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The dynamic characteristics of the propellers UAV

A new methodology of the research dynamic characteristics of the power plant of UAV is proposed. The basis of the methodology is the use of experimental data. To obtain real experimental characteristics a stand was developed with the information-measuring complex. The physical simulation was implemented by the stand and received transient characteristics of the power plant. Based on the experimental data, is building a mathematical model and received the dynamic characteristics of the power plant.

Formulation of the problem

The power plant is one of the important elements, and its dynamic characteristics significantly affect the dynamic characteristics of the aircraft as a whole. Taking as a basis the requirements for: maneuverability, controllability, maximum allowable overload, and dynamic characteristics of the control bodies, the selection of the power plant is carried out. Typically, UAVs use air propeller with using electric and gasoline engines for created traction force. Applying an electric motor that has little inertness, compared with gasoline, the dynamic characteristics of the power plant depend on the air propeller, namely: the number of blades, the geometric shape of the blade and the diameter of the air propellers. In this connection, it is necessary to study the influence of the geometry of the propeller on the dynamic characteristics of the power plant.

Main part

Transient characteristics are obtained by means of an information measuring bench for determining aerodynamic characteristics of air propellers (Fig. 1).

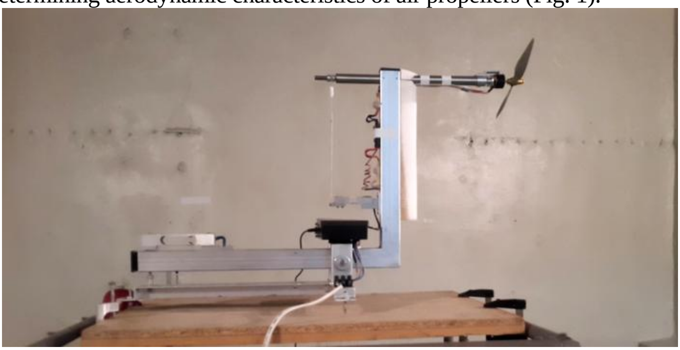

Fig. 1. Stand for the study of aerodynamic characteristics of air propellers.

This stand allows to simulate the input PWM signal and write the output signals of the thrust, the amperage and RPM.

Two screws (APC MR 10x4.5 and GWS 8x4) were select for the experiment, with different geometric characteristics that are widely used for small UAV (Fig. 2).

Fig. 2. Investigated air propellers: a) APK MR 10x4.5; b) GWS 8x4.

The tests were carried out under standard atmospheric conditions and the velocity of the incident stream V = 0. With the help of the program developed in the LabView environment, the control of the input PWM signal, the recording of measurement parameters with a frequency of 90 Hz and the formation of a protocol of experimental data.

The next step is to process the received information and obtain transitional functions. With the help of the "ident" subroutine of the MATLAB software system, the transfer function is intensified. Depending on the complexity of the transient characteristic, the method of selection determined the order of the transition function. The transient functions of traction, jet moment, rotation (Fig. 3-5) were checked for adequacy and convergence, where the convergence of the identified transfer functions with the experimentally obtained is more than 97%.

The transfer functions of the propulsion of the propulsion system with screw "a" and "b" are as follows:

$$\frac{T}{U_{вх}} = \frac{-6.715s^5 + 548.1s^4 - 2.995e04s^3 + 1.004e06s^2 - 2.023e07s + 2.064e08}{s^6 + 46.45s^5 + 2030s^4 + 4.675e04s^3 + 7.759e05s^2 + 7.175e06s + 3.087e07};$$

$$\frac{T}{U_{вх}} = \frac{-3.112s^5 + 222.3s^4 - 1.297e04s^3 + 4.767e05s^2 - 1.184e07s + 1.838e08}{s^6 + 33.86s^5 + 1762s^4 + 3.901e04s^3 + 7.493e05s^2 + 7.835e06s + 4.033e07},$$

where is the T-thrust air propeller, the U-PWM signal.

Transfer functions of the jet moment Q of the power plant system with propeller "a" and "b":

$$\frac{Q}{U_{вх}} = \frac{-0.804s^8 + 66.29s^7 - 4785s^6 + 2.997e05s^5 - 6.529e06s^4 + 3.53e08s^3}{s^9 + 64.49s^8 + 7779s^7 + 3.36e05s^6 + 1.724e07s^5 + 4.692e08s^4 + 1.15e10s^3}$$

$$\ldots \frac{-3.362e09s^2 + 8.951e10s + 5.065e11}{+1.598e11s^2 + 1.535e12s + 4.933e12};$$

$$\frac{Q}{U_{вх}} = \frac{0.7301s^8 - 114.2s^7 + 1.219e04s^6 - 7.534e05s^5 + 5.576e07s^4}{s^9 + 192.6s^8 + 1.735e04s^7 + 1.559e06s^6 + 7.586e07s^5 + 3.779e09s^4}$$

$$\ldots \frac{-1.447e09s^3 + 7.143e10s^2 - 8.171e11s + 2.348e13}{+1.071e11s^3 + 2.819e12s^2 + 3.82e13s + 3.701e14}.$$

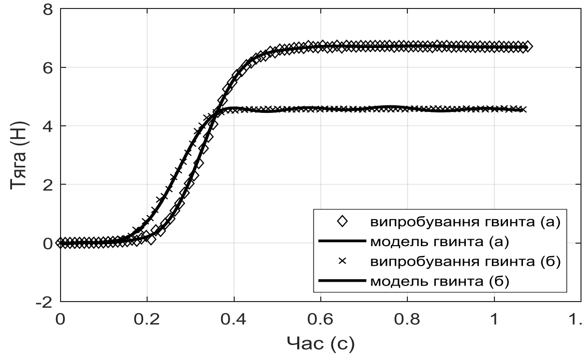

Fig. 3. Transient characteristic of traction of the power plant

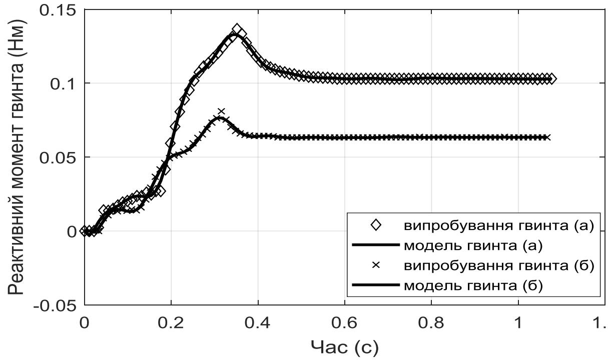

Fig. 4. Transient characteristic of the jet moment of the power plant

Using the diagrams "bode" was building, the amplitude-phase-frequency characteristics of the power plant (Fig. 6).

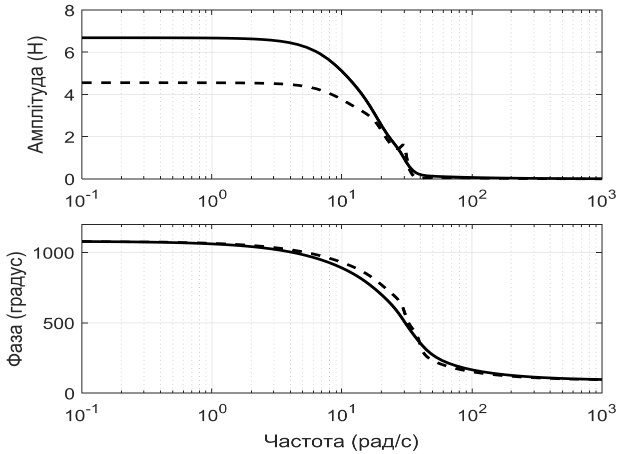

Fig. 5. Amplitude-phase-frequency characteristics of the traction of the power plant

Conclusions

The methodology of research of dynamic characteristics of power plants of the UAV is developed. On the basis of experimental data, a mathematical model was obtained and dynamic characteristics were determined. The obtained dynamic characteristics of the power plant can be solved by the following tasks: development of systems of automatic control of the power plant, optimization of the characteristics of the power plant and the plainer.

References

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