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Title: "Measurement and modeling of sound and vibration fields using a scanning laser Doppler vibrometer"

Abstract

In this dissertation new applications for the scanning laser Doppler vibrometer (SLDV) are investigated in the field of acoustics and vibration. The main advantage of the SLDV is the fact that it is a full-field optical non-contact vibration instrument. Besides in this research the SLDV is commonly used for modal analysis, structural damage detection, non destructive testing of aircraft and automotive components, bio-medical applications, and many more.

Although the SLDV measures vibrations it has been shown recently that it is possible as well to visualize acoustic fields. In this research these acoustic fields were not only visualized but more importantly used to calculate acoustic absorption coefficients, both under normal and oblique incidence.

To eliminate noise components when measuring an Operational Deflection Shape (ODS) to be used to determine the structural intensity, or power flow, in a vibration structure a new algorithm based on Generalized Regressive Discrete Fourier Series was developed. The spatial derivatives of the ODS can be computed much more accurately providing a better view of the power sources and sinks in the structure.

The recently developed 3D-SLDV was used to examine the dynamic surface strain on a small fan blade. Comparisons were made with a Finite Element Model and traditional strain gages. Results show that this measurement device has the potential to fill in the gap of accurately measuring small (full-field) normal and shear strains at both low and high frequencies, where other optical techniques would definitely fail.

Finally the concept of visualizing acoustic fields was used to visualize a steady-state velocity flow field. The technique is based on the use of an ultrasound field that is generated in addition to the flow field. At locations where a non-zero flow velocity is present, the ultrasonic wave fronts will be phase shifted making it possible to visualize flow phenomena without the need for seeding particles as in Particle Image Velocimetry.