

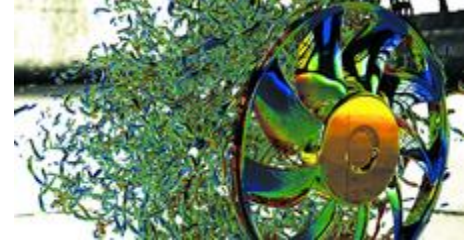
POWERFLOW FOR COOLING FAN NOISE



3DEXPERIENCE®

Industry Needs a Quiet Revolution

Low-speed rotating axial and radial fans are frequently used to manage engine temperature by ensuring adequate airflow through heat exchangers, especially at low vehicle speeds or idle. An undesirable side effect of these fans is generation of flow-induced noise, which is an annoyance to operators and passengers, and a source of community noise, especially for commercial vehicles and heavy equipment. In most cases and particularly for high mass flow configurations, a cooling fan is a major contributor to the overall noise, and in some cases dominates relative to other sources such as engine, transmission, tire, mechanical, or exhaust contributions.



Governments have imposed operator and community noise regulations, and a failure in the acoustic development of a product can lead to delays and expensive countermeasures to meet those requirements. In addition, cooling fan noise acoustics is a perceived quality issue that can affect brand image and customer satisfaction. Given the regulations and growing importance of acoustic comfort in these competitive markets, there is high value in addressing cooling fan, flow-induced noise problems as early as possible during product development.

Technical Challenges

Experimental assessment of fan acoustic performance is limited by the difficulties of physical testing, and is typically performed in stand-alone test bench configurations. The results might not correlate well to performance when integrated into a real system because this method tends to substantially alter the flow and acoustic environment of the fan. With physical testing, it is very difficult or impossible to identify the source of a noise. Simulation has the potential to overcome these difficulties, but must meet the challenges of accurately capturing the key physical mechanisms related to flow-induced noise from cooling fans:

- By definition, noise generation is a transient phenomenon and traditional CFD codes typically have difficulty accurately predicting transient effects in reasonable time frames.
- The complex interaction of rotating blades with nearby stationary geometry is a primary source of noise, and the typical moving reference frame (MRF) technique fails to capture this effect.
- Tonal noise, especially associated with the blade-passing frequency, can have significant dependence on the quality of the incoming flow, rotor casing interactions, existence of rotating stall conditions, and unsteadiness of the flow field.
- Broadband noise, which is usually related to vortex shedding, flow detachments, turbulent boundary layer noise, and tip vortex noise.
- Installation effects, which tend to influence the inlet flow conditions and the acoustic response of the system.
- Radiation of small amplitude pressure fluctuations (acoustics) outside the convective near field.

SIMULIA Solution

PowerFLOW, combined with PowerACOUSTICS, provides a complete computational aeroacoustics solution:

- PowerFLOW's inherently transient solution accurately predicts the complex time-dependent turbulent flow structures and the resulting noise sources induced by the cooling fan.
- PowerFLOW's true rotating geometry capability provides time-accurate simulation of rotation and captures all types of interactions more precisely than traditional MRF methods.
- PowerFLOW's inherently compressible solution predicts the radiated noise simultaneously with the flow-induced noise sources.
- PowerFLOW can handle fully detailed geometry and capture all the interactions between the fan and surrounding components.
- For applications requiring prediction of noise propagation to the far field (community noise), PowerFLOW transient results can be coupled with the PowerACOUSTICS far-field noise module, which uses an acoustic analogy method based on the Ffowcs-Williams and Hawkings equation.
- Easy-to-use analysis and state-of-the-art 3D visualization capabilities with PowerACOUSTICS and PowerVIZ provide insight into noise sources. Band-filtered pressure analyses can be used to isolate phenomena at specific frequency bands of interest (for example, to perform detailed investigation of the blade-passing frequency noise).