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Determining the angle of attack as a critical element of flight

In this paper, the author proves the statement that there are no and never will be such comprehensive aviation regulations that would replace the pilot's sanity. It is vitally important to equip passenger planes with indicators displaying angles of attack. This allows flight crews to instantaneously obtain necessary information, detect a failed device or devices, and safely complete the flight.

On June 1, 2009, the world was shocked by the news about an air crash of the Airbus 330, flight AF-447 from Rio de Janeiro to Paris, over the South Atlantic. All 228 people flying on the Air France liner were killed. Shocking conclusions were also made about the causes of the tragedy: the newest long-range aircraft was destroyed by ice crystals that blocked the aircraft control surfaces.

All modern avionics installed on board did not help the pilots to cope with the situation. Alas, the crew's experience gained during many years did not become an insurance against fatal errors, and the loss of confidence in the devices in a few seconds transferred the situation from emergency to catastrophic. Being discouraged by refusal of all the speed indicators, AF-447 flight pilots failed to follow the official recommendations prescribing the following guidance in such a situation: "pitch angles should be pre-calculated". I have a purely professional question: who checks the correctness of these recommendations in real conditions, when the crew loses confidence in their abilities every second?

Among the findings of the investigators, one very important fact was pointed out: "Only direct reading of the angle of attack can give the crew the possibility to quickly take the necessary action."

Unfortunately, this was not the first time that the failure of the speed indicator led to an air crash. For example, in 1996, the airplanes belonging to Birgenair airlines and Aeroperu airlines crashed because of clogged air pressure receivers that issued contradictory information to the crews.

Based on the personal experience of flights performed on the Antonov-124-100 plane, I averaged the angles of attack by modes and obtained the following values:

- the angle of attack after take-off (take-off) ≈ 10º,
- gaining a cruising level ≈ 8º,
- flight at a cruising altitude of ≈ 6º,
- approach in the landing configuration ≈ 8º,
- landing and maintaining the angle of attack until the front landing gear is lowered ≈ 10º.

The maximum holding time of the landing position (≈ 10º) reduces the mileage and load on the braking system. Moreover, in the international aviation references, there have been cases of destruction of the front landing gear.

There may be an appropriate question to ask: is the presence of angle-of-attack indicators in the cockpit a guarantee of improving the level of flight safety? Based on 50 years of flying experience and 55 years of instructor experience, I answer – yes, it is. However, the devices cannot prevent a conscious violation of the recommended restrictions by the crew, which often leads to great troubles. Another confirmation of this is the air crash of Tu-154 plane of Pulkovo airline on August 22, 2006 near Donetsk. In that flight, the aircraft commander deliberately went beyond the limits of the angle of attack, lost speed to 150 km/h and fell into a flat spin, and the further actions excluded even the theoretical possibility to get out of it.

A thorough analysis of the Donetsk tragedy (see Figure 1) makes it clear due to the records available in the Internet. The crew decided to bypass the high clouds by requesting the transcendental flight level 390 (the outside air temperature was above the standard by 20°C). The analysis was made over the last 5 minutes of flight, 2 minutes 37 seconds of which the plane was in a spin.

Fig. 1. Flight instrument indications of Tu-154 during the Donetsk tragedy

For the Soviet aviation design school, it was natural to equip passenger planes with devices showing the angle of attack and overload. This allowed crews, at any doubts in the correctness of the speed indicator, to instantaneously obtain vital information, to determine the failed device (devices) and safely complete the flight, being in the operational and safe speed range. The tradition of using such devices is preserved in the post-Soviet countries nowadays. In the West, commercial aircraft are equipped with attack angle indicators only optionally, on a specific order. The paradox of the current situation is that the attack angle indicators are on all passenger planes, but data from them come only to the electronic "brains" of the aircrafts, and the necessary information is not outputted to the multifunctional indicators for the pilots.

Another reason to think about the need for the attack angle indicators in the cockpit was the very similar aircrash that occurred in 2013 with Boeing 737-400 (see Figure 2) in Kazan and in 2016 with Boeing 737-800 in Rostov-on-Don. After these shocking tragedies, I simulated similar situations on the An-124-100 simulator. The purpose of the experiments was to determine the safe transition of an airplane into a steady flight from large (> 25º) pitch angles with control over the output of the angle of attack and overload indicator.

Fig. 2. Attack angle indicators in the cockpit of Boeing 737

Episodes and the analysis of situations

In 2012-2015, when the Cuban crews were retrained to the An-158, training programs included flights with failure of all speed indicators and maintaining the recommended angles of attack in the range of 6-8º for the flight configuration and 7.5-11º for the landing configurations.

In this case, there is no need to take into account the weight of the aircraft, when maintaining the recommended angles of attack. In this regard, it is safe to say that the speed is set automatically. After a little theoretical instruction and two or three trainings, the maintaining speed was within ± 5 knots (10 km / h), constantly being in a safe speed range.

Conclusions

Assuming that aircraft designers and manufacturers are imbued with the importance of the angle of attack indicator and began to equip their products with them, it is possible to recommend the following flight crew training methods.

1. Aerodynamic training with an explanation of the physical meaning of the use of the angle of attack in all operational modes of flight.

2. Awareness-based training to provide crews with the skills of safe piloting with confidence in information about the current angles of attack.

3. Mandatory training on the withdrawal from a complex spatial situation.

All operators must firmly understand that the pitch angle read from the air horizon has nothing to do, in common sense, with the angle of attack, at a pitch of ± 90 °, the angle of attack is 0°, and with a flat normal spin (Donetsk tragedy – TU-154), the pitch is 10-20 °, and the angle of attack reaches 90°, and to understand that the flight with the control of the attack angle indicator can raise both the safety of flights and the culture of piloting to a higher level.

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