EFFECT OF INFLOW CONDITIONS ON THE SOURCE NOISE OF LARGE ONSHORE WIND TURBINES

zEPHYR Marie Skłodowska-Curie project: towards a more efficient exploitation of on-shore and urban wind energy resources

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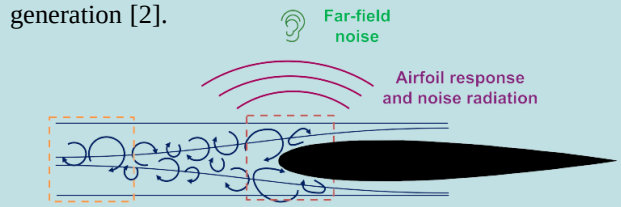
CONTEXT

The interaction of **turbulence** in the incoming flow, that may be due to the presence of mountains, trees, upwind turbines or buildings, with the leading edge of the blade generates **leading-edge noise**, also called **inflow turbulence noise**.

PROBLEM DEFINITION

In case of thick airfoils, turbulence in the incoming flow can be **distorted**. This phenomenon, studied and modelled by means of the **rapid distortion theory** [1], has been assumed to have an impact on the noise generation [2].



AMIET MODEL

The reliability of low-fidelity methods depends on the accuracy of the physical modelling they are based upon. The **Amiet Model** [3], developed for a flat plate, relates the far-field noise to the upstream flow conditions and provides inaccurate results for thick airfoils.

$$\underbrace{S_{pp}(\boldsymbol{x},\omega)}_{\text{Far-field acoustic pressure}} = \underbrace{\left(\frac{\omega z \rho_0 b}{c_0 \sigma_0^2}\right)^2 \pi U_0 d}_{\text{Specific parameters of the case analysed}} \int_{-\infty}^{+\infty} \frac{\sin^2\left[\left(K_y - k_y\right)d\right]}{\left(K_y - k_y\right)^2} \underbrace{|L(\boldsymbol{x},k_x,k_y)|^2}_{\text{Airfoil response and noise radiation}} \underbrace{\Phi_{ww}\left(K_x,k_y\right)dk_y}_{\text{Upstream undisturbed turbulence conditions}}$$

METHODOLOGY

The purpose is to **modify the inputs** of the Amiet Model by applying the **RDT equations** in order to account for the effects of turbulence distortion on the noise generation [4].

Far-field acoustic pressure = **Specific parameters of the case analysed** ✖ **Airfoil response and noise radiation** ✖ **Distorted turbulent conditions**

with:

Upstream undisturbed turbulence conditions → **RDT equations** → **Distorted turbulent conditions**

OBJECTIVES

The goals of this PhD project, that will carry out an analytical investigation combined with numerical and experimental validation, are the following ones:

- Analysis of the turbulence distortion mechanisms and their impact on the noise generation
- Enhancement of the noise-prediction method
- Ad-hoc developed noise-mitigation strategies

[1] Hunt, J. C. R. (1973), A theory of turbulent flow round two-dimensional bluff bodies, *Journal of Fluid Mechanics*, 61(4), 625 - 706

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[3] Amiet, R. K. (1975), Acoustic radiation from an airfoil in a turbulent stream, *Journal of Sound and Vibration*, 41(4), 407 - 420

[4] Zamponi, R., et al. (2021), Rapid distortion theory of turbulent flow around a porous cylinder, *Journal of Fluid Mechanics*, 915, A27

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