EXPERIMENTAL ASSESSMENT OF PARAMETERS INFLUENCING THE ACCURACY AND ROBUSTNESS OF TRANSIENT PNEUMATIC PROBE TRAVERSES

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ABSTRACT
An experimental study investigating numerous parameters that influence the accuracy and robustness of transient pneumatic wake traverses in steady flow fields has been conducted at the High-Speed Cascade Wind Tunnel of the Institute of Jet Propulsion at the University of the Bundeswehr Munich. Two pneumatic probes were traversed in the wake of a cylinder in cross-flow condition across a wide range of Mach and Reynolds numbers. Parameters investigated include the traversing speed, sampling rate, data post-processing, pneumatic setups and the order of the in-situ determined transfer function. By evaluating a large number of parameter combinations, inherent limitations of the method, as well as recommendations towards a robust set of parameters are determined.

INTRODUCTION
Transient pneumatic wake traverses offer a significant reduction in measurement time compared to conventional pointwise measurements, while simultaneously increasing the spatial resolution of the acquired pressure field. However, the dynamic response of the pneumatic measurement chain, consisting of probe, tubing and sensor, leads to a distortion of the measured pressure signal. In order to reconstruct the steady-state pressure distribution, an appropriate model of the dynamic system has to be applied.

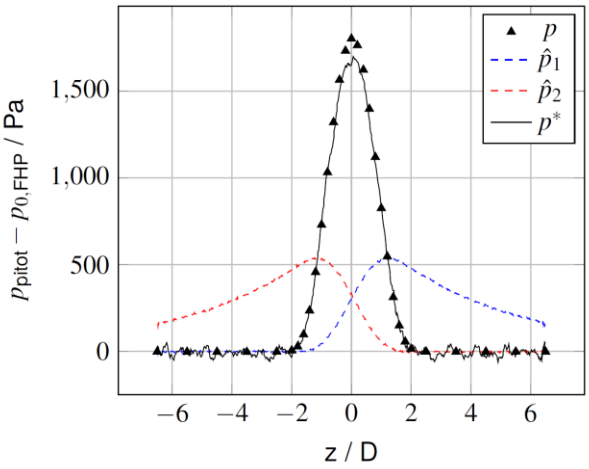
This paper aims to investigate influencing parameters for transient pressure probe measurements which allow faster conduction of field measurements in the wake of turbomachinery cascades compared to pointwise traverses while increasing the resolution simultaneously. By experimentally investigating various parameters, guidelines for selecting a robust set of process parameters shall be found.

Measurements were carried out at the High-Speed Cascade Wind Tunnel (HGK) of the Institute of Jet Propulsion. The wind tunnel is positioned inside a pressurized vessel allowing for the independent control of Mach- and Reynolds number. A five-hole pressure probe (FHP) with a head diameter of D_{FHP} =2.5 mm, as well as a pitot probe with a head diameter of D_{pitot} = 2 mm are traversed in the wake of a cylinder with a diameter of D_{cyl} =10 mm at various distances and velocities. The pneumatic probes are connected to a 9116 pressure scanner from PSI pressure System with an operating range of ±25 hPa to ±345 hPa and an uncertainty of 0.15 % and 0.05 % of the full-scale range (absolute: 4 and 17 Pa).

RESULTS AND DISCUSSION

For each parameter set (Ma, Re, Sampling rate, traversing speed, filter width), the deviation between reconstructed settled pressure $p^*$and the reference pressure p (obtained through a pointwise measurement), is evaluated as displayed in Fig. 1. Furthermore, the frequency response of the obtained low-order transfer function is compared to the frequency response of the pneumatic system as computed with the model by Bergh and Tijdeman. Results indicate that a first order transfer function adequately represents the dynamic behavior of the investigate pneumatic system.

Further investigations regarding the limitations of the method for measurements under high Mach-number conditions and different tubing configurations will be discussed in the full paper. It can be shown that the assumption of constant dynamic behavior does not hold true for operating points combining high Mach number and high total pressure loss coefficients.



Name	Symbol	Value
Maximum deviation	Δp_{max}	140.8 Pa
Standard deviation	Δp_{std}	43.0 Pa
Sensor uncertainty	Δp_{Sensor}	17.24 Pa
Assumed uncertainty	Δp^*	44.27 Pa
Time constant	T	4.40 s

Figure 1. Exemplary evaluation of a transient traverse with the transient measurement displayed by dashed lines. Operating point: Re 10k, Ma 0.5, Traversing speed: 10 mm/s, Distance: 5 D, Filter width: 11 samples.