Measurement and Calibration of Centrifugal Compressor Pressure Scanning Instrumentation

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Pressure Scanner Calibration

- In collaboration with Honeywell, the High Speed Compressor facility at Zucrow Laboratories has built a centrifugal compressor test cell with instrumentation to characterize the compressor performance at varying conditions
- Pressure transducers "drift" from their original sensitivity and offset calibration over time
- Outsourcing calibration is costly and causes significant downtime
- A pressure calibration process was automated with LabVIEW software to interfaces with a CPC6000 calibrator and the Digital Sensor Array (DSA) pressure scanners
- The LabVIEW VI is able to calibrate the DSA pressure scanners to within 0.05 FS measurements

Centrifugal Compressors and Instrumentation

- The basic components of the jet engine are: inlet, compressor, combustor, turbine, and exhaust
- The compressor increases the pressure of the air to prepare it for combustion (two types of compressors: axial and centrifugal)

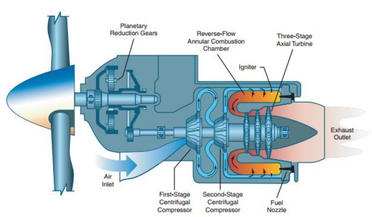


Figure 1: Air Flow of a Turboprop Engine (FAA Airplane Flying Handbook)

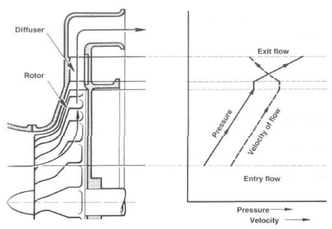


Figure 2: Centrifugal Compressor Air Flow (Jet Engines: Fundamentals of Theory, Design and Operation)

- Highly sensitive instrumentation is implemented to measure pressure, temperature, air flow rate and impeller velocity
- The Honeywell Test Cell at the High-Speed Compressor Laboratories utilizes Scanivalve piezoresistive pressure scanners

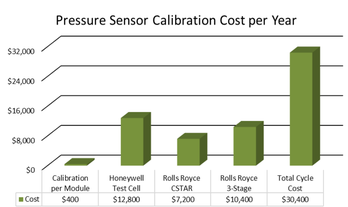
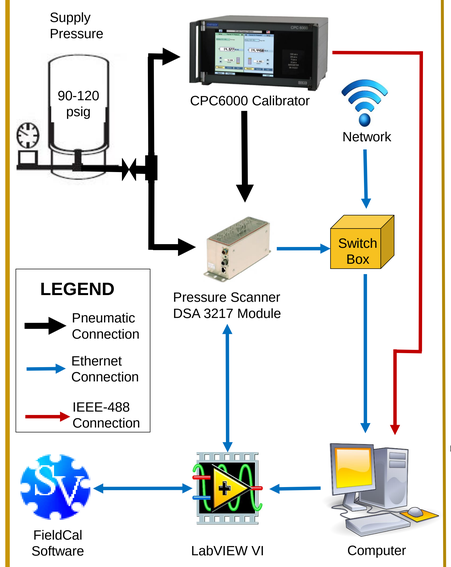


Figure 3: Calibration costs per pressure scanner module (Quote from Scanivalve Corp.)

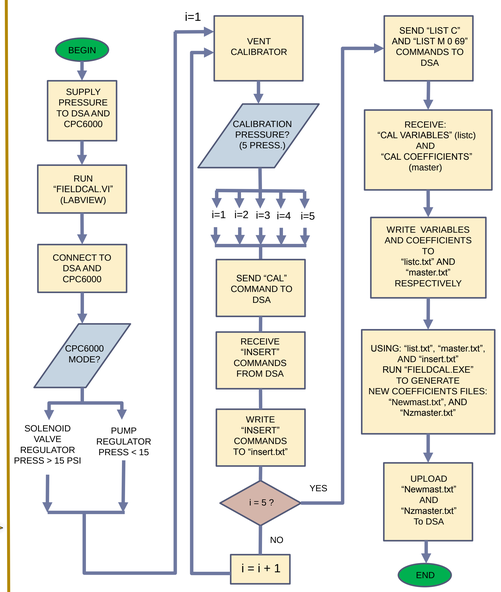
- A CPC6000 pressure calibrator was purchased, and a LabVIEW visual instrument (VI) was developed to interface with the calibrator and calibrate the Scanivalve DSA3217 5.0psid pressure scanner module

Systems Communication and Logic

SYSTEMS COMMUNICATION



LABVIEW LOGIC FLOWCHART



Calibration Results

Source Press.	Device Press.	Delta	% Error	Tolerance	Failed
-5	-5.0053	0.0053	0.106	0.05	****
-3.75	-3.7544	0.0044	0.087	0.05	****
-2.5	-2.5035	0.0035	0.069	0.05	****
-1.25	-1.2528	0.0028	0.055	0.05	****
0	-0.0009	0.0009	0.017	0.05	
1.25	1.2503	0.0003	0.006	0.05	
2.5	2.5008	0.0008	0.015	0.05	
3.75	3.7512	0.0012	0.023	0.05	
5	5.0017	0.0017	0.034	0.05	

Figure 4: Table of pressure measurements prior to calibration of channel 1 from DSA3217

Source Press.	Device Press.	Delta	% Error	Tolerance	Failed
-5	-5.0013	0.0013	0.026	0.05	
-3.75	-3.7514	0.0014	0.028	0.05	
-2.5	-2.5009	0.0009	0.019	0.05	
-1.25	-1.2515	0.0015	0.029	0.05	
0	-0.0006	0.0006	0.011	0.05	
1.25	1.2498	-0.0002	-0.004	0.05	
2.5	2.4998	-0.0002	-0.004	0.05	
3.75	3.7496	-0.0004	-0.008	0.05	
5	4.9992	-0.0008	-0.016	0.05	

Figure 5: Table of pressure measurements after calibration of channel 1 from DSA3217

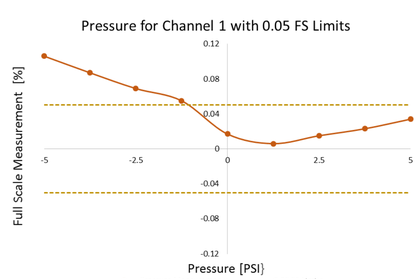


Figure 6: Graph of pressure measurements prior to calibration with 0.05 FS limits

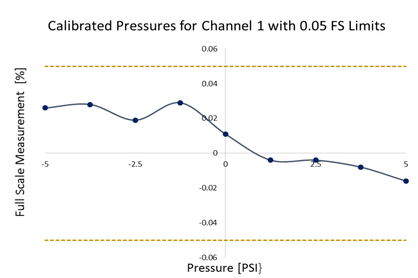


Figure 7: Graph of pressure measurements after to calibration with 0.05 FS limits

Discussion

- The LabVIEW VI was designed around a Scanivalve "executable" program, called "FieldCal". Calibration commands are provided to FieldCal, at one temperature (~30C)
- FieldCal produces new calibration coefficients for all temperatures between 0C - 69C
- LabVIEW overwrites the DSA pressure scanner's previous calibration information to read measurements within 0.05 FS

$$FS\ \% = \frac{Pressure\ Standard - Device\ Pressure}{Module\ Pressure\ Range} * 100$$

- The results show the calibration information from channel 1 of 16, where the VI reduces the max FS % value from 0.106 to 0.029 after calibration
- The LabVIEW overwrites calibration information of all 16 channels of the DSA3217 module

Conclusion and Future Work

- LabVIEW VI can interface with both, calibrator and DSA module, to perform a fully automated calibration
- The integrated VI can achieve calibrated measurements within 0.05 FS
- Further work can be done to condition the VI to calibrate up to 8 modules at once within 10-15 min
- The VI can be modified to calibrate other DSA models (such as DSA3016) at varying pressure ranges: 2.5psid, 5.0psid and 100psid
- Results will be used to maintain measurement fidelity in compressor experimentation

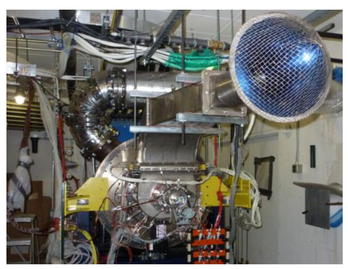


Figure 8: Honeywell Centrifugal Compressor Test Cell

Figure 9: Scanivalve DSA3016 8 module enclosure

Acknowledgements

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