ASSESSMENT OF CANTILEVER PROBE AEROELASTICITY: ENHANCING MEASUREMENT PRECISION IN TURBOMACHINERY

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ABSTRACT

The present study consists of a low fidelity problem–specific modeling of the flow–probe interaction, to minimize the measurement uncertainties in turbomachinery applications.

Despite the occurrence of quasi-steady thermodynamic phenomena, common measuring non-optic instruments are not exempt from the highly aeroelastic environment of turbomachines. Fluid-structure interaction (FSI) phenomena induce measurement accuracy tradeoffs contributing to false pressure gradient diagnosis.

The scope of the present paper is to further illuminate the flow interaction of traversable instrumentation in turbomachinery annuli, by prognosticating their angle of deformation and dynamic response, via one – way FSI simulation in programming environment. Such an approach allows flexibility, customization, expansibility, and the actualization of sensitivity analyses.

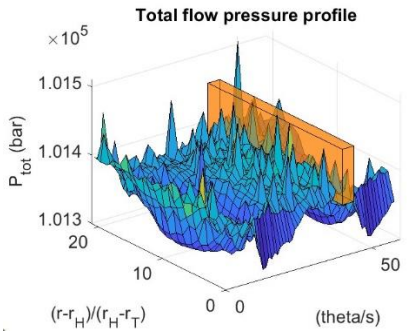

Figure 1: The pitot probe – symbolized as a cuboid – introduced in the non-dimensional flow pressure profile.

To precociously ensure the fidelity of the simulation model, which consists of axially arranged one-dimensional beam elements, the results of the eigenproblem, as obtained from the analytical solution of a flexural beam with fixed cross-sectional area, from the corrections introduced by the Rayleigh-Ritz method for variable cross-sectional area, and from the finite element method are compared.

Figure 2: The cobra pitot probe.

The maximum deformation of the beam is calculated, considering the force induced by the pressure field – extracted from previous experimental studies – as a distributed load, and for further verification of the model, the results are compared, as obtained from the one-dimensional superposition of bending elements, and from a more complex case of a three-dimensionally meshed beam. The response of the beam is extracted via transient one – way FSI, considering the bending deflection as the measure of change of the force component on the beam.

The study aims to create a simple, “quick and dirty”, but well-founded model, with robust assumptions. Overall, by assessing the dynamic nature of measurement, the study contributes to maintaining high reliability and precision in turbomachinery measurements.