ON THE POSSIBILITY AND PROSPECTS OF TURBULENT FLOW NOISE CONTROL

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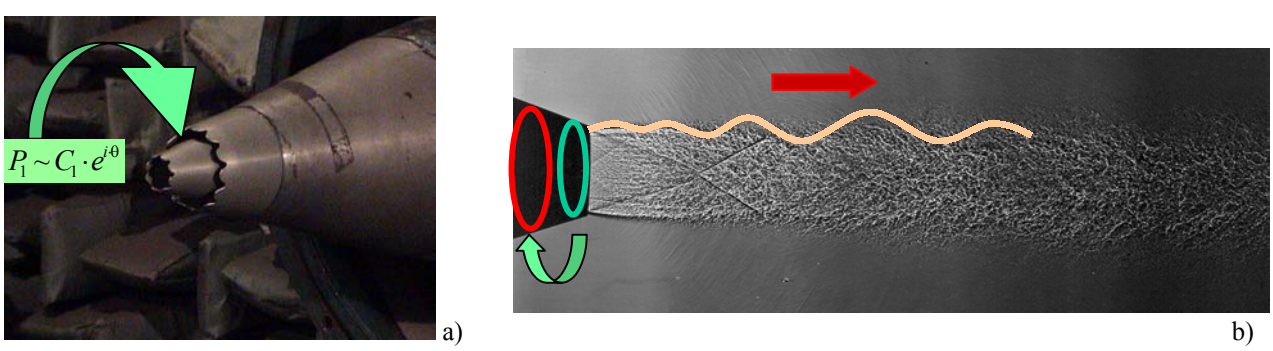
Summary The main problem of realizing the idea of active noise control rests on the absence of conceptual study of the reduction strategy itself and this, in its turn, reflects our insufficient understanding of the principal mechanisms of noise generation by turbulence, i.e. understanding of the radiating turbulence structure and peculiarities. The situation turns out to fundamentally different for subsonic and supersonic jets. The mechanism of noise generation for supersonic jets is essentially clear and is connected with instability waves developing downstream from the nozzle. This situation is quite different from that for subsonic flows, where a complete understanding of these mechanisms is yet absent. The situation for supersonic and subsonic turbulent jet noise control is considered in some detail.

The intensive development of aviation technique, the advent of passenger transport of the new generation led to a sharp increase of intensive noise sources affecting a human being. The application of turbo-jet by-pass engines permitted improving the acoustic characteristics of aircraft but an active offensive role of ICAO and other international ecology organizations introducing more and more stringent requirements for the current aircrafts and for those being under development requires an intensification of works in this direction. The situation is complicated additionally by the fact that the idea of cardinal noise reduction of advanced aircraft by 20 dB in the nearest future 20 years becomes increasingly popular. Despite the fact that for further noise reduction different sources are to be taken into account (fan noise, airframe noise, etc.), jet noise seems to remain the main stumbling stone in solving this complex task. Therefore the need is felt at present for putting forward new ideas including those that are based on attempts of active controlling the turbulent jet noise in addition to development of traditional approaches to the problem of aviation engine noise reduction.

However the main problem of realizing the idea of active control rests on the absence of conceptual study of the reduction strategy itself and this, in its turn, reflects our insufficient understanding of the principal mechanisms of noise generation since for elimination of the noise cause, i.e. an active action on the radiating part of turbulence, at any case, understanding of the principal mechanisms of this cause occurrence is required, i.e. understanding of the radiating turbulence structure and peculiarities. Here the situation turns out to fundamentally different for subsonic and supersonic jets. The mechanism of noise generation for supersonic jets is essentially clear and is connected with instability waves developing downstream from the nozzle [1]. This situation is quite different from that for subsonic flows, where a complete understanding of these mechanisms is yet absent [2].

Consider first the supersonic jets. It is known that the supersonic jet noise is determined mainly by large-scale disturbances or by wave instabilities developing in the flow. Therefore the task of control can be formulated as the task of reducing the instability wave amplitude and, in particular, of those waves which radiate sound. This task can be formulated in two ways (Fig.1): (i) as a task of non-adaptive control, through introducing the respective stationary devices or surfaces (tabs, chevrons, corrugations, etc.) in the flow, or (ii) a task of adaptive action on the initiating waves, i.e. as a task of generation of the instability waves being in the anti-phase with the most dangerous (from the standpoint of acoustics) waves, naturally appearing and developing downstream from the edge. The main methods of non-adaptive control are made on checking some a priory proposed configurations and on experimental search for the optimum. It is obviously, that this optimum substantially depends on the quantity of the models investigated and on the experimenter's good luck. The adaptive approach is based on the action through production of an anti-wave in the initial part of the mixing layer. We think that the main problem of the adaptive control lies at present, first of all, in development of a suitable elementary basis for anti-wave creation and in elaboration of methods for the experimental separation of that small part of turbulence, which is responsible for radiation in the near field. Exactly the idea of controlling a small part of turbulence (not the whole one) makes this approach attractive and realizable in the case of solving the problem of transducers-actuators.



a) b)

Fig.1 Non-adaptive and adaptive noise control: a) transformation of radiated initial disturbance in non-radiated one; b) creating anti-face initial signal using two rings of transducers and actuators to reduce radiating disturbance amplitude.

The task of noise control in subsonic jets rests, first of all, on the absence of understanding of the radiating turbulence structure itself. Only after a successful solution of this fundamental (and extremely complex) task, one can hope for formulating a reasonable strategy of subsonic jet noise control. Nevertheless, the realization of such an approach "blindly" through multiple investigations of different configurations can appear to be rather useful not only as a possibility of guessing the optimum configuration or the one close to the optimum, but as a way of using this method of control to identify that very structure which cannot yet be identified with using other methods.

References

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