

Investigation of the density and velocity distribution of a wing tip vortex by means of stereoscopic Background Oriented Schlieren Method (BOS) and stereoscopic Particle Image Velocimetry (PIV)

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Introduction and objectives

The phenomenon 'vortex' is still not totally understood. Modern optical measurement techniques give new possibilities approaching local details about the flow concerning the density and velocity distribution. In case of Background Oriented Schlieren Method (BOS) and Particle Image Velocimetry (PIV) the information about the flow can be taken simultaneously in the whole flow field. Coupling these two techniques enables the measurement of the thermodynamic state of the flow. The test in an industrial transonic wind tunnel was carried out to show the feasibility of coupling these two techniques for the investigation of axis-symmetrical flows.

Procedure

The wing tip vortex of a modern large transportation aircraft in the transonic wind tunnel in Göttingen was investigated by means of stereoscopic BOS and stereoscopic PIV. Thus, the density and the velocity distribution of the flow behind the wing tip were observed. The whole set-up is shown in figure (1). Three different flow speeds (Mach = 0.5, 0.6 and 0.7) and four different angles of incidence (-3° , $+1^\circ$, $+2^\circ$, $+3^\circ$) were investigated.

Results

Using in-house developed algorithms (VRIEDER and Ring-Method) the position of the vortex and its density distribution was derived from the stereoscopic BOS-data. The PIV recordings give exact information about the velocity distribution. The results of the calculated vortex positions for all flow velocities and angles of incidence are presented in figure (2).

Conclusions

With BOS as an easy to install measurement technique, it is possible to obtain quantitative density information of the flow. Based on investigations about the possibility measuring the local density distribution with BOS accurately, with information on the position of the density variation, a further development of the measurement technique was achieved by new post processing algorithms. Further on it was possible to derive criteria for setting up the BOS system in order to obtain reliable data.

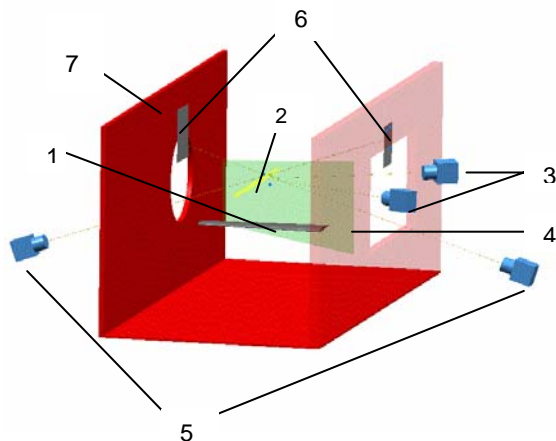


Figure (1):
 The experimental set-up in the wind tunnel:
 1: half wing model
 2: wing tip vortex
 3: PIV Cameras
 4: Laser light sheet
 5: BOS Cameras
 6: BOS Backgrounds
 7: Wind tunnel wall

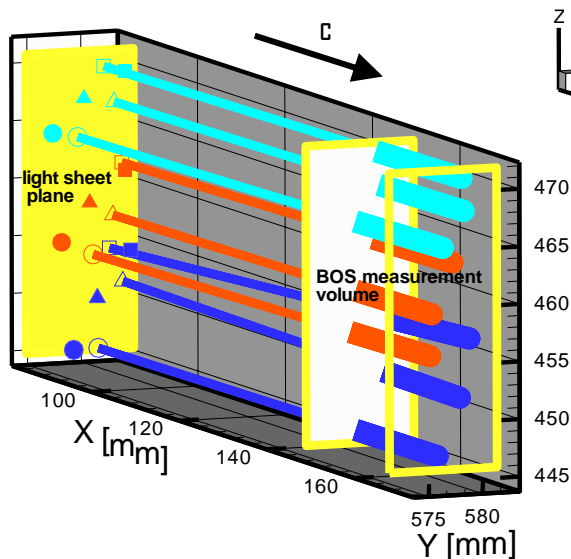


Figure (2):
 Comparison of the vortex position measured by PIV and BOS. Since the BOS investigation volume is different from the PIV recording plane (light sheet plane), the BOS results are linearly extrapolated.