

Application IEM for modelling airplane and atmosphere electrical fields

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Abstract:

The models of process of a defeat by a lightning of a airplane are constructed and the methods of account of an electric field strength of the airplane and atmosphere are developed. Because of of conducted researches the features of shaping of the category from surfers of a airplane with allowance for of various own capacity and availability on it an excess charge are investigated. The technique permitting for airplanes of any types and sizes to calculate a dangerous electric field strength of a airplane, necessary for initiation of a lightning by a airplane is developed. The conclusion about a primary defeat largemass airplanes by lightnings, by airplane is made.

Keywords:

electrical fields of airplanes and atmosphere, method of integral equations.

Continuously increased saturation of atmosphere by flight vehicles the increased dimensions of airplanes and magnification of duration of flights have increased probability of a defeat of airplanes by lightnings. On the other hand large volumes of fuel and the use of a low-voltage electronic equipment can reduce in heavy consequences from such defeat.

The increase of reliability of work of means on an air transport requires a safety of flights in complicated meteorological conditions, including in thundery circumstances.

Problem of the airplane descending, lightning, developing from a cloud, is devoted much researchs. However there is other aspect of the given problem connected with initiation of a lightning by a airplane itself. The airplane can take any position rather thundery of a cloud, and are not eliminated a situation, for want of with which the flight vehicle, creating a local amplification of a field of atmosphere, can become the initiator of the category of a lightning.

The careful analysis of operational datas and the number of full-scale researches shows, that thundery to a flight vehicle of a lightning contacts by accumulation on suirfers airplanes of a means (owing to start-up of rockets, takeoff and landing of airplanes, passing by them thundery of clouds etc.) excess charge in process of an electrization. The given hypothesis is practically unique, however it fails to be confirmed neither laboratory, nor full-scale datas. In this connection there was a need for realization of researches of process initiation of a lightning isolated and object, deleted from ground, with what is the airplane.

The analysis of experimental data has shown also, that depending on height of flight of airplane two their is basic: in essence various effects on a lightning are possible. At each height (is lower 200m) mainly intercept descending, lightnings, developing from a cloud. In too time on higher flight the airplane is capable initiation category of a lightning, for want of it it the shaping is carried out from a surface of the airplane in the party of a cloud.

Is established, that the airplane has higher strikeless by lightnings on a comparison with ground structures of the same dimensions. The latter is explained by two facts:

- with magnification on exponent of impacts of descending lightnings in a airplane located closer to a cloud, than any ground object.,
- initiation by airplane of the additional categories of lightnings, which would not be held in it absence.

The conducted researches have shown that development of a lightning from a airplane probably and it the shaping should happen by simultaneous development from a surface of a airplane two variety polarity of the leaders progressed simultaneously or in the party of a cloud and ground, or in a direction of two centres of unlike charges in clouds

In work the model of account of an electric field strength of a airplane is offered and atmosphere for want of initiation of a lightning by airplane according to which the excitation of a lightning happens from a surface of the airplane

$$(4\pi) \int_{\Gamma(t)} \sigma_0(s,t) R^{-1} ds + V(t) = V_0(t) \quad (1)$$

$$\sigma_0(s,t) - a \int_{\Gamma(t)} (\sigma_0(s,t) - \sigma_0(\xi)) \frac{\cos(n,R)}{R^2} d\xi = 4\pi a \left( \int_{\Gamma(t)} \sigma_0(s,t) \frac{\cos(n,R)}{R^2} d\xi + E_0 \right) \quad (2)$$

Where  $\sigma_0 = \sigma \epsilon_0^{-1}$  - denseness of a charge on a surface  
 $\Gamma(t)$ ;  $\Gamma(t)$  - association of surfaces of cargo clouds  
 and plane (airplane) in time t:  $V_0(t)$  - potential of an

external field;  $E_0(t)$  - normal component strengths of an external field;  $a = (\varepsilon_{i+1} - \varepsilon_i)\varepsilon_i^{-1}, i = 1, N$  - amount

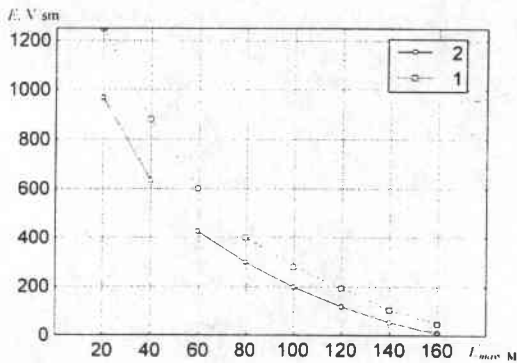


Fig. 1. The designed dangerous electric field strengths for airplanes at height 4000 m

thunder of clouds;  $n$  - external normal.

Despite of a number of assumptions the solution of such problems requires application modern and of perfect mathematical means.

On one from such modern methods a method of integral equations (IEM) by us was reported on World Conference of Mechanics in Istanbul, Turkey in a 1997 [1].

As of today for a solution (1) - (2) by most effective is IEM, which has a number of conclusive advantages, basic of which are considered:

- the lowering of geometric dimensionality of a problem per unit of (account of an electrostatic field, in distinguishing from a method of final differences and finite element method, is made only on the boundary);
- the account of complicated variables and mixed boundary conditions;
- the extension of a class consideration of curves (up to Jordan), circumscribing thundery of a cloud and surface of a airplane;
- especially IEM it is good itself has built up a reputation for for want of consideration of multiply connected areas of a complicated configuration etc.

For calculation of singular integrated operators which are included in (1) - the discrete operators of potentials simple and double layer (2) are investigated, their communication(connection) is shown and the evaluations of an error are obtained (the converging two-parameter quadrature processes in multiply connected areas) in terms of modules of a continuity are constructed the evaluations such as valuations Zigmound are obtained, is similar as in

[2-5].

Because of of assumed model (1) - (2) initiation of a lightning the plane(airplane) developed a method of account of an electric field strength of atmosphere  $E$ . For account of an electrical field in locality of the airplane for want of of required potential difference on deleting -strimmer zone of the leader of critical length, from a airplane is taken into account a configuration and dimensions of a airplane, and also vector of strength of a undisturbed electrical field of atmosphere,

Account of dangerous levels of an electric field strength for airplanes at height 4000m (look a fig. 1) has shown, that with magnification of a maximum dimension of a airplane ( $L_{max}$ ) of significance  $E$  are sharply reduced. So for airplanes of length 40-60m makes 500 V/sm. The maximum decrease  $E$  at the expense of an electrization of the airplane represented in a fig. 1. On this Figure the various decrease  $E$  for airplanes of different dimensions is shown. For want of it the curve 1 is designed for not charged airplanes, and curve 2- for airplanes charged up to 2 MV.

For airplanes with  $L_{max} < 25$ m  $E$  up to 40 % is reduced, and for large-sized airplanes even for want of maximum excess charge of a airplane 2 MV the decrease  $E$  does not exceed 15 %. The found decrease  $E$  allows approximately to evaluate a degree of magnification of probability of initiation by a airplane of a lightning in case of an electrization. It is necessary to mark, that in case of purchase by the airplane of an excess charge 2 MV from him the channel of the unipolar leader on length, non exceeding half of length of a fuselage of the airplane can develop.

As have shown researches, on points of possible excitation of the leaders from a surface of a airplane (with allowance for configurations and dimensions) in an electrical field of atmosphere can be found zones of a defeat in case of initiation of a lightning by a airplane.

For want of it excited from a surface of a airplane the category of a lightning must to be advanced from a skew field with a small own capacity. Is established, what even for want of maximum excess charge of a airplane decrease  $E$  capable to increase

Probability of initiation of a lightning only for airplanes of small sizes with  $L_{max} < 40$ m. For large-sized airplanes the purchase even is maximum of an excess charge be not capable how many considerably to increase probability of a defeat of a airplane by a lightning.

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