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Prevention factors by stall the aircraft during landing

Modern avionics systems installed to prevent by stall the airplane during landing, but they take into account only some risk factors of stall. To improve safety during landing it is proposing to consider additional factors that warn the crew about the possibility of stall.

Analysis of statistics flight accidents of recent years shows many accidents resulting from errors in pilots at critical modes of flight. During this period, the main causes of aviation accidents were: loss of control in flight and loss of control during landing [1].

Control of the aircraft by director mode and simultaneous of monitoring of stall requires installation of the airplane, warning alert systems of critical flight modes. It is to provide the crew with an alarm signalling approaching the maximum permissible values of flight parameters and in some cases correct the control aircraft, to prevent access to critical modes.

The plane is kept in the air due to the lift force (L), which depends on air density (ρ); the air speed (V); wing area (S) and lift coefficient (C_L) in accordance with the conditions [2]:

$$L = 1/2 \rho V^2 S C_L$$

The lift of the aircraft rapidly changes relative to the air speed (V) and lift coefficient (C_L), which is a function of the angle of attack (α) [3]. In addition, the parameter that takes into account the totality of all forces acting on an airplane is overload (n), which characterizes its controlling. Lift reduced to a level less than the force of gravity of the aircraft leads to loss of height, and a sharp decrease in the lift leads to stall. Therefore, the main dangerous for the plane is to loss of speed or increase of the angle of attack above its critical value.

To improve flight safety criteria necessary to analyse factors affecting stall during landing.

Prevention of critical flight modes requires the presence of avionics systems on board the aircraft, which provide the crew with alarms about approaching the maximum permissible flight parameters, and in some cases adjusts the aircraft control system.

Risk factors leading to a stall during approach and landing are:

- critical angles of attack (AOA);
- losing true airspeed (TAS);
- excess the landing vertical speed (VSL);
- critical roll angles (AOR);
- excess landing weight (LW);
- nose-up moment (MZT) by engines;
- the influence of weather conditions.

Decreasing the lift to a level that less than the weight of the aircraft leads to a loss of height, and a sharp decrease in the lift leads to stall of the airplane. Therefore, one of the main dangers for the airplane is to decrease of lift and stall of the airplane due to loss of speed or increase of the angle of attack above its critical value.

The loss of true airspeed (TAS) during approach and landing will lead to a loss of lift and control torques, and as a result, the aircraft becomes uncontrollable and stalls.

Exceeding the vertical speed (V_{SL}) leads to a loss height of the aircraft at the leveling stage, resulting in touching the ground before the runway or the aircraft will be to the critical angle of attack at the decrease of the vertical speed.

Critical roll angles (γ) influence aircraft lift during landing. During bank, the lift (L) is divided as the horizontal (L_H) and the vertical one (L_V), which compensating the weight of the aircraft. Therefore, necessary to increase lift to avoid a stall. For example, with the roll angle $\gamma = 45$ ° the lift should be increased in 1.41 times to height stabilize (Fig. 1).

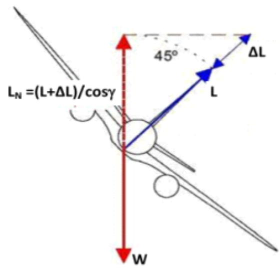

Fig. 1

The excess of landing weight during landing results in an increase in the estimated stall speed (V_{SR}) accordingly the minimum landing speed (V_{MCL}) should also be increased. This factor is important for landing an airplane after long flight where the aircraft weight may decrease in 1,2-1,7 times (Fig. 2).

During go-around to second approach with unsuccessful landing, the engines of the aircraft create maximum thrust in a short time. A fast thrust increase in aircraft engines with lower placing on the wing can cause increase into the critical angles of attack. In this case, in addition to the current angle of attack that is needed for the climb is the added angle of attack set up by an engine's nose-up moment (M_{ZT}). This leads to an excess of the critical angle of attack accordingly, the loss of control and loss of height, which increases the stall speed.

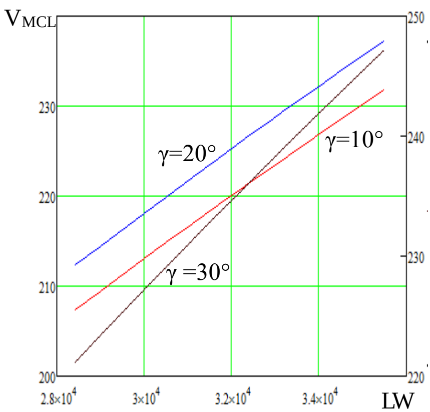

Fig. 2

Almost all the risks that lead to the crash of the aircraft during the approach and landing are associated with a critical angle of attack and the minimum speed range. Therefore, constant monitoring of the minimum landing speed and the stall speed is required to eliminate these risks.

Thus, the use of the signaling of the approach to the minimum speed (V_{MCL}) as a function of the angle of attack, roll angle and landing weight of the airplane will increase the attention of pilots to the aerodynamic characteristics at low speeds, which will help to improve the safety of aircraft landing.

Thus, the critical angles of attack during landing are the result of ground speed excess or vertical speed (V_{SL}) during landing, and can result in loss of lift and stall the aircraft at low altitudes.

The weight of the aircraft does not affected on the critical angle of attack change, but affects on the vertical overload (n_{ZW}). For a rough calculation the following pattern is used: an aircraft weight change by 20% leads to a stall speed change by 10% (Fig. 3)

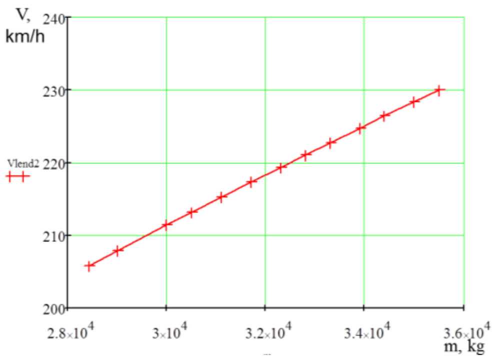

Fig.3 Dependence landing speed of the weight

In rectilinear horizontal flight with maximum lift coefficient (CLmax) it is impossible to have the angle of heel and maintain altitude simultaneously. Trying to increase the lift will increase the stall speed according to conditions:

$$V_{SRoll} = \frac{V_{SR}}{\sqrt{\cos\gamma}}.$$

For example, if the calculated stall speed of the aircraft (V_{SR}) is 150 knots, with the roll presence there will be following law:

γ (AOR), degrees	25	30	45	60
V_{SR}, knots	158	161	178	212

So during landing it is essential to avoid large angles of roll, especially at low altitudes and speeds

References

1. ICAO Safety Report 2016 Edition. International Civil Aviation Organization 999 Boulevard Robert-Bourassa Montréal, QC, Canada H3C 5H7. 2016, 24 p.

2. Flight Operations Support & Services Airbus S.A.S. 31707 Blagnac Cedex, France. 2007. 211 p.

3. . V. Kastorovsky Fundamentals of aerodynamics and dynamics of flight. Riga: Transport and Telecommunication Institute, 2010. 105 p.

4. M. Kotik V. Filipov Flying in extreme conditions. Moscow, Military Publishing, 1977, 239 p.

5. Chuzha, O.O. “Minimum landing speed criteria generated by means of avionics.” Proceedings of the Methods and Systems of Navigation and Motion Control: IEEE December 2016, pp 271-274.