A study on aerodynamic noise source and its directivity identification based on microphone array CSM modeling

Weiyang Qiao*
School of Power and Energy, Northwestern Polytechnical University
West Youyi Road 127#, 710072, Xi'an, China

ABSTRACT

A common method for the localisation of sound sources is beamforming with microphone array. The results are presented in form of beamform maps, which are, mathematically, convolutions between the true source distributions and the point spread functions of all sources. The estimating of source strengths can be solved with deconvolution techniques in which it is assumed that sources are point monopoles with uniform directivities. It is well known that the most aerodynamic noise source, such as aero-engine noise, has a very strong directivity, and the directivity of sound source cannot be measured by traditional beamforming of the microphone array. SODIX, which was firstly proposed by Prof. Michel in DLR, is a deconvolution processing method of microphone array specially used for engine noise directivity identification and quantification. However, the SODIX adopts an unknown continuously distributed aerodynamic noise sources to form a simulated cross spectral matrix(CSM), thus a complex and huge set of nonlinear algebraic equations is to be solved. In particular, due to the cross-spectrum matrix of the full array microphone signal, SODIX contains the cross spectrum of the microphone signal with large separation distance and poor correlation, which further brings the solving stability problem. In order to overcomes the unstable calculation and long calculation time in SODIX, a new extended SODIX method – SODIX-Bes for sound source directivity identification and quantification is developed in this paper. In SODIX-Bes, the sound source positions in the flow field are firstly obtained by beamforming technology, and then the directivity and power spectrum of each sound source are identified by fitting the simulated sound source CSM with the array CSM. The computational simulation results show that the error of the SODIX-Bes method is less than 0.17 dB. A linear array with 31 microphones was designed to identify and analyse the leading-edge noise directivity and leading-edge noise reduction with wavy configuration for NACA65(12)-10 blade. The experimentally results show that SODIX-Bes is reliable and effective.

Correspondence: qiaowy@nwpu.edu.cn; lianjianxin@mail.nwpu.edu.cn; Tel.: +86-13709183956