METHOD FOR DETERMINING THE ACCURACY AILERONS CONTROL MECHANISM OF THE IAK 52 AIRCRAFT

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Abstract: *In any mechanism, the dimensions of the kinematics elements are different from the given or calculated ones due to the execution errors, clearances in the kinematics couples, elastic and thermal deformations. In order to establish the optimal execution technology, which guarantees the global precision of the analyzed mechanism, it is necessary to know, from the very designing phase, the influence of these errors.*

This paper presents the way to determine, by the analytical method, the constructive error of the control mechanism of the IAK 52 instructing and training aircraft ailerons, a plane manufactured by S.C. "Aerostar" S.A..

Keywords: *execution errors, kinematics couples, position functions for ailerons mechanism, aviation technology, Taylor series expand.*

1. INTRODUCTION

A key feature in the mechanisms used in aviation technology is the accuracy of transmitting and receiving signals flow. For this reason, it is necessary to determine existing error propagation signal flow and how they affect theoretical law of transmission.

Aircraft movements of roll, pitch and yaw are possible by turning the control surfaces. Control levers in the cab with kinematic chains of transmission of movement of the levers to control surfaces on the airplane IAK-52 are:

- *order ailerons*, provides roll motion;
- *depth control,* ensures pitching motion;
- *steering,* providing a turning movement.

The stick is the pilot control lever acting on ailerons (by moving left and right) and the elevator (by moving front and back). Sticks of two cabins are trapped on a common shaft through joints that allow movement forward and back rounds. Common shaft is attached to the aircraft structure through ball, which allows rotation (left-right) together with sticks, around an axis parallel to the *x* axis plane.

Because movement is simultaneous rounds, they are caught in bottom joints with flat shank ends.

Ailerons are control surfaces are mounted on wing tips. To lateral movement of leg, ailerons are moving one up and one down. In this way creates an asymmetry of lift forces and their resultant point of application is no longer the center of gravity. The effect of this is the emergence of a roll moment. A feature on airplane IAK-52 is that it move ailerons up with an angle of 220°, and down at an angle of 160°.

Ailerons consist of metal frame and cover. In turn, the metal frame is composed of a tubular strut duralumin, nine ribs and a smooth back. Shell fabric is impregnated except leading edge is covered with duralumin sheet. They are joined by three joints console plane wing strut riveted on ailerons.

Ailerons powertrain control (Fig. 1) consists of: all rounds; mechanism task (simulation effort leg) tubular control rods, sticks. Ailerons order to ensure their steering in the opposite direction (a spoiler up the other down) and differentiated (upward deflection angle is greater than the angle of lock down).

Load mechanism is bound by a common shaft rocking the rounds near the front sleeves. He is to oppose a resistance to lateral movement of the stick. The moving leg more, with greater effort to move them.

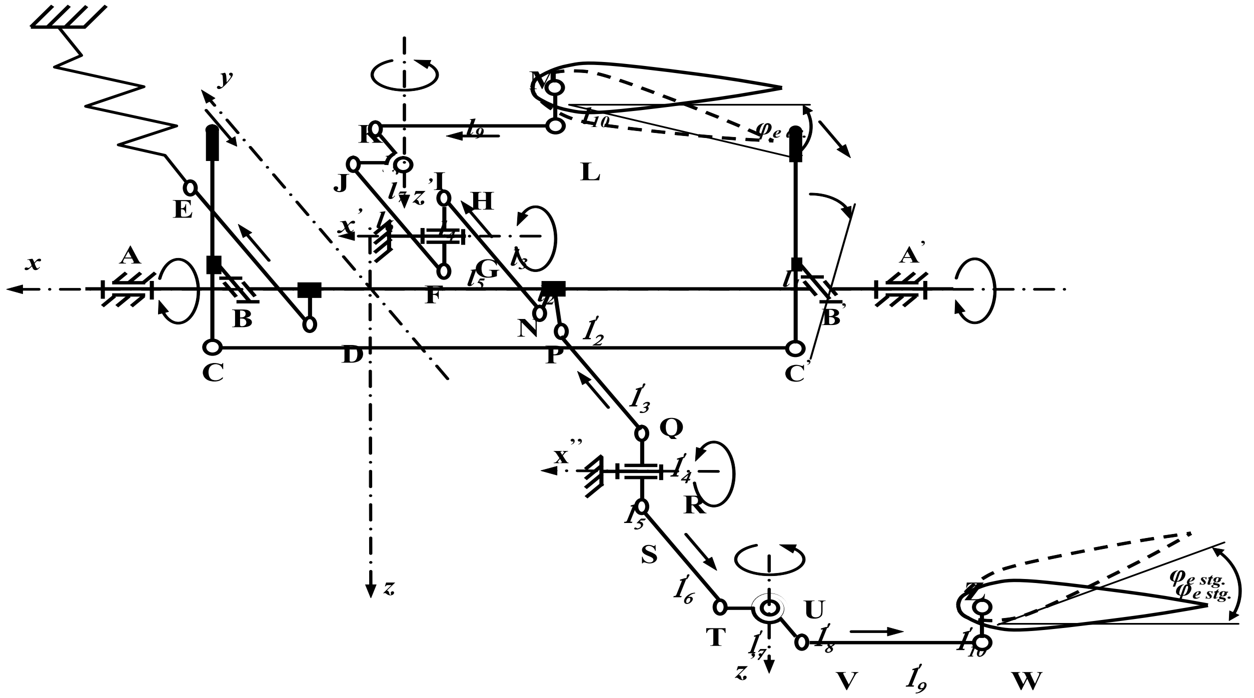

Fig.1 Diagram of the ailerons motion mechanism

Ailerons command has the following kinematics:

- move to the left leg;
- joint shaft rounds will rotate counter-clockwise;
- stick in the shape of "v" will move to the right control rods;
- vertical sticks will rotate clockwise around the axes x' and x'' axis parallel to the plane;
- control rods will move to the left side of the airplane;
- horizontal sticks will rotate counter-clockwise around some axis z' and z'' plane parallel to the z axis;
- left control rod moves back up to deflection of the control wing and right rod moves to the front spoiler move down.

2. THE ANALYTICAL METHOD FOR CALCULATING THE ERROR CONSTRUCTIVE

Position functions for both ailerons mechanism is of the form:

$$\varphi_{e\,dr.} = \varphi_{e\,dr.}(\varphi_1, l_{10}, l_{20}, l_{30}, l_{40}, l_{50}, l_{60}, l_{70}, l_{80}, l_{90}, l_{100}) \tag{1}$$

$$\varphi_{e\,stg.} = \varphi_{e\,stg.}(\varphi_1, l'_{10}, l'_{20}, l'_{30}, l'_{40}, l'_{50}, l'_{60}, l'_{70}, l'_{80}, l'_{90}, l'_{100}) \tag{2}$$

Admitting that there are theoretical and formal errors, angular displacement of the shaker φ1 is influenced by manufacturing tolerances$\Delta l_1, \Delta l_2, \Delta l_3, \ldots, \Delta l_{10}, \Delta l'_1, \Delta l'_2, \Delta l'_3, ..., \Delta l'_{10}$, the nominal dimensions of cinematic elements of the composition mechanism l_{10}, l_{20}, l_{30},…, l_{100}, $l'_{10}, l'_{20}, l'_{30}, ..., l'_{100}$.

Control mechanism that can reproduce ailerons position functions (1), (2) only the approximate each value of the driving angle φ1. These errors appear called constructive errors; random errors can be measured by the procedure described below.

Actual position functions carried out by elements of the mechanism kinematic analysis is determined by the relationship:

$$\varphi_{e\,dr.} = \varphi_{e\,dr.}(\varphi_1, l_{10} + \Delta l_1, l_{20} + \Delta l_1, l_{30} + \Delta l_3, \ldots, l_{100} + \Delta l_{10}) \tag{3}$$

$$\varphi_{e\,stg.} = \varphi_{e\,stg.}(\varphi_1, l'_{10} + \Delta l'_1, l'_{20} + \Delta l'_1, l'_{30} + \Delta l'_3, \ldots, l'_{100} + \Delta l'_{10}) \tag{4}$$

Errors introduced ailerons control mechanism is determined by the relations:

- the right wing:

$$\Delta\varphi_{e\,d\,r.} = \varphi_{e\,d\,r.} - \varphi_{e\,d\,r.0} \qquad (5)$$

- for the left wing:

$$\Delta\varphi_{e\,stg.} = \varphi_{e\,stg.} - \varphi_{e\,stg.0} \qquad (6)$$

In calculating these errors constructive develops, functions given by relations (5) and (6) in Taylor series, considering the actual dimensions of the mechanism components cinematic elements l_1, l_2, l_3,…, l_{10}, $l'_1, l'_2, l'_3, ..., l'_{10}$ as variable sizes :

$$\varphi_{e\,d\,r.} = \varphi_{e\,d\,r.0} + \left(\frac{\partial f}{\partial l_1}\right)\cdot\Delta l_1 + \left(\frac{\partial f}{\partial l_2}\right)\cdot\Delta l_2 + + ... + \left(\frac{\partial f}{\partial l_{10}}\right)\cdot\Delta l_{10} + \left(\frac{\partial^2 f}{\partial l_1^2}\right)\cdot\Delta l_1^2 + . + \left(\frac{\partial^2 f}{\partial l_{10}^2}\right)\cdot\Delta l_{10}^2 + ... \qquad (7)$$

$$\varphi_{eg\,.} = \varphi_{e\,stg.0} + \left(\frac{\partial f}{\partial l'_1}\right)\cdot\Delta l'_1 + \left(\frac{\partial f}{\partial l'_2}\right)\cdot\Delta l'_2 + + ... + \left(\frac{\partial f}{\partial l'_{10}}\right)\cdot\Delta l'_{10} + \left(\frac{\partial^2 f}{\partial l_1'^2}\right)\cdot\Delta l_1'^2 + . + \left(\frac{\partial^2 f}{\partial l_{10}'^2}\right)\cdot\Delta l_{10}'^2 + ... \qquad (8)$$

Assuming that the manufacturing tolerances are endless Δ are small compared to the nominal dimensions of cinematic elements, the second and higher order terms of their Taylor series expand can be neglected. Errors constructive global chains of movement kinematics of both ailerons can be calculated with the following relations:

$$\Delta\varphi_{e\,d\,r.} = \left(\frac{\partial f}{\partial l_1}\right)\cdot\Delta l_1 + \left(\frac{\partial f}{\partial l_2}\right)\cdot\Delta l_2 + + \left(\frac{\partial f}{\partial l_3}\right)\cdot\Delta l_1 ... + \left(\frac{\partial f}{\partial l_{10}}\right)\cdot\Delta l_{10} \qquad (9)$$

$$\Delta\varphi_{e\,stg.} = \left(\frac{\partial f}{\partial l'_1}\right)\cdot\Delta l'_1 + \left(\frac{\partial f}{\partial l'_2}\right)\cdot\Delta l'_2 + + \left(\frac{\partial f}{\partial l'_3}\right)\cdot\Delta l'_1 ... + \left(\frac{\partial f}{\partial l'_{10}}\right)\cdot\Delta l'_{10} \qquad (10)$$

Relations (9), (10) Δ parameters Δl_1, Δl_2, Δl_3, …, Δl_{10}, $\Delta l'_1, \Delta l'_2, \Delta l'_3, ..., \Delta l'_{10}$ are random sizes that vary between two sizes but known limits (upper and lower deviation tolerance fields).

Structural errors are determined considering that the dimensions of all cinematic elements are affected only limit errors. The probability of error in practical limit is relatively small, however. In kinematic analysis of the mechanism studied the flow of signals from element to element leader-led leg wing can have constant sensitivity S = ct., namely:

$$s_{e_0} = S \cdot s_i \qquad (11)$$

Considering that the sensitivity of signal flow right aileron is:

$$S_{d\,r.} = \frac{l_{20}}{l_{10}}\cdot\frac{l_{40}}{l_{30}}\cdot\frac{l_{60}}{l_{50}}\cdot\frac{l_{80}}{l_{70}}\cdot\frac{l_{100}}{l_{90}} \qquad (12)$$

and for the left aileron:

$$S_{stg.} = \frac{l'_{20}}{l'_{10}}\cdot\frac{l'_{40}}{l'_{30}}\cdot\frac{l'_{60}}{l'_{50}}\cdot\frac{l'_{80}}{l'_{70}}\cdot\frac{l'_{100}}{l'_{90}} \qquad (13)$$

and that the dimensions l_i respectively l'_i are affected by random errors were Δl_i, $\Delta l'_i$, the errors introduced in the mechanism studied are:

- for the right aileron:

$$\Delta s_{d\,r.} = s_e - s_{e_0} = \sum_{i=1}^{10}\left(\frac{\partial s_e}{\partial l_i}\right)_0 \cdot\Delta l_i \qquad (14)$$

- for the left aileron:

$$\Delta s_{sgr.} = s'_e - s'_{e_0} = \sum_{i=1}^{10}\left(\frac{\partial s'_e}{\partial l'_i}\right)_0 \cdot\Delta l'_i \qquad (15)$$

or expressed as:

$$\Delta s_{d\,r.} = \frac{l_{20}}{l_{10}}\cdot\frac{l_{40}}{l_{30}}\cdot\frac{l_{60}}{l_{50}}\cdot\frac{l_{80}}{l_{70}}\cdot\frac{l_{100}}{l_{90}} s_i \sum_{i=1}^{10}\frac{\Delta l_i}{l_i} \qquad (16)$$

$$\Delta s_{stg.} = \frac{l'_{20}}{l'_{10}}\cdot\frac{l'_{40}}{l'_{30}}\cdot\frac{l'_{60}}{l'_{50}}\cdot\frac{l'_{80}}{l'_{70}}\cdot\frac{l'_{100}}{l'_{90}} s_i \sum_{i=1}^{10}\frac{\Delta l'_i}{l'_i} \qquad (17)$$

3. CONCLUSIONS

The method presented in this paper enables the identification and calculation errors that arise in building constructive linkages of the mechanisms used in aviation technology.

Depending on the size of these errors can take a number of variants and technology from design stage to compensate them.

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