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Accurately quantifying turbulent flow behavior FREE

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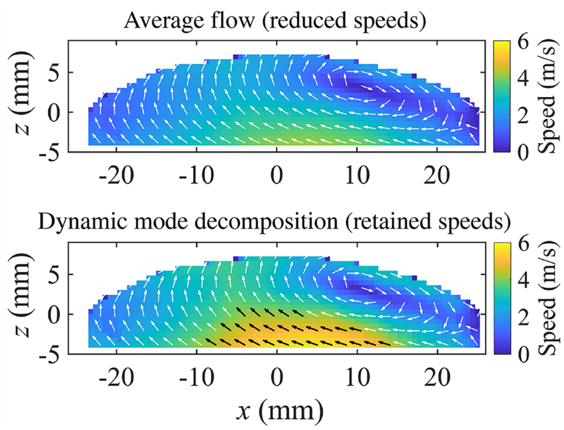
Developing a more reliable prediction of velocity fields in internal combustion engines.



Intake air flow is a significant source of kinetic energy in an engine cylinder, influencing important processes such as fuel-air mixing and combustion efficiency. However, accurately representing this flow is challenging due to the random nature of high turbulence often found in internal combustion engines.

The ensemble mean velocity field (EM) is commonly used to provide a representation of the general airflow patterns and compare one dataset to another. This averaging process can cause opposing velocity components to cancel, reducing the overall vector magnitudes. Baker et al. used an advanced numerical method, called dynamic mode decomposition, to collapse the data into a single image while retaining accurate flow speeds.

“Turbulent flows crucially underpin many advanced propulsion technologies that power our planes, trains, and vehicles,” said author Samuel Baker. “Improving our understanding of turbulent flows is essential in the effort to decarbonize our transport.”

The team compared flow field velocity data from particle image velocimetry and large eddy simulations using EM and sparsity-promoting dynamic mode decomposition (SPDMD). The findings showed that while EM underestimated the magnitudes, SPDMD removed under-predictions and more accurately produced a reliable 0 Hz mode for relatively small datasets.

“This proposed technique will allow engineers and researchers to gain a more accurate understanding of turbulent flow behavior, which can be used to optimize the efficiencies of propulsion systems, diagnose problems, or validate simulations of these technologies. We hope this work also inspires researchers to delve into the data behind other problems in fluid mechanics and propulsion physics.”

Source: “Extracting vector magnitudes of dominant structures in a cyclic engine flow with dimensionality reduction,” by S.J. Baker, X.H. Fang, A. Barbato, S. Breda, M. Magnani, S. Fontanesi, F.C.P. Leach, and M. H. Davy, *Physics of Fluids* (2024). This article can be accessed at https://doi.org/10.1063/5.0189368.

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