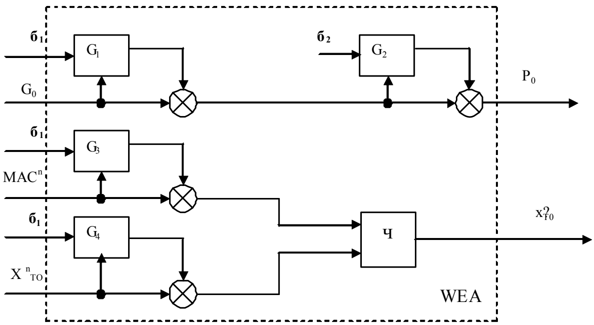

Fig. 1. The structure of the simulation model WEA

The structure thus created (Fig. 1) allows creating its numerical implementation in the visual programming environment SIMULINK. The text of the program is presented in the form of two mimic diagrams in Fig. 2 and Fig. 3.

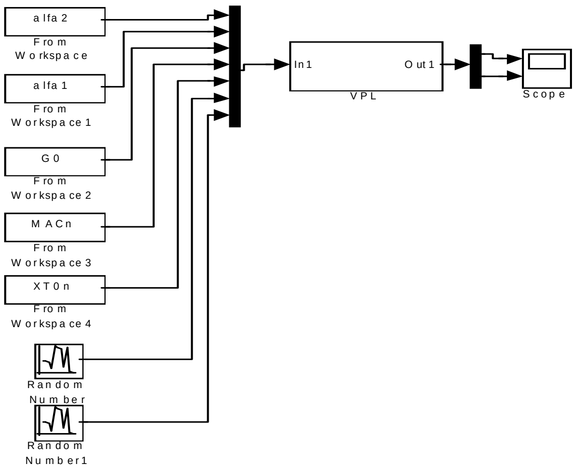

Fig. 2. The mimic diagram of the simulation model of the subsystem WEA

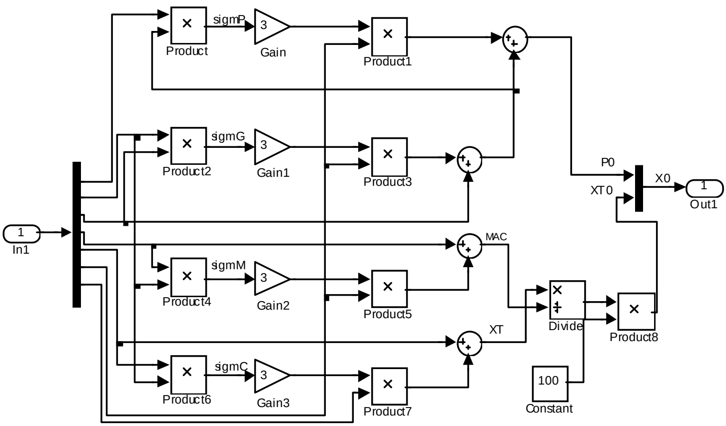

Fig. 3. The mimic diagram of the subsystem WEA in the SIMULINK environment

As can be seen, the scheme includes several classes of software tools for modeling. The first class of tools is the source of the constant values of the signals that are set in the working space of the MATLAB system. Such sources are five blocks from Workspace (Fig. 2). The first block represents the coefficient α_2 of the marginal relative error of measurement of the weight from the equation (2). The second block defines the relative tolerance for the accuracy of the manufacture of the aircraft: the value of α_1 from the ratio (1). The third block defines G_0 and is not labeled G_0. The task of the fourth block - to submit the input value of the model MAC_n, and the fifth - the value of x_{T0}^n from the formulas (4). The second class is the tools intended to simulate the emergence of a sequence of random numbers with a normal probability distribution law, zero mathematical expectation, and unit dispersion. This class represents two Random Number blocks. The transformation of signals in a model that implements the process of statistical tests is carried out using the third class of tools. It includes Product Multiplication Blocks, Gain, Divide, and Sum Amount. Formation of the vector X_0 is accomplished by using the MUX multiplexer unit, which belongs to the fourth class of tools, along with the vector separation unit on the DEMUX components.

In addition, the following symbols have been entered on the mimic diagram (Fig. 3):

$$sigmP = \sigma_P;\ sigmG = \sigma_G;\ sigmM = \sigma_M;\ sigmC = \sigma_C \ . \quad (5)$$

An important task of the safety of air transportation is the proper loading of the aircraft. When placing the goods must consider two factors:

- the weight of the aircraft flight;
- the position of its center of mass.

In the study, we have developed the structure of the simulation model of WEA subsystem's work. Also we have created its numerical implementation in the visual programming environment SIMULINK. Using this model will develop an automated system for decision support for loading and balance of the aircraft, which can be used in domestic airlines.

References

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