Investigation of shock-induced flow separation over a transonic compressor blade by conditionally averaged PIV and high speed shadowgraphs

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HIGHLIGHTS

- Flow separation control is investigated in a highly loaded transonic compressor cascade at Ma_1=1.21, a chord based Reynolds number of 1.4 x 10^6 and positional shock fluctuations of up to 23% of chord.
- The size of the separation region is assessed through large sets of statistically independent PIV samples conditionally averages at different positions of the moving passage shock at a resolution of 1% of chord.
- Prior to PIV evaluation, flexure of the blade surface due to buffeting is compensated in each shot by measuring the blade displacement by a correlation based approach.
- Frequencies of shock movement are analyzed based on time-resolved shadowgraphs and show a broadband spectrum with singular peaks indicating feedback from upstream propagating pressure waves.

ABSTRACT

The impact of flow control on both downsizing the separation region and reduction of shock unsteadiness has been investigated for a transonic compressor blade. Flow control consists either of a surface roughness stripe or of air jet vortex generators. Comparative flows without transition control imply variations of the upstream turbulence. PIV shots indicate shape variations of the lambda shock pattern and of the associated separation region (see Fig. 1). The mean size of the separation region can be assessed through conditional averages about the shock position. Therefore, the shock position is estimated through the maximum absolute axial velocity gradient in each PIV sample. It turns out, that transition control based on a roughness patch leads to a significant reduction of bubble separation at both the rear and front shock positions and lowers amplitudes of shock movement.

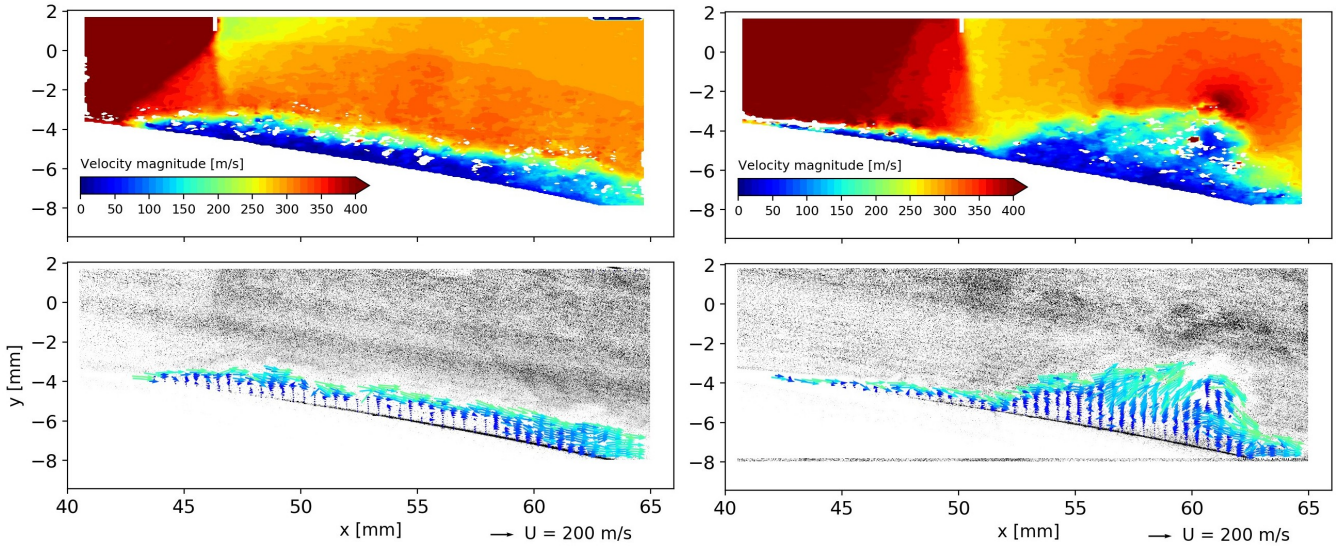

Fig. 1 PIV samples indicating large variations of the lambda shock pattern and separation region; Vectors> 200m/s are clipped; conditional averaging is based on the automated estimation of the shock position, marked by the white vertical bar.