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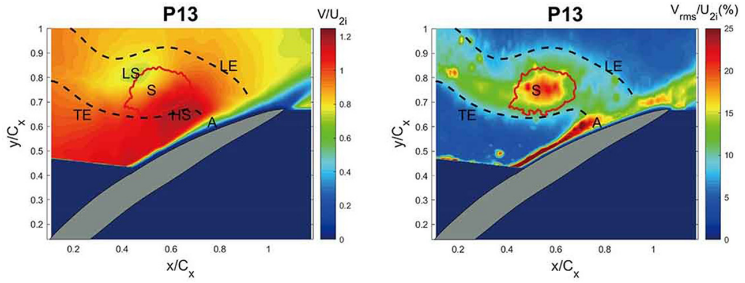
Wake-blade and wake-wake interactions shed light on turbomachine design optimization

Savannah Mandel

Researchers study wake-blade and wake-wake interactions in a two-stage compressor in air to obtain groundbreaking data on near-wall turbulence.



When designing rotating blades, scientists must account for turbulence and specifically near-wall turbulence. This complicated problem bottlenecks current engineering applications.

Authors Tengda Zou and Cunbiao Lee experimentally studied the flow environment around rotor blades in a two-stage compressor. They examined wake-blade and wake-wake interactions using particle image velocimetry (PIV) to visualize this two-dimensional velocity field.

The authors observed the turbulent hot spot within the second-stage rotor blade passage caused by the distorted wake of the first-stage stator, and the dynamics of the rotor boundary layer development. This development under wake impingement over rotating blades in air has not previously been investigated due to the challenges of acquiring near-wall data from PIV in a turbomachine due to light pollution and strong shear.

The authors observed a high-speed region and a low-speed region around the turbulent hot spot. They also found the turbulent hot spot to be more unstable and active than the wake, as well as a periodic thickening of the boundary layer related to the wake passing cycle.

“Modern turbomachine design requires researchers to have a deep understanding of the turbulent flow around rotor blades. At present, near-wall experiments are expected to better meet necessary demand,” said Lee. “For a modern design of compressors at the high loading levels, flow loss increases due to boundary layer separation. Therefore, the boundary layer behavior influences the efficiency and the flow loss of the whole compressor.”

In the future, the authors plan on developing the corresponding turbulence theory in near-wall turbulence of rotating blades. They also want to test their experimental results on engineering applications.

Source: “Rotor boundary layer development in a two-stage compressor,” by Tengda Zou and Cunbiao Lee, *Physics of Fluids* (2019). The article can be accessed at https://doi.org/10.1063/1.5131805.

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