DATA ACQUISITION, CONTROL AND PROCESSING OF THE PURDUE EXPERIMENTAL AEROTHERMAL LABORATORY

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ABSTRACT

The Purdue Experimental Aerothermal Laboratory (PETAL) is a pressure driven facility capable of steady state and transient testing with three different test sections of increasing technology readiness level (TRL). These go from a linear test section, an annular cascade and a full rotating turbine test module. Higher TRL indicates greater fidelity towards the final application of the test article. In this manuscript we describe the increasing complexity requirement of the data acquisition and control system with increase in TRL and how it was implemented for the PETAL facility. The impact this architecture has on the uncertainty of the measurement is presented. The processing code is also presented that is able to combine data from different data acquisition systems and is flexible enough to be applied to all test sections

INTRODUCTION

Data acquisition and control is an important part of the design of experimental rigs. The design and implementation of it also creates restrictions on the experimental setup. This manuscript presents the implementation of the data acquisition and control system for the Purdue Experimental Aerothermal Laboratory. The effect of the data system on the measurement uncertainty is also quantified.

The PETAL facility is a pressure driven facility with dry high-pressure air stored in stored tanks of 56 m^3 volume. The air can be passed through either directly to the test section (Cold line) or passed through a heater (Hot line). Both lines are mixed and passed through a critical venturi, where the total mass flow is measured. Downstream of that, the air can be diverted into either of the two tunnels labelled PT1 and PT2, or purged into the atmosphere using three fast actuation valves, which can actuate in less than 100ms. The air from the test section is released into a 283m^3 large vacuum tank, which can be open to atmosphere or under vacuum as low as 10mbar. The design and operation envelope of the facility is described in [1].

The facility consists of three test sections as shown in **Σφάλμα! Το αρχείο προέλευσης της αναφοράς δεν βρέθηκε.**, that are designed to test components in increasing order of Technology Readiness Level (TRL) [2]. These are the Linear Experimental Aerothermal Facility (LEAF) for TRL 1-2, for fundamental geometries and flow field testing as described in [3] and [4] . Big Rig for Aerothermal Stationary Turbine Analysis (BRASTA) described in [5], is an annular cascade for TRL3-4, to test turbine components in a stationary or rotating frame of reference. The final test section is the Small Turbine Aerothermal Rotating Rig (STARR), introduced in [6] which is a full rotating facility for TRL5-6, where production level geometries can be tested. STARR has the capacity to spin at 21KRPM at 450Nm Torque. These test sections provide the PETAL lab to test a concept design and production geometries in the same test facility. To ensure this, the architecture Control and Data Acquisition must be able to adjust for the specific requirements of each level of testing. This paper will address the complexity associated with increased TRL testing and requirements of modularity to allow for this range and how it was implemented in the PETAL facility.

RESULTS AND DISCUSSION

A distributed architecture is implemented with local control and conditioning systems which are all then communicated and controlled with central machines. The facility employs primarily three main communication modes. Almost 7 km of hardwire (analog signals) is implemented for the facility control and instrumentation signal. These signals interface with four National Instruments chassis. The facility is also equipped with an internal network on which devices communicate through TCP/IP and Modbus protocol. This allows to decentralize computing resources closer to the test article for instrumentation and using local PLC's for control of subsystems. This also reduces the resource requirements of the central machine. Sensor devices that communicate over TCP/IP such as Scanivalve pressure scanners are used, which can be mounted close to the test section. This allows the flexibility to switch between the two wind tunnels and reduce the physical time response by shortening the length of the pneumatic tubing.

The facility also employs eight traverse systems and two sonic valve controls that use serial communication over RS232. These are all routed through a USB hub that allows a single machine to control all serial communication devices

Due to the sheer number of sensors, it is important to have a post processing architecture that provides consistent methodology and a robust and maintainable code. At the same time, due to the variation in test conditions and objectives of each test rig, the code needs to be flexible and easy to use for users with different background on data processing. The file handling system stores data into a centralized data repository at Purdue, as part of the Purdue Research Computing Data Depot. Each test run is assigned a folder that contains both the raw data and the experiment metadata. Figure 1 shows the flowchart of the processing routine. Experimental metadata consists of documentation regarding the test section configuration, test notes, instrumentation list, including the channel mapping and sensor position data for the traversing system. All of this is important in understanding the data and ensures comparison with other data sets.

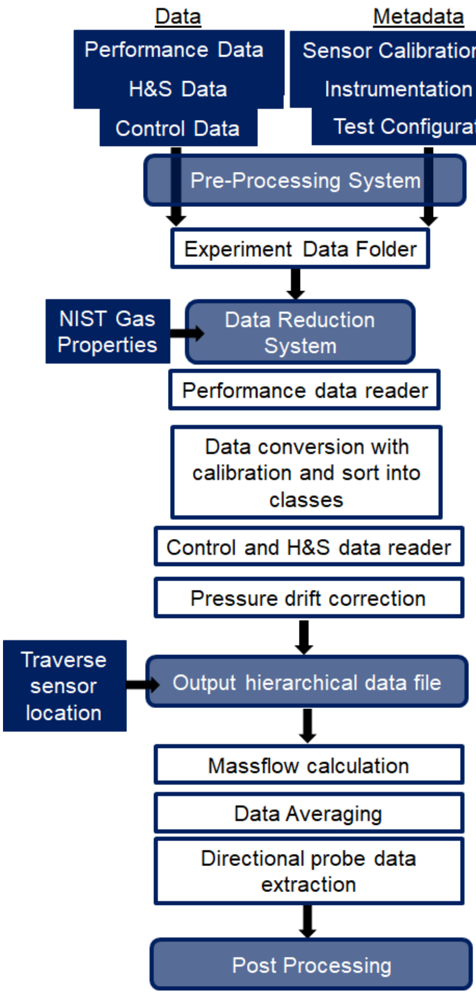

Figure 1. Data processing routine

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