MODELS FOR PREDICTION OF WAKE VORTEX DYNAMICS

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Abstract

Safety of aircraft flights is determined by a large set of outer factors, which action could change flight, stability, and control characteristics of aircraft (A/C). One of essential factors determining the flight safety level is the coflowing vortex wake.

It is well known that flying aircraft generate the coflowing stream consisting of two descending vortex cores. The stream power depends on the aircraft weight, speed and altitude, as well as on its g-load. The aircraft, besides the coflowing stream behind the wing, generates also coflowing streams behind the fuselage and the power engines. The studies show that the air particles demonstrate mainly turbulent motion in the fuselage coflowing stream and motion along the stream axis with air leak-in from outside in the engine streams. The experience shows that the fuselage and jet engine streams lose their energy relatively quickly and are practically diffused already at distances 150...200 m from the aircraft. As opposed, the wing wake vortices have greatly larger momentum and are preserved for a long period.

The airplane encounter with wake vortices causes considerable changes in its angle of attack and sideslip resulting in essential violation of the flight regime. Incidents and fatal accidents caused by this reason have being occurred in the flight practice.

The world economics rise in the last 30 years and simultaneous reduction of flight tariffs by airlines (in real numeration) has caused ten-fold increase in demand for air services. However, the largest world jumbo capacity has not almost changed. To cope with the task, large airlines have increased the number of flights. The flight intensity growth amplifies the probability of aircraft encounter with wake vortices, particularly for takeoffs and landings.

Therefore, the development of vortex forecasting systems functioning in real time and evaluation of vortex danger for the sake of flight safety increase is the topical problem. Moreover, such the systems could promote objectivity of flight accident investigation, offering the basis for sound acceptance or rejection of the wake vortex version. Otherwise, the real cause of the accident is ambiguous and the workable measures for flight safety are inefficient. Another area of vortex forecasting systems is the simulator engineering. The simulation training could develop skills of pilot effective behaviour in wake vortices.

The authors have developed a set of models for real time simulation of evolution of wake vortices and their action on aircraft. The models could inform pilots on predicted position of wake vortices.

These models are based on the method of discrete vortices accounting for mutual influence of vortex cores, environmental turbulence, wind shear, and viscid interaction of wake vortices with the underlying surface resulting in the ground boundary layer separation. The computer simulation has supplied the authors with numerous data on effect of different factors on evolution of aircraft vortex cores.

Moreover, efficient algorithms for real time simulation of vortex perturbation effects on aircraft are designed on the basis of the authors' method of additional kinematical parameters. A vast material for evaluation of vortex danger for different type of aircraft is accumulated.

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