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MODELING AND ANALYSIS OF THE "AIRPLANE-AUTOPILOT" SYSTEM IN DESCENDING ATMOSPHERIC DISTURBANCE

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ABSTRACT: *The study examined the behavior of the "autopilot-airplane" system under a strong downward impulse. The airplane is modeled through a complex turbulent turbulence that forms at mountain peaks. The airplane's behavior is controlled and controlled by various autopilots. Comments and conclusions were made on the results of modeling for a possible catastrophic situation if the stock height is less than 50 m and the control is from a simple pilot structure.*

KEY WORDS: *FLIGHT SAFETY, MODELING, CONTROL CONTROL, FLIGHT DYNAMICS.*

Problem under investigation

Passage of an area with severe atmospheric disturbance is always associated with potentially dangerous consequences for the airplane, crew and passengers. A case is considered a flight with an autopilot and the following questions are answered:

- When the autopilot can complicate the flight and create a crash hazard?
- Should the autopilot be switched off when flying in high atmospheric disturbance?

Study method

As a far as flights in strong atmospheric disturbance are always considered to be one of the major versions for a number of crashes and accidents, flights in such areas are potentially dangerous, and the flight instructions define the means for safe passage in automatic or manual control. Answers to questions put in the research can be solved by modeling and such a method is chosen for the specific situation.

1. Introduction

In flight practice, there is a view that autopilot should be excluded in conditions of strong turbulence and other atmospheric disturbances associated with upward or especially more dangerous downward gusts in restricted space areas. This issue is controversial, especially for modern aviation, and in most cases is related to the level of technology in the area of automatic control systems. There is no adequate response valid for all cases and the pilot should therefore follow the specific instructions. A common answer can be given by modeling a type situation where the consequences of the management of different autopilots have been checked.

2. Ways to solve the problem

In order to achieve the objectives set in the study, Matlab-Simulink was modeled on a hypothetical subsonic maneuver in automatic mode of flying over a mountain peak of about 2000 meters with a strong counter-wind, where before flit over a mountain peak and to the airplane hit downward gusts of about 17 m / s. A common pattern of the modeled flight is shown in Figure 1.

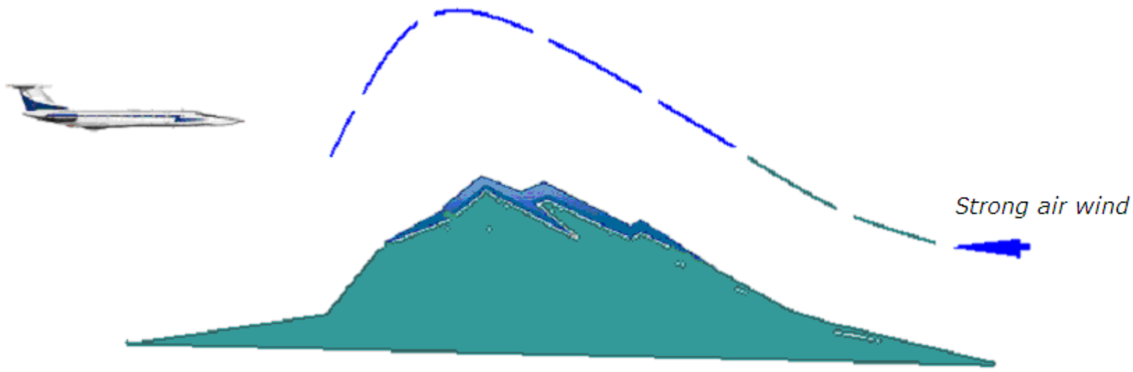

Fig.1. Scheme of the modeled situation

3. Solution of the research problem

The "autopilot" system has been tested for two types of autopilot. The first type has the simplest structure and law for elevator:

$$\delta_в = K_в^{\vartheta}(\vartheta - \vartheta_{зададено}) + K_в^{\omega_z}\omega_z \; ; \quad (1)$$

The second type of autopilot is with vertical speed signals and height control and stabilization.

$$\delta_в = K_в^{H}(H - H_{зададено}) + K_в^{Vy}V_y + K_в^{\vartheta}(\vartheta - \vartheta_{зададено}) + K_в^{\omega_z}\omega_z \quad (2)$$

The indices and designations in the control laws correspond to the modeling in GOST 20058-80 according to the longitudinal motion equations known from the flight dynamics (3) and have the following meanings:

$\delta_в$ - Variation of the steering elevator (degrees);

$K_в^H$ - Transmission coefficient for the flight height control channel;

$K_в^{Vy}$ - Transmission coefficient of the channel at the vertical speed.

$K_в^{\vartheta}$ - gearbox in the pitch pitch channel;

$K_в^{\omega_z}$ - Transmission coefficient at tangent angular velocity;

ϑ - pitch angle (degrees);

ω_z - angular velocity of pitch (degrees / s);

H - flight height (m);

V_y - Vertical speed (m / s)

The general appearance of the model is shown in Fig.2

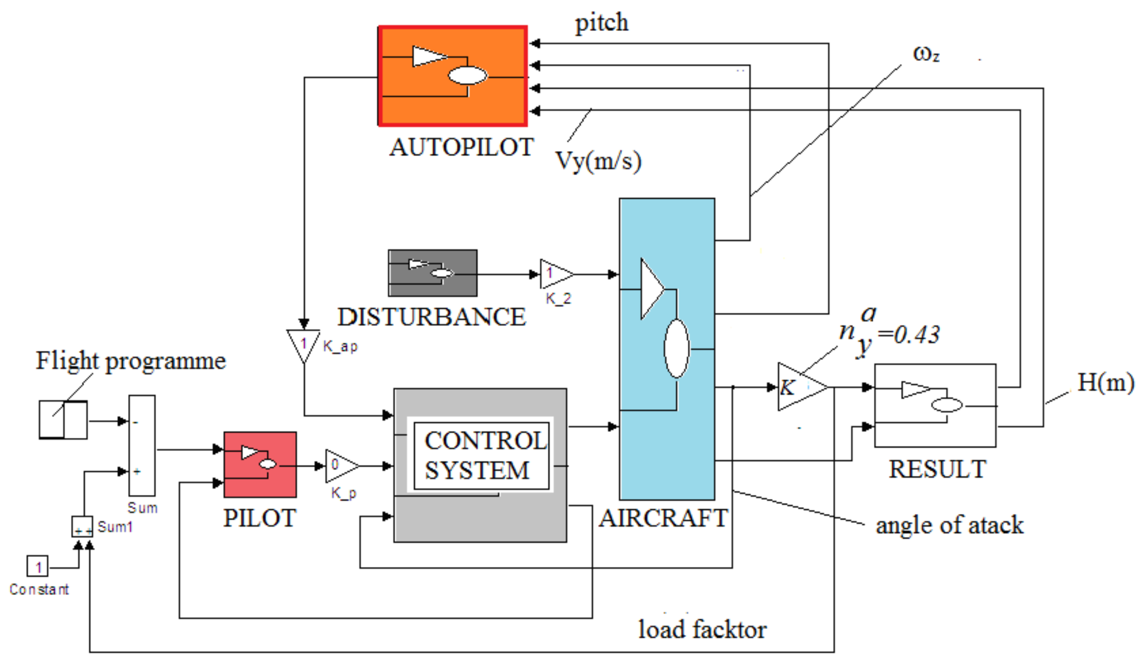

Fig.2. General appearance of the model

4. Results

Figures 3 and 4 show results of the airplane response without autopilot control during a downward flight. The elevator is fixed around the mode balance.

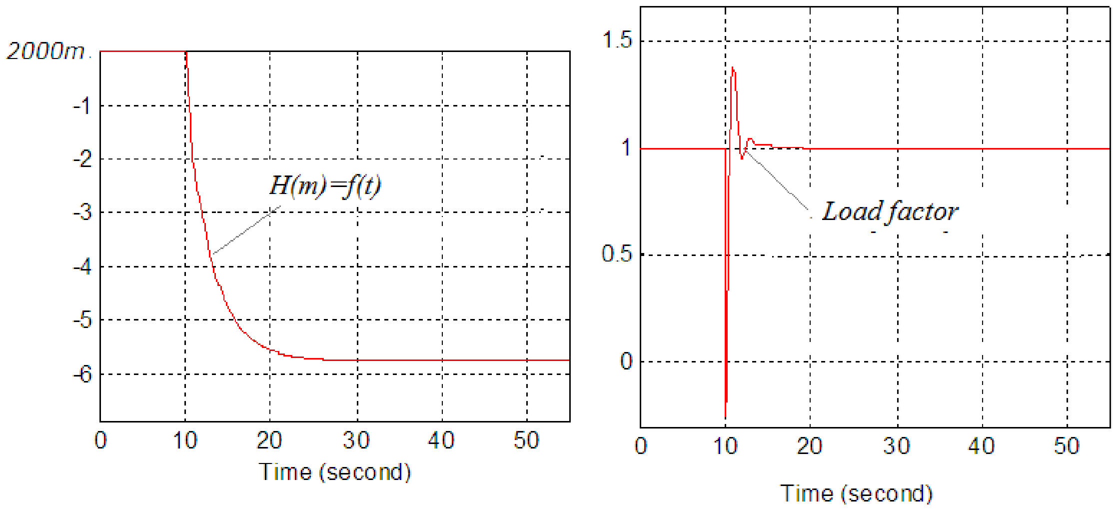

Fig. 3. Flight height change and normal overload without autopilot control.

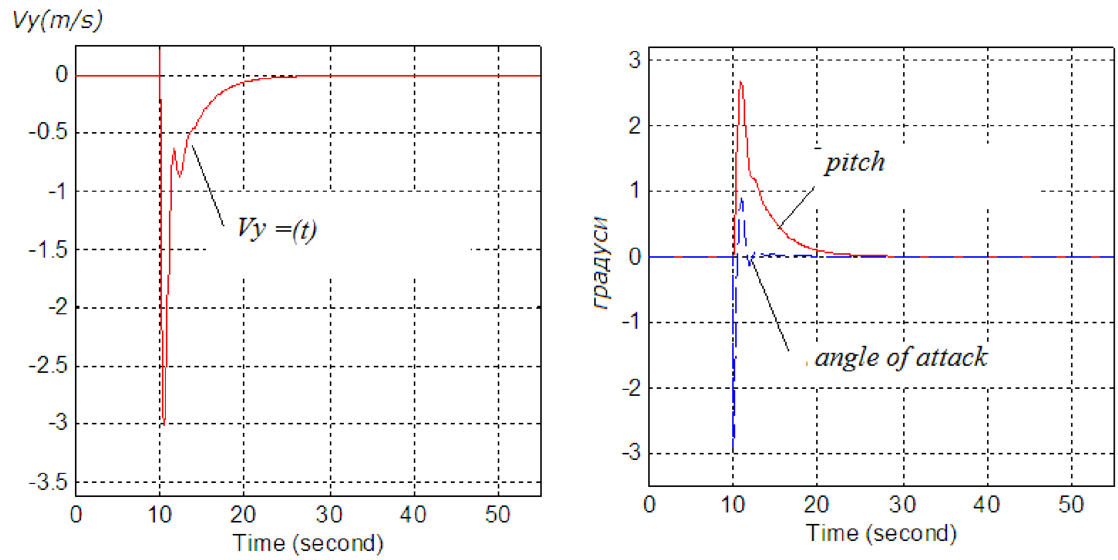

Fig.4. Modification of vertical speed, pitching angle and attack without autopilot control (only changes are added to the output mode)

Figures 5 and 6 show the reaction results of an autopilot control with a simplified control law structure (Law 1) when passing through a downward air storm.

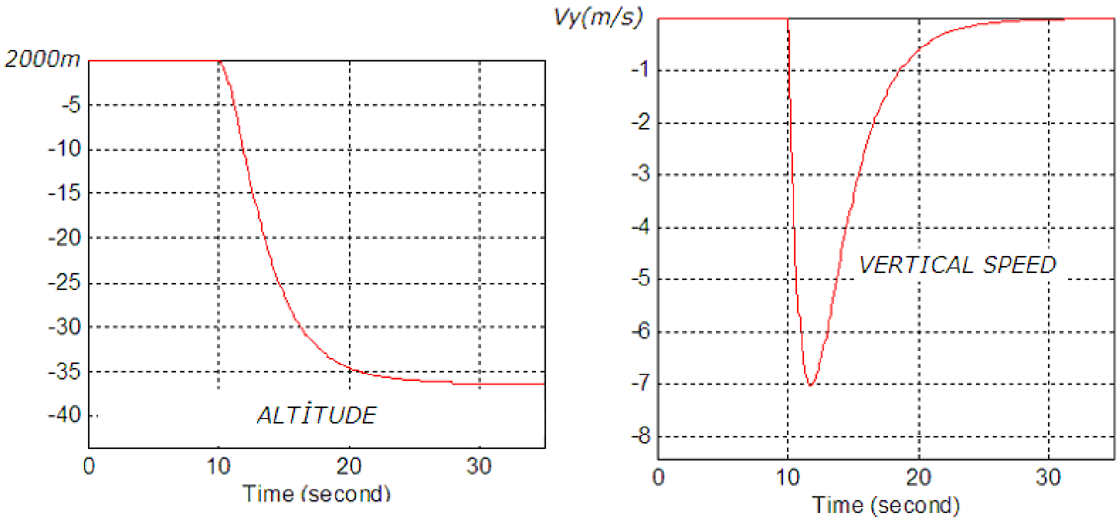

Fig.5. Flight altitude and vertical speed change from autopilot control with simplified control law structure - autopilot does not restore flight height

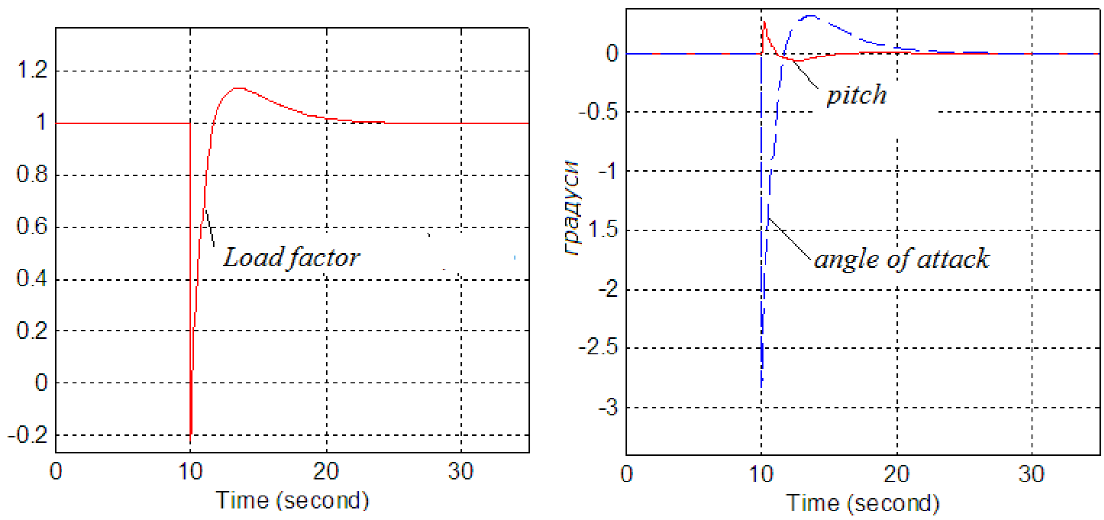

Fig.6. Modification of normal overload and pitch corners and autopilot control attack with simplified control law structure

Figures 7 and 8 show the reaction results of the autopilot control with law 2 (with altitude and vertical speed signals) when passing through the simulated atmospheric disturbance (downward air gust around a mountain peak).

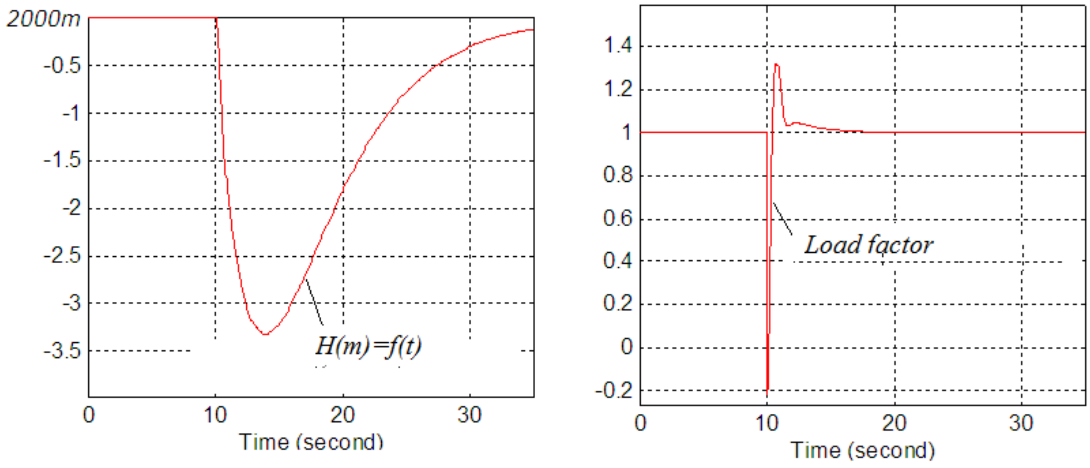

Fig.7. Flight height change and normal overload on autopilot control with altitude and vertical speed signals

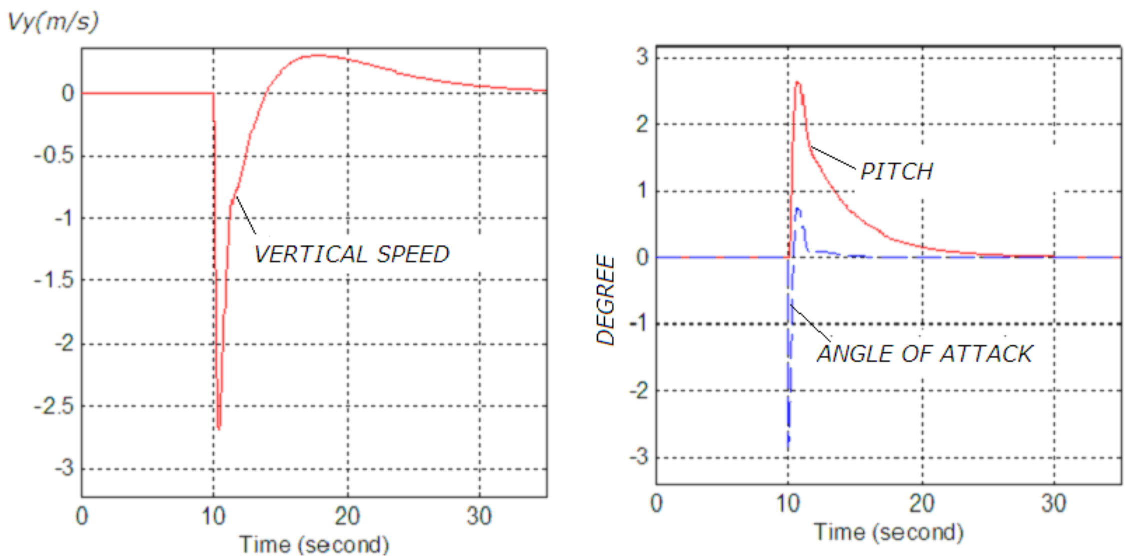

Fig.8. Modification of vertical speed, pitching angles and autopilot control with altitude and vertical speed signals

5. Conclusion of modeling and conclusions

• The modeling results (Figures 3 and 4) show that when overfly through a downward atmospheric impulse, the overload resistant airplane " go under ", but it seeks to increase its pitch angle and thereby lessens the negative effects of gust. " Go under " in height is limited in this case to 5 to 6 meters, and the horizontal flight continues about *6 km* with a lower altitude. This behavior is also referred to as "getting into an air pit". The pilot can not pilot exactly and is not advised to seek to limit the movement of the controls by increasing the pitch of the pitch because it will increase the collapse (the plane go under with the rear and the nose is lifted). Such behavior of the pilot is called "allowing the airplane to be entrapmented in the disturbed atmosphere."

• In autopilot control with simplified structure (with tangent angle signals and angular velocity of pitching - results in Figures 5 and 6), the autopilot complicates the situation and the "dropping" is about 35 ... 40 meters at a high vertical speed (more from 7m / s). There is a real danger that the autopilot may cause a catastrophic situation to develop (in this case - falling on over a mountain peak or before it). If the airplane is equipped with such an autopilot, it should be switched off when passing through zones of any atmospheric disturbance.

• The autopilot with altitude and vertical speed signals quickly recovers flight altitude, fly down with a small vertical speed, and including such an autopilot when flying across some atmospheric disturbances is useful for flight safety. The modeling results are shown in Figures 7 and 8.

• The physiological impact on the pilot is almost the same for all modeled cases - in fast portions the normal overload reaches negative values and the pilot's body has a tendency to " hangs on the belts". The change in pitch and attack angles for the cases under consideration differs only by value but not by type - always at the beginning of the downward gust, the plane increases the angle of the pitch and reduces the angle of attack - ie. "Falling" has with the tail down.

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