AERODYNAMIC AND AEROACOUSTIC ANALYSIS OF WING WITH SERRATED TRAILING EDGE

CFD Insights services

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Objective

The objective of this project was the analysis of a blade with various types of serrated trailing edges, focusing on evaluating how these serrated characteristics impact both their aerodynamic and aeroacoustic behavior. Inspired by the study of owl wings, this design concept aims to optimize the performance of modern turbomachinery in terms of noise reduction and aerodynamic efficiency.

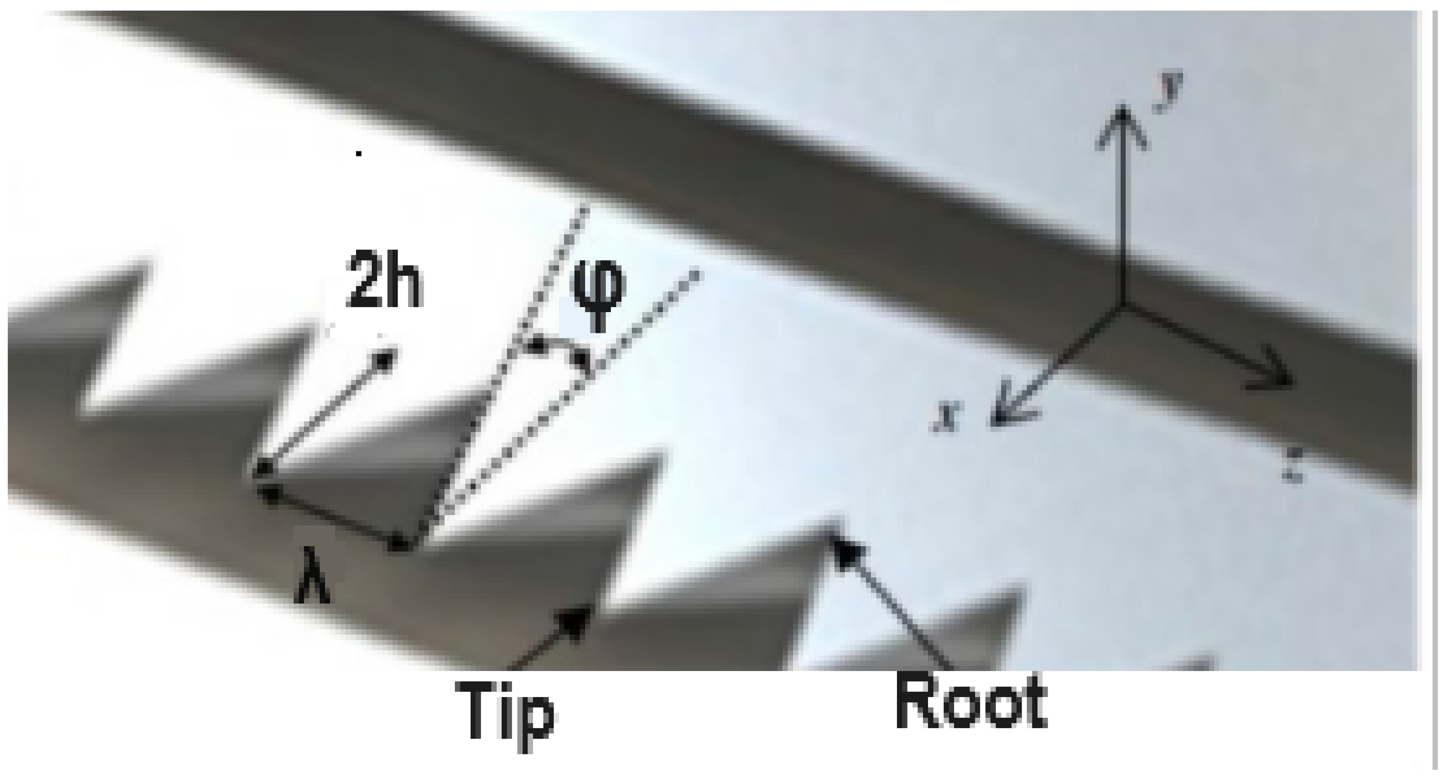

Figure 1:Characteristics of serrations.

Methodology

A total of seven geometries were examined, as outlined in Table 1. The numerical results underwent validation through comparison with bibliographical and experimental data. For the baseline geometry, a wing based on the traditional NACA 0012 airfoil was selected, as it corresponds to the profile intended for use in the client's project. Due to considerations of structural integrity, the various modifications to the wings were treated as integral components of the geometry rather than additions. Figure 1 showcases some of the examined geometries, while Figure 2 illustrates the characteristics of the serrations.

Table 1:Considered scenarios

ID	2h(%)	ϕ(cm)	λ(°)
S1	20	0.49	7
S2	20	0.85	12
S3	20	1.87	25
S1*	10	0.49	15
S2*	10	0.85	24
S3*	10	1.87	50

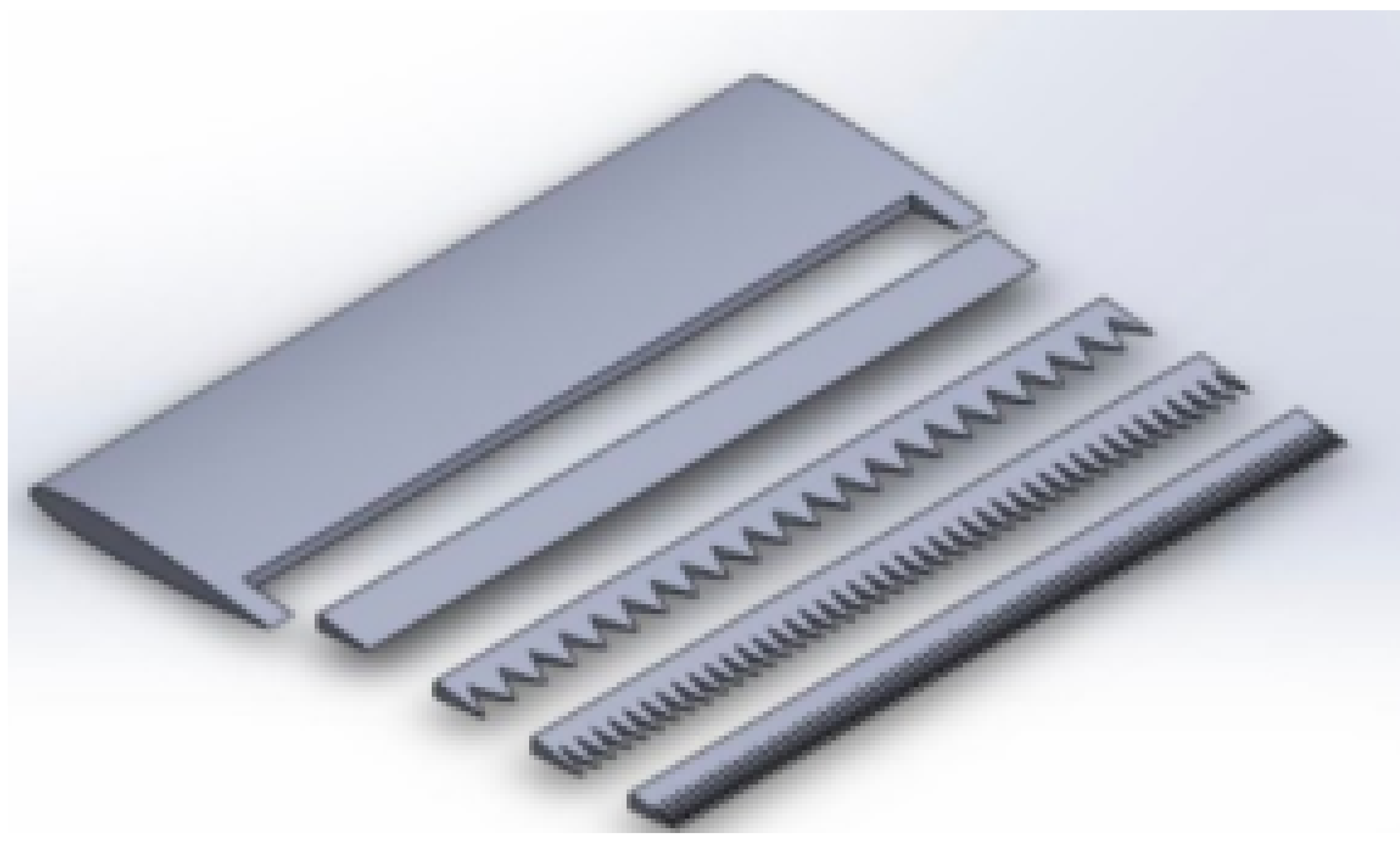

Figure 2:Some of the examined geometries.

Results (Aeroacoustics)

The overall trend observed in the results aligns with findings in existing literature. Specifically, the presence of serrations is noted to decrease broadband noise levels at high frequencies by approximately 5-6 dB. It is notable that an increase in   corresponds to a reduction in power intensity within this frequency range. However, this decrease is accompanied by a significant increase in noise at a narrowband tone, attributed in the literature to fluid spinning within the serrated morphology of the vanishing edge.

Regarding the impact of tooth length, it is evident that increased height is associated with a greater reduction in acoustic power levels. This is attributed to longer indentations affecting flow and the existing boundary layer for a prolonged period. Conversely, shorter tooth height leads to reduced acoustic power levels at lower frequencies, primarily due to fluid agitation in the blunt openings of the serrations. Consequently, a decrease in indentation height results in a reduced available surface area for solid-fluid interaction. Figure 3 presents the acoustic results of experiments performed on geometries that fully correspond to the first four scenarios of this project. Additionally, figures 4 and 5 showcase the Sound Power Level given by the coupled simulation for the four cases from the two softwares (Ansys FLUENT and OpenFOAM) used for the project.

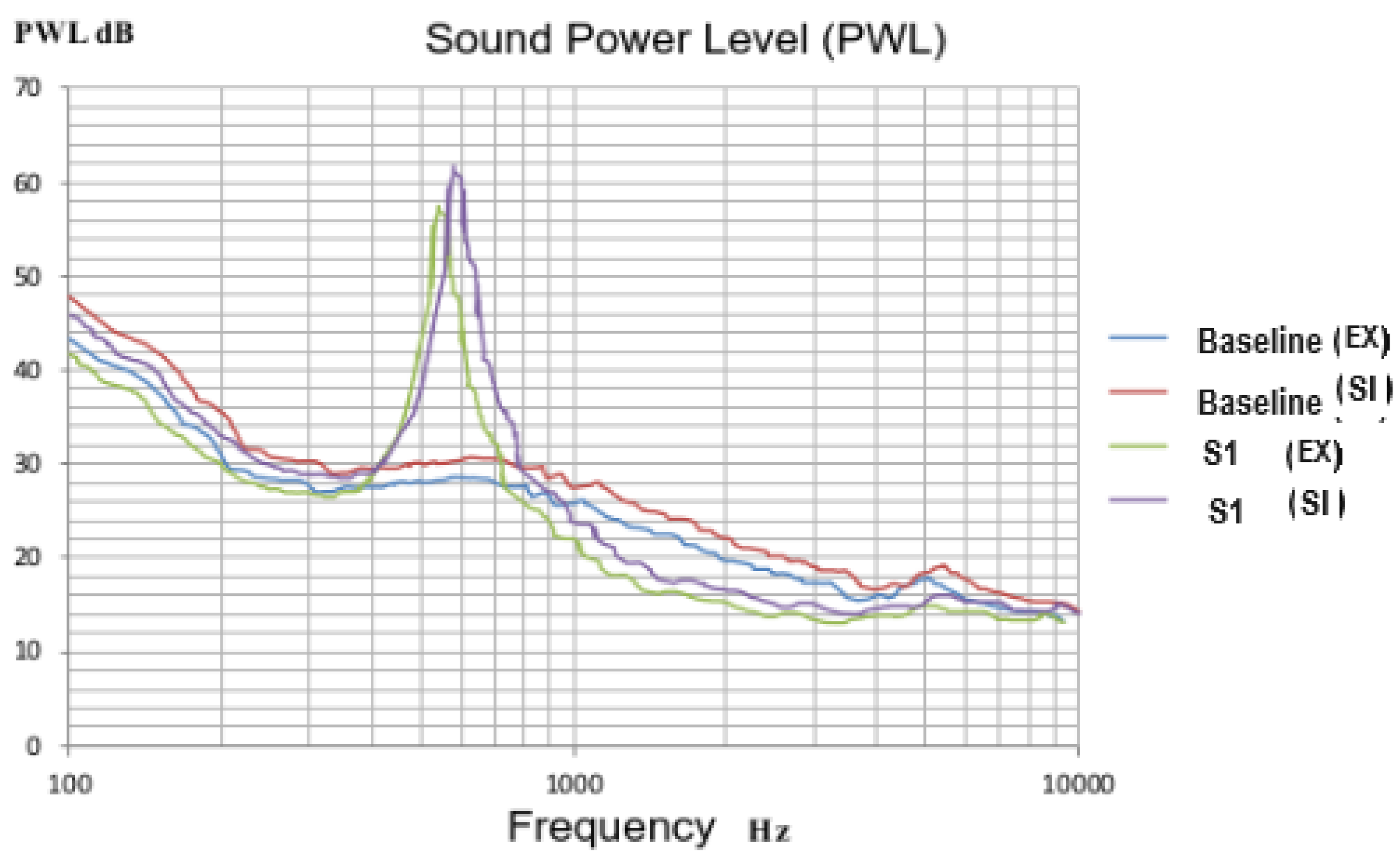

Figure 3:Aeroacoustic results for the baseline and S1.

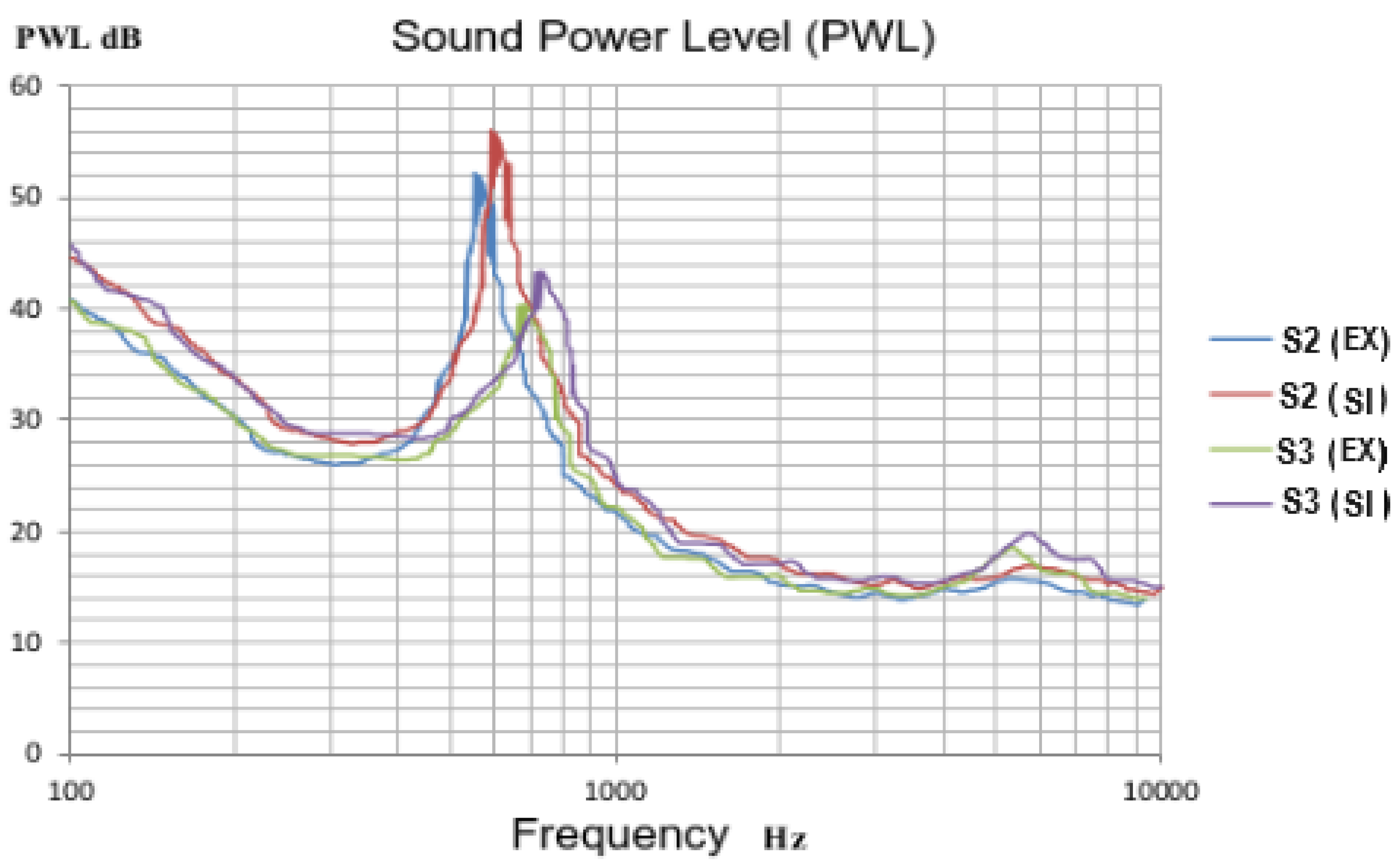

Figure 4:Aeroacoustic results for the S2 and S3 cases.

Conclusion

The project entailed a numerical study of serrated geometries intended for use as blades in the client's turbomachinery applications, specifically pumps. Both the aerodynamic and aeroacoustic behaviors of these geometries, influenced by the serrations, were thoroughly examined. The insights gleaned from these studies were then utilized to inform and guide the design process.