In this film presented the origins of establishing relationship between the two great nations such a thin field as science. The program is fully justified. It gave the opportunity to start a fully exchange students, including between the universities as bright as the Moscow State University, Moscow Institute of Physics and Technology and Massachusetts Institute of Technology, and the Michigan University of Aerospace Engineering. And now, after so many outstanding achievements by the former Russian students, Russian students are studying in America and American students are studying in Russia when between us this film becomes special urgency! This paper is supported by Russian Foundation for Basic Research (Project No. 14-07-00564).

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THE CRITICAL REGIMES OF FLIGHT AT HIGH ANGLE OF ATTACK (EXPERIENCE OF USE IN EDUCATION)

Vikulin S., Akhrameev V.I., Khlopkov Y.I., Goman M., Shulepov D.I.

Moscow Institute of physics and technology (state University), Moscow, e-mail: khlopkov@falt.ru

The work presents scientifically-educational video film "The flight at high angles of attack". This video film is about the physical aspects and, mathematical models, wind tunnels experiments for the flights of airplanes at high angles of attack. Bright present aero physical experiments in the wind tunnels of Central Aero hydrodynamics Institute (TsAGI), flight experiments in Flight Research Institute (LII), mathematical models elaborated with Moscow Institute of Physics and Technology (MIPT). Besides it's shown the role of this video film in the educational process of the Department of Aeromechanics and

Flight Engineering of Moscow Institute of Physics and Technology.

The work concerns the most difficult, "eternal" aerodynamic problem – the flight under critical regimes. High angles of attack lead to breakdown of flow with foil's surface, abrupt to deterioration aerodynamic characteristics, loss of a stability of a flying machine, entrance it in fail. Problem is multiplane. It is connected with a research of complicated structure of flow in laminar and turbulent boundary layer, conduction thin aero dynamical experiment, connected with nonstationarity, solution Navier-Stokes and Reynolds equations, research of a stability and control aircraft, conduction bench and flight experiment, tutoring of the pilots.

On faculty of aeromechanics and flight engineering MIPT in many chapters of teaching of aerodynamics by and large concern questions of critical regimes of flight. Already with second year, since "Introduction in aerodynamics", concerned the question of critical regimes of flight.

The educational plan of faculty of aeromechanics and flight engineering MIPT consists of institute cycle, uniform for the students of all faculties, fundamental aerospace cycle, uniform for all students of aeromechanics faculty, and base cycle, where for the students are read special courses (different for various sub-departments of a base). There are 10 base sub-departments on the faculty, placed in three scientific centers – Central Aero hydrodynamic Institute, Flight Research Institute, Central Institute of Aviation Motors. On these sub-departments are read about 100 courses.

We have ten sub-departments: Theoretical Aero hydromechanics, Flight Dynamics; Aero physical Experiment, Information Measurement Computing Systems, Flying Engineering, Durability, Systems of Automatic Planning, Flight Experiment, Force Installations, Gas Dynamics, Combustion and Heat Transfer. The main courses, which deal with the critical regimes are: Theoretical Hydrodynamics, Introduction to Turbulence, Monte-Carlo Simulation in Aerodynamics, High speed Aerodynamics, the Boundary Layer and Heat Transfer Theory, Gasdynamics, Physical Gas Dynamics, Computational Aerodynamics, Dynamics of Unstationary Viscous Fluid and Gas Flows, Wing Theory, Aerodynamics Heating and Heat Protection of Aircraft, Aircraft Aerodynamics, Power Plant of Aircraft, Wind Tunnels, Optical and Physical Investigation Methods, Aerodynamic Test Technique, Dynamics of the Aircraft Motion and Critical Flight Regimes, Aircraft Scheme Design, Aircraft Control Systems, Flutter, Structural Mechanics. The film illustrates some aspects of this course.

The maneuvering abilities of the aircraft depend a great deal on the capability of the aircraft to fly at high angles of attack. Let us remember the formulas which connect the values of the turn radius R and the turn angular velocity with values of the load factor and the air speed:

$$R = \frac{v^2}{g\sqrt{a_z^2 - 1}}, \quad \Omega_t = \frac{g\sqrt{a_z^2 - 1}}{v},$$

where a_z – load factor.

Analyzing these mathematical relations it is possible to say that the radius of the turn will be minimum and the turn angular velocity will be maximum if the airspeed of the flight is rather small but the load factor is maximum. The maximum load factor is reached at the low speed flight if the maximum of the lift coefficient is reached.

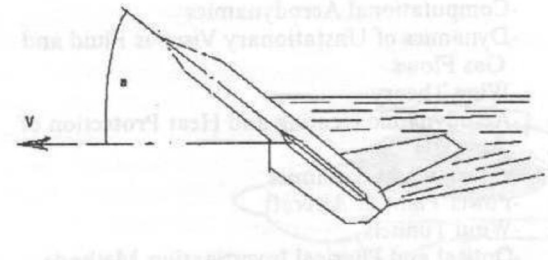

Fig. 1. Flow separation

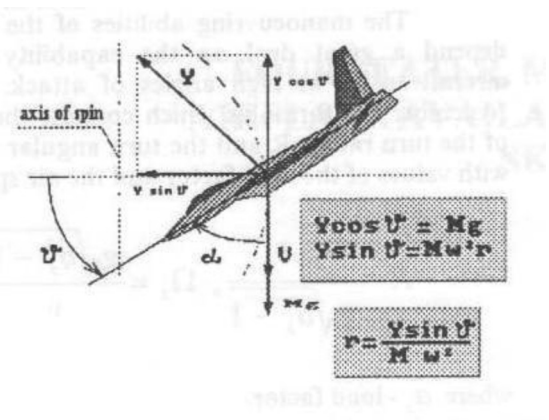

Fig. 2. Aircraft dynamics

Thus the using of the high angles of attack allows the aircraft to execute the maneuvers in a smaller space during a shorter time interval. For example, maneuvers called "Pugachev's Cobra" can be used as a defensive technique for the running out of the tail of attack.

The purposes of this video film: understanding of the physical fundamentals of the high angle of attack and low air speed flight aircraft aerodynamics, understanding of the physical phenomena of the post-stall and spin regimes, gaining the experience of the device information analyzing and using of the aircraft control methods for the stall-prevention and spin-recovery.

The film tells about some important questions:

1. Aerodynamics of aeroplanes at high angles of attack.

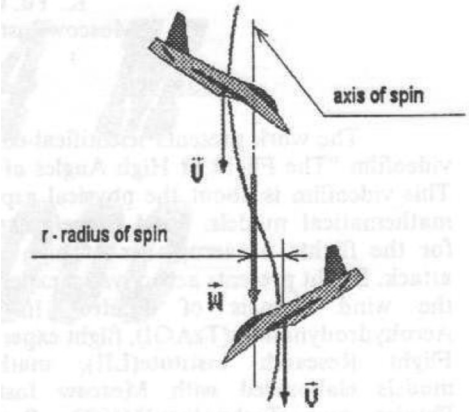

Fig. 3. Kinematic of spin

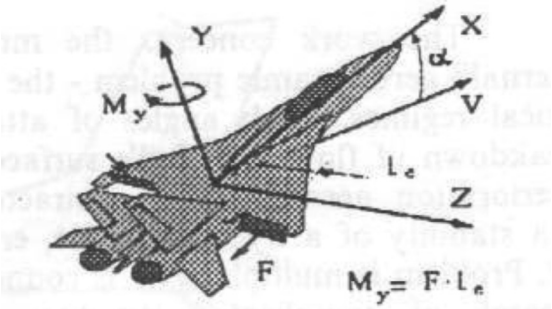

Fig. 4. Dynamics of spin

This part tells about the main physical reason of the aircraft stability and control loss at high angle of attack, the phenomena deterioration of the aerodynamic characteristics, phenomena of the spin rotation.

2. Aircraft dynamics at high angles of attack.

In this part one is able to acquaint with main peculiarities of aircraft motion, stability and control.

3. Aircraft dynamics and control at post-stall and spin regimes.

The success of the mastering in the high angles of attack flights will depend on the achievements of science and technology in the field of aerodynamics, dynamics and control, which were reached due to the hard work of the scientists, researchers, engineers and test pilots of all countries in the world developing aircrafts.

The 70s gave the start to the mastering of the high angles of attack, when the numerical methods of analysis and computers came to the aerospace science. Everybody may to have copy of this video film. This work is supported by Russian Foundation for Basic Research (Project No. 14-07-00564).

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