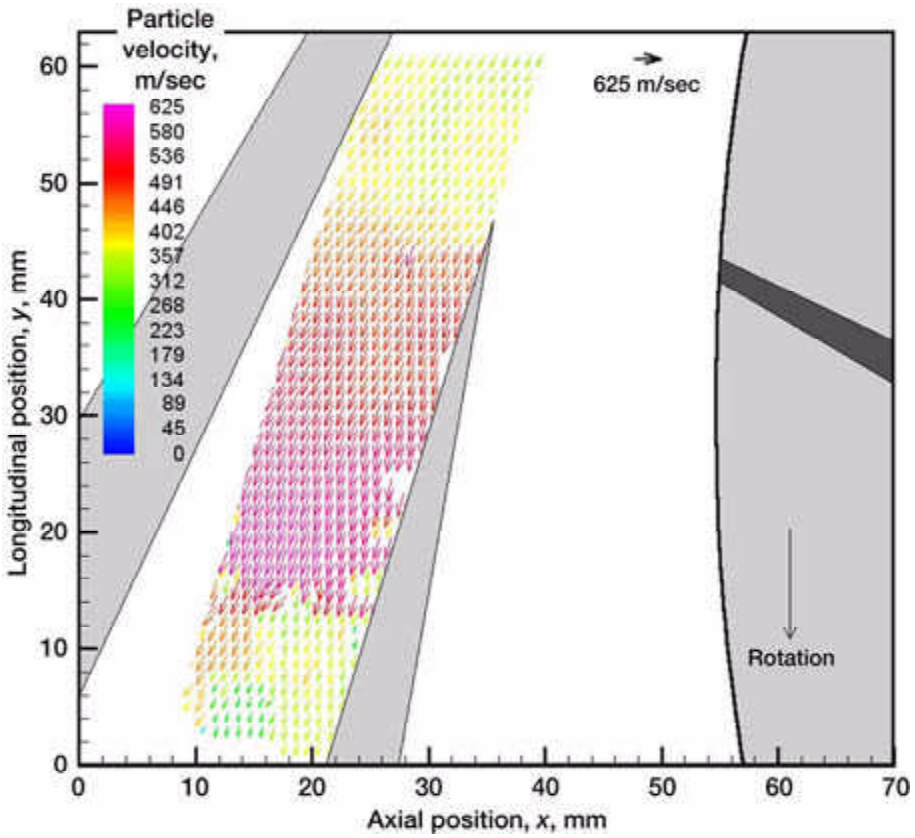
# Surge Flow in a Centrifugal Compressor Measured by Digital Particle Image Velocimetry

A planar optical velocity measurement technique known as Particle Image Velocimetry (PIV) is being used to study transient events in compressors. In PIV, a pulsed laser light sheet is used to record the positions of particles entrained in a fluid at two instances in time across a planar region of the flow. Determining the recorded particle displacement between exposures yields an instantaneous velocity vector map across the illuminated plane. Detailed flow mappings obtained using PIV in high-speed rotating turbomachinery components are used to improve the accuracy of computational fluid dynamics (CFD) simulations, which in turn, are used to guide advances in state-of-the-art aircraft engine hardware designs.

Compressor stall is a catastrophic breakdown of the flow in a compressor that can lead to a loss of engine power, large pressure transients in the inlet and nacelle, and engine flameout. The distance on a performance map between the operating point of a compressor and its stall point is referred to as the stall margin. This margin must account for increased clearances within the compressor caused by throttle transients and component deterioration due to aging. Optimal engine designs tend toward minimal stall margins, since modifications to increase the stall margin typically result in heavier, less efficient, and less loaded compressors. However, if active or passive stall control is employed instead, stable operation over a wider range of flow conditions (improved stall margin) can be obtained with a minimal loss in performance.

Traditionally, dynamic pressure measurements have been employed to decipher the flow changes occurring during stall and surge events. These measurements yield vague indications of the kinematic changes in the flow field. The instantaneous flow-field capture capability of Digital Particle Image Velocimetry (DPIV) is better suited to the task of studying the change in flow conditions surrounding the development of stall precursors, stall cell propagation, and eventually, compressor surge. DPIV has been used at the NASA Glenn Research Center at Lewis Field to study the changes in the compressor flow field occurring during surge in a centrifugal compressor. The DPIV measurements show that flow reversal occurs in the diffuser during surge and that forward flow is reestablished via a supersonic shock front that propagates down into the diffuser, as shown in the figure. These results are being used to understand the flow changes occurring during rotating stall that eventually lead to surge, and to optimize the stall control strategies that will be implemented in the compressor.




*The instantaneous velocity field captured during compressor surge. The velocity vector magnitudes are coded by color. The position of the impeller is shown on the right, and the diffuser vanes are shown on the left. Velocity measurements are obtained in the region of the flow field illuminated by the laser light sheet.*

**Find out more about this research http://www.grc.nasa.gov/WWW/OptInstr/piv/.**

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