Extended Abstract

Review and improvement of TNO type trailing edge noise models

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The aim of this work is to give a review of the work which has been conducted on predicting trailing edge noise with the so-called TNO model and modified versions of it. We propose some modifications of the model which significantly improve the agreement of the predictions of the surface pressure and far field sound compared to measurements.
A fast and computationally low cost trailing edge (TE) noise model was developed at the TNO Institute of Applied Physics in the Netherlands by Parchen [1]. The model was applied to predict wind turbine noise by Moriarty et al. [2]. Since then the model has been further improved by various research groups [3,4,5,6,7,8].
The TNO type TE noise models use a two-step approach. First the surface pressure spectrum is related to parameters of the boundary layer flow. The boundary layer flow parameters can be computed with CFD RANS calculations or other computational methods like XFOIL [10]. The analytical expression for the surface pressure spectrum was first derived by Kraichnan [11] and further developed by Blake [12]. As second step the convecting surface pressure spectrum upstream of the TE is related to the radiated far field sound. There are two independent theories. We use the generalised theory by Howe [13] which was initially developed by Chase [14] and Chandiramani [15]. Alternatively, there is the theory of Amiet [16] which has recently been refined by Roger and Moreau [17]. A detailed analysis of the difference of the two theories is found in [6].
The main focus of this work is on improving the first part of the model. The largest challenge is modelling the spectrum and vertical length scale of the vertical velocity fluctuations which act as sources in the model. Three modifications of the model were introduced:

- We revised the assumptions by Blake [12] and came up with two different new ways to model the vertical length scale.
- The tuning of the anisotropy coefficients introduced by Bertagnolio et al. [5] was revised. We used the Mann turbulence model [9] which was optimised to match a measured spectral tensor to obtain the anisotropy coefficients. The empirical relation to the local pressure coefficient was dropped.
- A method to account for the effect blockage of the aerofoil surface on the spectrum and length scale of the vertical velocity by using rapid distortion theory developed by Mann [9] was introduced in the model. The final version of the correction we applied was different than the one proposed by Mann [9].

The main shortcoming of the previous TNO models was that the response of the far field sound pressure to changes of the angle of attack of the aerofoil was much less than the

one observed in measurements. For high angles of attack most models predicted a lower far field sound than the one which was measured. The improvements introduced in the present work helped to give a better response to angle of attack changes and let to a better agreement between computation and measurement.

Sample results:

The new model gives a good agreement of the surface pressure predictions and measurements on a modified NACA64-618 aerofoil presented in [6], figure 1 and 2.

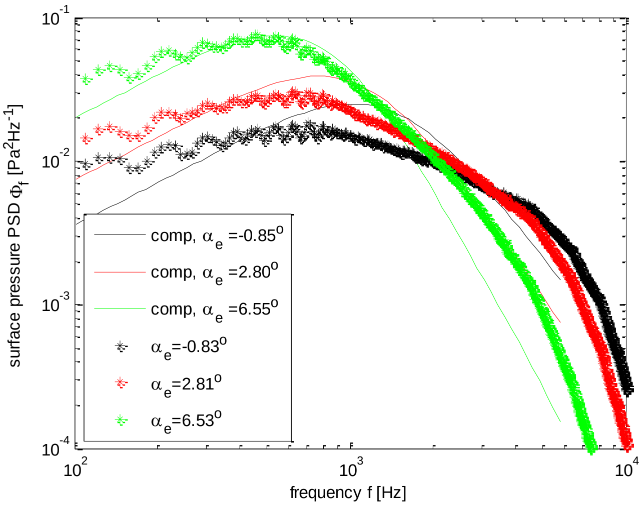

Figure 1: Improved model without surface blockage correction.

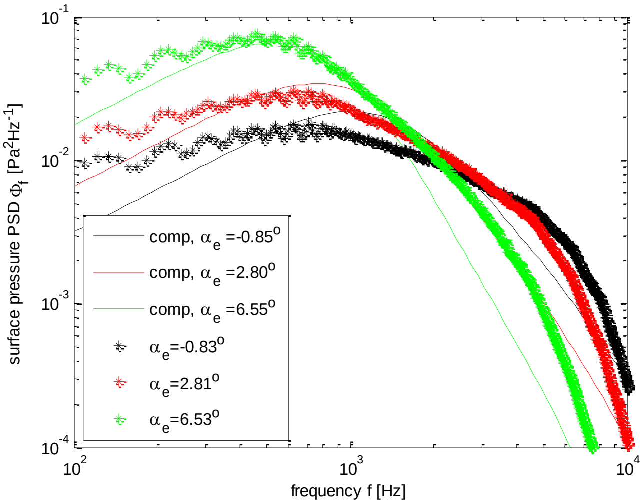

Figure 2: Improved model with surface blockage correction.

The improved model without blockage correction gives too high values for low angles of attack. Introducing the blockage correction leads to significantly improved results and a better response to angle of attack changes.

A more detailed analysis including comparison of the far field sound predictions with a large data base of measurements will be presented in the full paper.

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