Simulating the Fluid-Structure-Acoustic Interaction of the Confined Flow in a Centrifugal Fan

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Centrifugal fans are prevalently applied in industrial and civilian applications, including a wide range of manufacturing processes, air conditioning systems, and cooling systems in automobiles. This type of fan typically consists of an impeller that is housed in a spiral casing. The impeller exploits centrifugal forces to accelerate the fluid radially outwards, redirecting it by 90° at the inlet. The external sound of a circumferential fan is generated by two mechanisms: first, the fluid flow through the fan directly induces vibration to the casing. Second, the same flow field causes acoustic pressure fluctuations in the interior that also transmit through the casing walls. The latter mechanism dominates the fan's sound emission for low-Mach-number flows/incompressible fluids and is the topic of this work. Here, we deal with the finite-element simulation of these fluid-structure-acoustic interactions in our centrifugal test fan. We employ the so-called hybrid aeroacoustic workflow to obtain forward coupling between the flow field and the acoustic wave radiation [1]. The sound excitation is modeled via the Perturbed Convective Wave Equation (PCWE), exploiting the temporal pressure derivative of an incompressible CFD simulation. Additionally, we utilize and rehearse the kinematic-coupling strategy to obtain direct coupling between the acoustic velocity potential and the structural vibration velocity [2]. Finally, we validate the simulations to acoustic reference measurements.

Keywords: ICTCA 2023; computational aeroacoustics; computational fluid dynamics; finite element method; confined flow; centrifugal fan; PCWE;

References

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