MODELLING OF INFLUENCE OF MECHANICAL FLUCTUATIONS ON SMOOTHNESS OF FLIGHT OF FLYING MACHINES

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It is established, that at change of spatially-speed characteristics of flights in atmospheric layers, and also in extreme situations arise in mechanical fluctuations not only in the case, but also in all systems of flying machines. These fluctuations have numerous harmonics differing on amplitude and frequency. It is necessary to notice, that at neglect of influences specified to vibration at flight control of objects quality of flight and in certain non-standard situations can be changed. These the phenomenon can lead object accident.

Given article is devoted drawing up and computer to simulation of dynamic model of system management of flying object.

As a result of the spent researches the dynamic model of a control system of flights of flying objects taking into account transfer functions 1st, 3rd and 5th harmonics, arising mechanical fluctuations has been made at operation of the above-stated objects.

In the block diagramme W_t - transfer function of the plane, W_{t1}, W_{t3}, W_{t5} - corresponding transfer functions under the relation of the first, third and fifth harmonics of arising fluctuations (Fig.1). The general transfer function of the plane which is made taking into account harmonics of these fluctuations were are received:

$$W_t(p)=\frac{\tilde{\vartheta}_q(p)}{\tilde{\delta}_b(p)}=\frac{k^{\phi}_{\delta_b}(T_c p+1)}{p\left(T^2p^2+2\xi Tp+1\right)}+\frac{(A/1)(1\omega)_1}{p^2+(1\omega_1)^2}+\frac{(A/3)(3\omega)_1}{p^2+(3\omega_1)^2}+\frac{(A/5)(5\omega)_1}{p^2+(5\omega_1)^2}. \quad (1)$$

Transfer functions of other links of the block diagramme are resulted more low [1, 2]:
For a steering wheel:

$$W_{sm}(p)=\frac{\tilde{\delta}_b(p)}{U_g(p)}=\frac{k_{sm}}{T_{sm}^2p^2+2\xi_{sm}T_{sm}p+1}, \quad (2)$$

for a stabilising gyroscope:

$$W_{st.g}(p)=\frac{U_{dg}(p)}{\tilde{\psi}(p)}=\frac{k_{dg}}{T_{dg}^2p^2+2\xi_{dg}T_{dg}p+1}, \quad (3)$$

for a course gyroscope:
:

$$W_{sg}(p)=\frac{U_{sg}(p)}{\tilde{\psi}(p)}=k_{sg}, \quad (4)$$

for correcting blocks of gyroscopes:

$$\begin{cases} W_{k1}(p)=\dfrac{U_{k1}(p)}{U_{dg}(p)}=\dfrac{T_1p+1}{T_2p+1} \\ W_{k2}(s)=\dfrac{U_{k2}(p)}{U_{sg}(p)}=\dfrac{T_3p+1}{T_4p+1} \end{cases} \quad (5)$$

for the amplifier:

$$W_g(p)=\frac{U_g(p)}{U_e(p)}=k_g. \quad (6)$$

The purpose of researches is working out so-called compensating system which is capable to prevent destructive action of fluctuations. The compensating system consists of the engine of a direct current with independent excitation and the operated converter which are captured a negative feedback on frequencies of rotation of the engine.

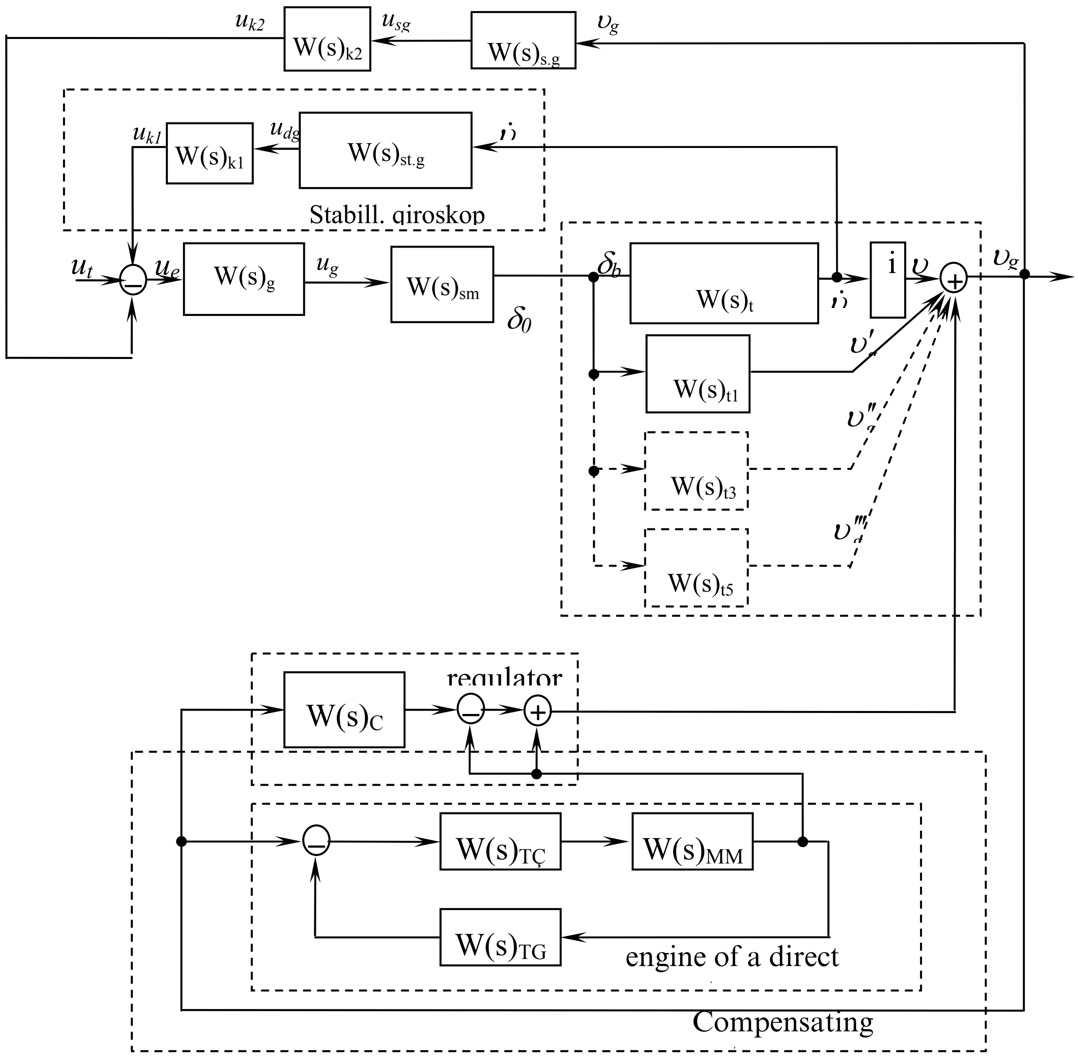


Fig. 1 Block diagramme of flying object with compensating system of fluctuations

Transfer functions of the engine: $W_{mm}(p)=\dfrac{k_m}{T_mT_1p^2+T_mp+1}$; of the operated converter: $W_{tc}(p)=\dfrac{k_c}{1+\tau p}$; a feedback on speed: $W_{TG}(p)=k_G$ [4].

The compensating system works as in parallel connected proof-reader to a fuselage. After synthesis of a regulator of the most compensating system it turns to an inertial link of the first order:

$$W_{ten}(p)=\frac{1}{T_ts+1}$$

On the basis of approximate data and calculations the structural model of the plane with compensating system in program MATLAB environment is made: $W_t(s) = \dfrac{0.02s+1}{0.2s^2+0.8s+1}$; $W_{sm}(s) = \dfrac{0.45}{0.22s^2+0.8s+1}$ (fig.2) [3].

After simulation of structural model following features are revealed.

1. To some value of amplitude of arising fluctuations the steady condition of the plane can be kept without connection of compensating system. With this I aim it is necessary to reduce a target signal of the amplifier of the steering wheel. Thus it is necessary to consider influence of reduction of a target signal of the steering wheel on quality of control of airplane. So, for example at fluctuations with harmonics:

$$A_{n1}=15, f_1=10Hs;\ A_{n3}=5, f_3=30Hs;\ A_{n5}=1, f_5=50Hs;$$

$$W_{har1}(p) = 15\frac{10}{s^2+100},\quad W_{har2}(s) = 5\frac{30}{s^2+900},\quad W_{har3}(s) = 3\frac{50}{s^2+2500};$$

the steady condition of the plane can be kept with amplifier *W(s)=k*$_g$, reducing its factor from 1,2 to 0,8.

2. At fluctuations above $A_{n1}=30$ (at simulation: $A_{n1}=60, f_1=10Hs;\ A_{n3}=20, f_3=30Hs;\ A_{n5}=12, f_5=50Hs;$ $W_{har1}(p) = 60\dfrac{10}{s^2+100}$, $W_{har2}(s) = 20\dfrac{30}{s^2+900}$, $W_{har3}(s) = 12\dfrac{50}{s^2+2500}$ should join automatically compensating system and the action counteracts increase in fluctuations to destructive value.

All told are visually given on fig. 3

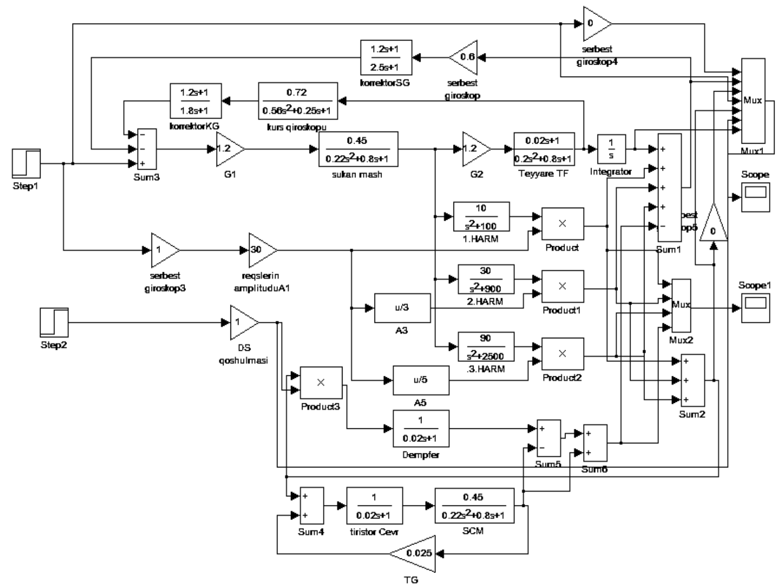
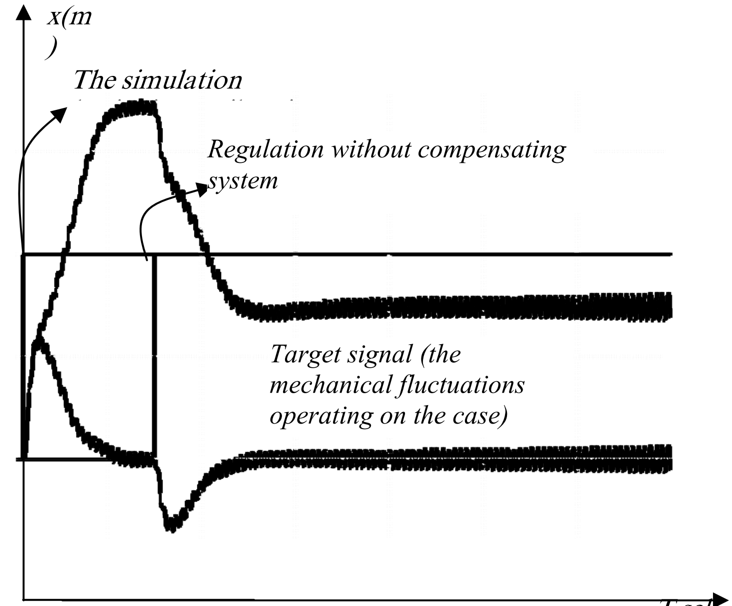


Fig. 2 Models of simulation of flying object with compensating system.



a)

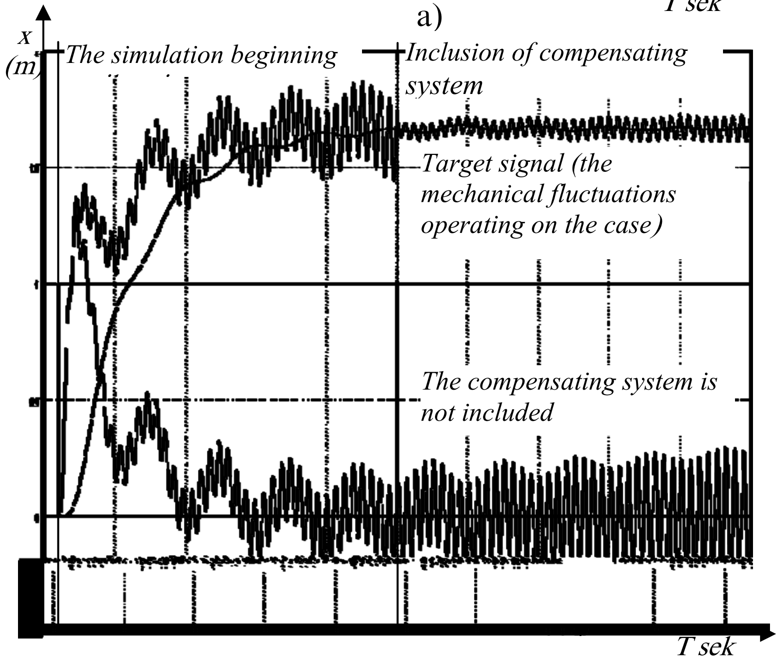


Fig. 3 Curves received from simulation of flying object with compensating system
a) regulation without compensating system ; b) Inclusion of compensating system

References

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