ON THE APPLICATION OF BAYESIAN INFERENCE FOR TURBOMACHIENRY COMPONENTS PERFORMANCE ASSESSMENT

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ABSTRACT

Reducing the instrumentation required to evaluate the performance of a turbomachine is essential to reduce intrusiveness error and to limit the cost of a measurement campaign. A data assimilation methodology based on Bayesian Inference is employed to reduce the required instrumentation effort. A numerical model is employed to provide an initial belief of the flow, that is then updated based on experimental observations. The developed methodology has been validated on analytical cases on which a thorough parametric study was also performed. Preliminary results on a low aspect ratio axial compressor stage show a good prediction of the corrected compressor map, as well as a good prediction of the inter-row pressure ratio of the machine.

INTRODUCTION

With the trend of achieving higher pressure ratios, more compact machines are being designed, making turbomachinery components more sensitive to instrument intrusiveness in the flow. A hybrid measurement technique was developed that assimilates experimental observations into an existing model of the test. The missing information is then reconstructed, therefore reducing the number of required spatial measurement points. The assimilation algorithm is based on statistical inference (Ensemble Kalman Filter Inversion (EKI) [1].

The methodology was preliminary validated on analytical test cases such as the Lorenz equations and a Rankine vortex. At this step, a detailed parametric study was performed to conclude on major guidelines for an effective application of the methodology.

Eventually, a preliminary assessment of the quality of the methodology was carried out on the LEMCOTEC H25 compressor stage for which a wide experimental database exists together with a thoroughly validated CFD model.

RESULTS AND DISCUSSION

Synthetic cases results show a good ability of the methodology to predict the initial condition imposed on the chaotic Lorenz system. The constants of the Rankine vortex equation have been also inferred with minimal error. These two results highlight the capability of the methodology to deal both with extremely chaotic phenomena and well-organized stationary ones, being the flow field within a turbomachinery somewhere in between these two extreme conditions. The low computational cost of running synthetic cases, allowed a complete parametric study. Different parameters have been investigated, such as the amount and the location of the available experimental data, their associated uncertainty and the influence of the accuracy of the numerical model. A marked case-dependency is shown by the results.

20 CFD runs were performed in a coarse mesh of the H25 domain and used as an initial belief for the algorithm. This CFD runs are then updated at a time for each experimental point available. Only the outlet experimental total pressure measurements have been employed for the assimilation process. The preliminary results are shown in Figure 1: the hybrid technique predicts with some accuracy the corrected compressor map, based only on outlet pressure measurements.

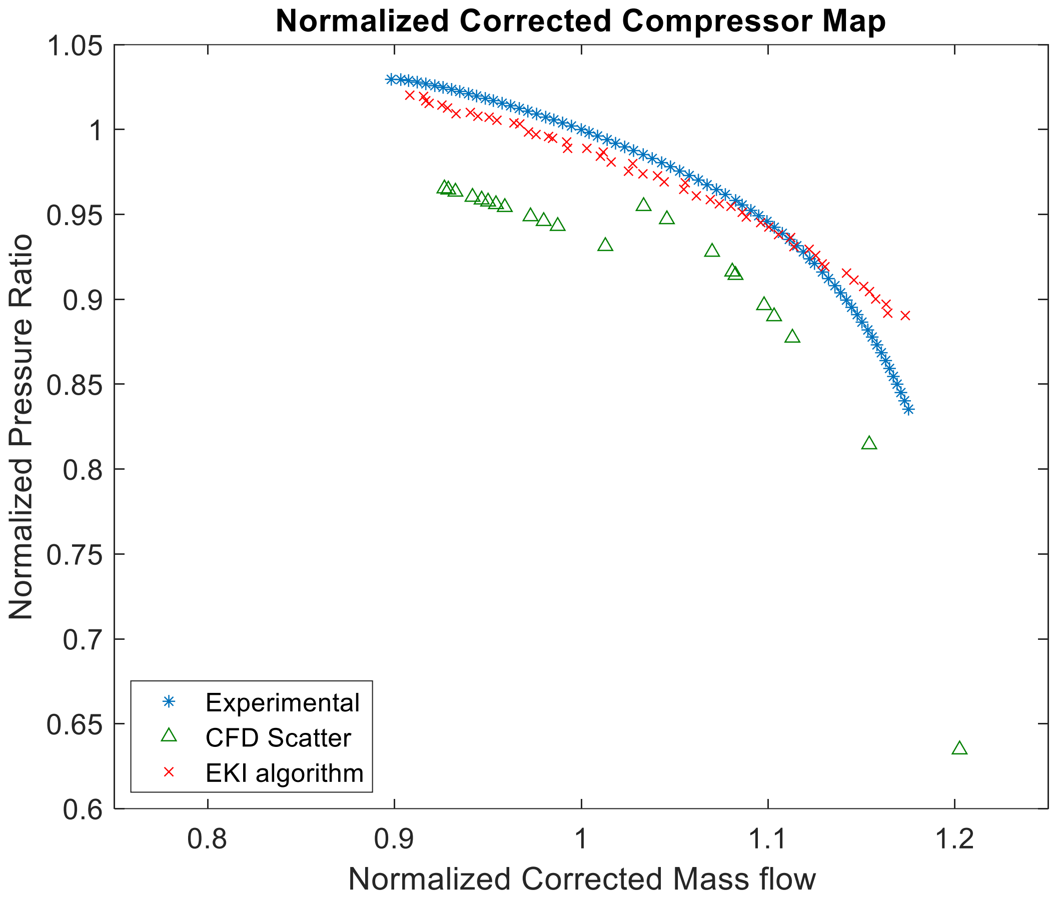

Figure 1. Corrected Compressor Map obtained with methodology application

REFERENCES

[1] Marco A. Iglesias, Kody J.H. Law, and Andrew M. Stuart. "Ensemble Kalman methods for inverse problems". In: Inverse Problems29.4 (2013).