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A MODEL OF THE INTERNAL CONTOUR OF HELICOPTER NAVIGATING SYSTEM

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Abstract

In this project propose methodology for mathematic modelling and research the internal navigation channel of helicopter on the basis of testing the helicopter, the autopilot and pilot models

For the purpose of modelling the helicopter Mi – 8T has been chosen, with a performance aggregate in the navigation channel – combined hydro aggregate, type RA-60. While modelling the internal contour for navigation it is necessary to create in advance sub models of the object of navigation, the control system, the pilot and external disturbance. The assembly of the models in a contour should account for the real special features of the construction and the restriction. In this particular case we choose the following purpose of research: the reaction of the system "helicopter – autopilot" under strong external disturbance and operation of the performance aggregate RA-60 in regimes, which brings the steering-machine up to its working capacity limit.

1. A model for helicopter

The starting parameters in modelling the dynamics of the object are: common general features of the helicopter performance under disturbance and ruling commands; data for maximum possible angular acceleration, as well as the time for this acceleration's reduction to zero, as a result of the damping moment. The starting regime for the concrete modelling tasks is the "hang on" regime. The maximum theoretical angular acceleration of the helicopter, achieved through step-like pedal-fed commands from neutral position to the end is $\varepsilon_y = 1.5\ (1/s^2)$ [5]. Under the damping moment, in the process of motion, the angular acceleration of helicopter Mi-8 reduces till zero within 12 *s* [5]. The model of the helicopter's motion within the tail channel is shown in Fig.1.

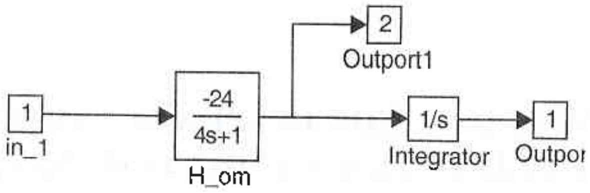

Fig.1. A model of isolated motion of course

2. Model of the control system

The control system of the helicopter is a mechanic chain including combined hydro accelerators connected in an irreversible scheme with a mechanical entrance form the pilot and electrical entrance from the autopilot. The aggregate of performance in the tail wind channel RA-60 features variable dynamics, depending on the strength of disturbance, which the autopilot tries to neutralize in the process of stabilization (the "peregonka" regime). This main feature is accounted for in a manner similar to the one described in [8]. The transmission coefficients of the autopilot have been chosen by data for autopilot AP-34B and have been broken down along the chain in the "peregonka" regime.

3. Model of the pilot

To neutralize the disturbance in the tail wind channel of the helicopter, we have to choose the simplest model of transmission function for the pilot, which is typical for the elementary regime of stabilization under conditions of disturbance: $W_p=Ke^{-\tau t}$. The parameters are adjusted by taking into consideration the specifics of the helicopter – joint operation with the autopilot in the "damping" regime. In Fig. 2, the model of the pilot is shown. The transmission coefficient *K=0.6 [mm/deg]* is consistent with the limit of the contour resistance (Klim=0.9) and the condition for maximum possible speed of the pedals movement with the pilot's reaction under strong disturbance. The delay of τ= 0.3s is typical for most pilots. Both quantities are random, but in this particular case, the average parameters are studied. Typical parameters for the pedals and the chain leading to aggregate RA-60 are added to the pilot's model.

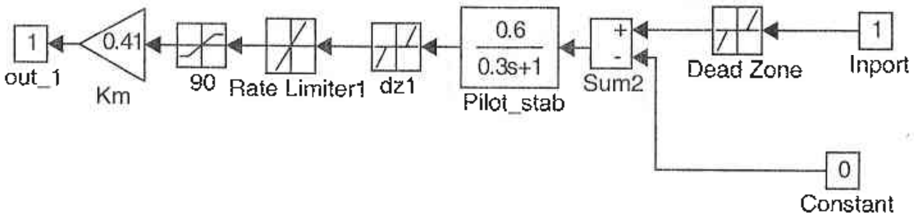

Fig.2. A model of the pilot and the mechanic chain leading to aggregate RA-60

4. Model of the disturbance

Except for uncoordinated control, the most typical cases are those under influence of side wind while in the "hang on" regime. All kinds of disturbances produce angular acceleration, based on the moments' balance disturbance around axis OY. Such disturbances could be modulated through deliberate changes in the step tail screw, whereas these changes are of various natures corresponding to the external disturbance. With this model, the background of the disturbance-caused route could be also modelled. The side wind changes the velocity triangle and the stream-line conditions of the tail propeller (changes in axis velocity).

5. Model of the "helicopter-autopilot-pilot" contour

The model of the "helicopter-autopilot-pilot" contour is shown in Fig.3. Different navigation conditions are formulated through keys "Key_AP", "Key_Pst" (with the coefficients 0 and 1): from autopilot, pilot in a combined regime – together with the autopilot. The "Switch" block switches off the autopilot's "stabilization" regime when the pilot is working in combined regime.

The results – angular velocity and course angle are visualized in block "R". The used symbols have the following provisional meaning: – Subsystem "EMB" (Embarrassment) – model of disturbance; "Control_AP"- signals from the autopilot (V),"Control_P"- signals from the pilot's model (mm).

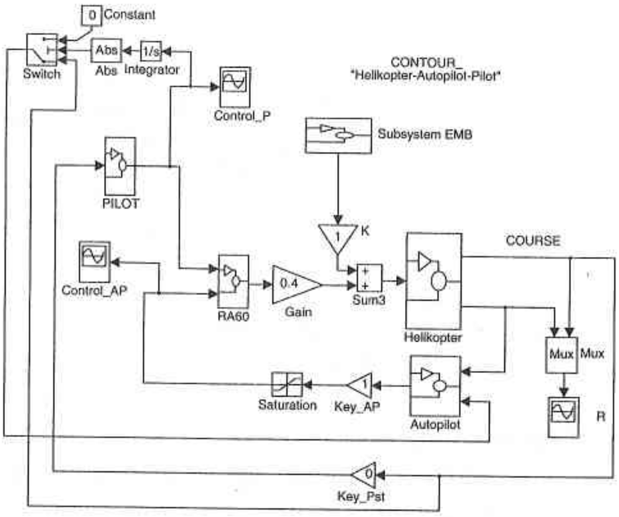

Fig.3. A "helicopter-autopilot-pilot" model

This model has been studied under various disturbances and working conditions of the contour. Figures 4, 4.1 and 5 present the modelling results, which illustrate the work of the "helicopter - autopilot" system.

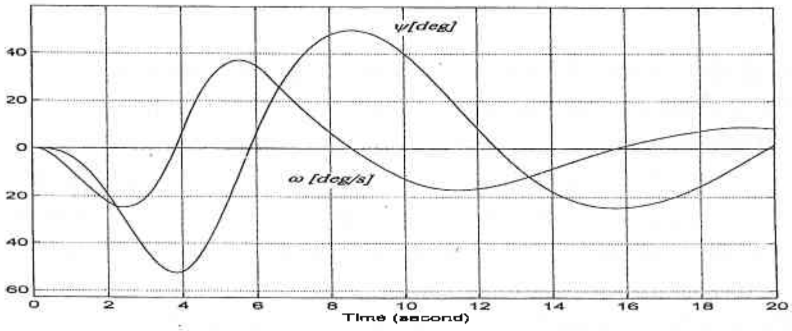

Fig.4. Transitional process in neutralizing a quick damping side-wind surge of the "pulse" type

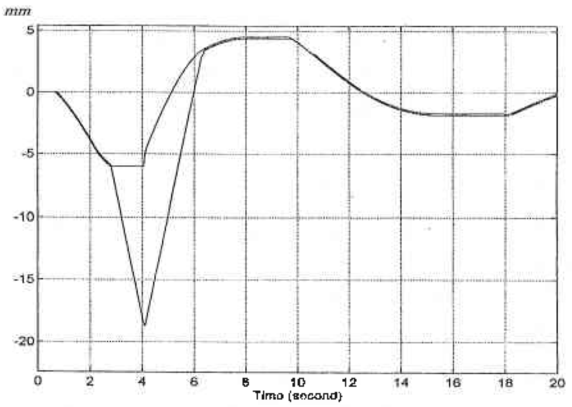

Fig. 4.1. Pace of the executive mechanism PA-60 under "pulse" disturbance.

The steering machine is fluctuating around neutral position, reaching in the beginning (from 3s to 4s) the restriction of *6mm* and providing conditions for the "peregonka" regime.

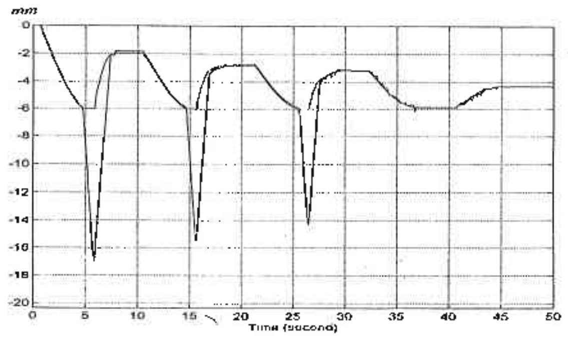

Fig.5. Pace of the executive mechanism PA-60 under constant disturbance – right-hand side wind of 15 m/s. The "peregonka" regime – 6s, 16s, 27s.

6. Conclusions

Considering the modelling results, conclusions for the operation and repair practice could be made as follows:

- The specific "peregonka" regime of aggregate RA-60 is reasonable if implemented for a short time (up to 1..2 s) in the beginning to neutralize the disturbance of constant side wind or strong, but short-lasting surges ("pulses");

The “peregonka” regime resembles the initial stage of the pilot work when neutralizing disturbance and imitates the reflector type of navigation disturbance – with maximum speed of movement of the aggregate of performance;

In “peregonka”, long-term stabilization of the process is impossible;

- In repair and diagnostic operations, special attention should be paid to adjustment of the assembly, switching on and off the “peregonka” regime; early switching on in the presence of side wind (before the steering machine reaches its constructive limit pace) could result in strong fluctuations of the helicopter the “hang on” regime;
- The insensitivity area of the steering machine of aggregate RA-60 affects unfavourably the contour’s stability under strong external disturbance.
- The potential unfavorable consequences of the “peregonka” regime under strong disturbance have resulted in its elimination in next-generation combined aggregates.

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МОДЕЛ НА ВЪТРЕШНИЯ КАНАЛ ЗА ПОПЪТНО УПРАВЛЕНИЕНА ХЕЛИКОПТЕР

Д.Йорданов, Р.Радушев, Н.Стойкова,

Резюме

В разработката се предлага методология за математическо моделиране и изследване на контура за попътно управление на хеликоптер по данни от изпитание на обекта за управление, модели на автопилота, пилота и изпълнителния агрегат на системата за управление.