

# INTEGRATION OF DATA ACQUISITION TECHNOLOGY

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***Abstract** - This paper will explore the dynamics of integrating data acquisition technology into a university level course. The complete process from instructor training and competence, to end delivery of materials in a digital format, will be explored. The equipment necessary, the supporting material development required, and the costs will be shown. This paper will be based upon my experiences at Purdue University. I implemented a complete unit of instruction related to data acquisition and diagnostics into my aircraft powerplant technologies course. I prepared digital classroom materials, developed supporting laboratory projects, and programmed the equipment to support our specific needs. The result has been a comprehensive introduction to data acquisition and diagnostics for our students.*

## **INTRODUCTION AND CONTEXT**

I would like to review some of my experiences with integrating data acquisition and virtual instrumentation (VI's) into my powerplant courses at Purdue University. The implementation of the equipment and procedures was a natural evolution of our educational goals. The more we discussed the inner dynamics of an engine, the more the students and I wanted to measure specific parameters and show their values over time. This activity gave us a window of insight into the effects of changes that were introduced into the engines.

Intentional modifications, as in a troubleshooting exercise, or unintentional changes, such as a component failure, both provided a host of indications to be measured and evaluated. The quality and quantity of the information available from utilizing digital data acquisition was a welcome change from interpreting analog gages of questionable calibration.

## **BACKGROUND**

The evolution of the courses in this particular area of interest began with installation of standard aircraft EGT and CHT instruments in each of our seven, piston engine running stands. This was a step foreword from the past. It allowed the students to more accurately diagnose engine malfunctions. The instruments were single probe, single cylinder units. Although an improvement, many of the students recognized the need for information from all of the cylinders in order to effectively pinpoint malfunctions. This led to the purchase and installation of a Graphic Engine Monitor system in one of our operational engine stands. The GEM provided multipoint EGT, CHT, and TIT indications during engine operation but lacked the ability to record data for later analysis. The unit was prohibitively expensive to install in all of our running stands. The need for a system that was portable, and could

be used on multiple engines, was identified. Another disadvantage of the GEM was the display was fixed and could not be modified to more clearly show indications. The students had trouble distinguishing the bars from the gaps between bars, or the significance of EGT being a relative temperature while CHT was represented in degrees Celsius. Clearly, a multipoint system that was flexible in its display options, and easily transported, was needed.

## **DESIGN AND CONSTRUCTION**

The LabView diagnostic center was constructed with portability and flexibility as primary goals. The center could accommodate turbine, as well as reciprocating engine, data acquisition. This flexibility was of primary importance as the cost was shared between several areas of the curriculum. The parameters to be measured included multiple temperature and pressure inputs. The "channels" as they are called, were not greatly different from turbine to piston engines. The display screens are very similar and the operation is consistent. This helped student's transition easily from the piston engine measurements to the turbine as they progressed through their plan of study.

The diagnostic center consists of a rolling stand, PC, monitor, keyboard, DAQ (data acquisition) cards in a chassis, and the associated hoses and wiring to connect the components to ports on the outside of the stand. National Instruments Corporation provided all of the components except the PC and the wiring/hose harness and probes. The labels for the various inputs were made from magnetic cards and can be easily moved around the side of the cabinet for added flexibility. The stand requires only a 110-volt source, and the harness consisting of wires and hoses to connect the engine inputs to the appropriate port on the side of the stand. Each parameter to be measured is assigned a channel, and each channel is represented on the screen of the monitor. The signal can be shown as a conventional gage, a bar graph, a chart, or virtually any other visual representation imaginable, (virtual instrumentation). All of the signals can be displayed simultaneously, or a select channel can be shown.

## **USE IN CURRICULUM**

During a typical laboratory exercise, the data acquisition equipment harness and probes are attached, the data acquisition system is started, and the parameters are recorded to a file. The engine is operated throughout the required test sequence. At the conclusion of the exercise, the system is turned off and the harness stowed away for the next group. We have used this equipment primarily at

the end of the piston engine overhaul class as a way to measure the effectiveness and correctness of the overhaul. It has been invaluable in quickly identifying malfunctions such as mistimed magnetos, failed spark plugs, and plugged injectors. Additionally, it is easy to show the uneven cooling of an un-shrouded engine and its effect upon cylinder head temperatures. An observation that is made in the classroom, but not demonstrated, prior to this equipment being implemented.

The impact of this equipment and curriculum on the student's depth of knowledge has been very positive. Not only are students now more familiar with data acquisition engineering as a discipline, they are able to converse intelligently with industry personnel regarding engine performance and how that performance is measured. In speaking with personnel from Textron Lycoming, Caterpillar, and Teledyne Continental, among others, it became clear that this form of training would be valuable to employers as they make hiring decisions.

The curriculum, as it stands at this time, includes a brief classroom introduction to the hardware and programming principles involved. It also includes hands-on use of the equipment including harness and probe installation, operating, and data logging the results. The students are exposed to, and evaluated in, such fundamentals as: thermocouple operation and selection, transducer operation, and creation of simple VIs.

The future plans for this technology include a complete package of course work built around data acquisition and virtual instrumentation. The quantity of material will quickly overtake a small, dedicated portion of an existing course, as even a basic introduction is rather lengthy. Of course, in our case, the work will be aviation powerplant specific. The examples and projects will all relate to some aspect of aircraft propulsion. I note this because this technology is used in many other disciplines including medicine, racing, manufacturing, and the automotive industry.

### **INSTRUCTOR COMPETENCE**

One of the apprehensions my colleagues and I had going into this initiative was the need for instructor competence and training. This is not something that is "plug-and-play", it is not difficult to learn but the vast capabilities of the system can be overwhelming. The construction and initial set-up of the stand required support from our computing staff. I attended an introductory forty-hour training course offered by National Instruments. This course covered the creation of simple, functional, temperature and pressure measurement devices. I have practiced with the creation and implementation of virtual instruments every opportunity I get. I visited our

Mechanical Engineering labs where the students are introduced to this technology as a means of acquiring data for a host of engineering applications. I worked through their assignments on my own time and applied many of their techniques to my own projects. All of this effort was to elevate me to the level of beginner or novice. As I said before, this is a field of study, or career, in and of itself. I simply wanted to learn enough to apply it to our situation and to bring that level of insight to our students.

The other consideration that has become a concern with my colleagues and I is recurrent training. This equipment is used in one unit of instruction in each semester. This is not enough time for the instructor to remain current. If something malfunctions, or an upgrade to existing capabilities is needed, a person that is intimately familiar with the hardware and programming is needed. We had a situation where a graduate assistant was delayed momentarily in operating an engine for a final run because someone had turned the DAQ chassis switch off inside the cabinet and neither her, or the instructor in charge, knew the switch even existed. This is an ongoing commitment of resources including time for training and finances for repairs, upgrades, and replacements.

### **CONCLUSIONS**

As stated earlier, this is a significant commitment initially and has many related, ongoing, expenses. The rolling stand, PC, and LabView hardware/software exceeded \$10,000. At that point, it still had to be configured and calibrated. I was attending training during the configuration phase and when I returned, I programmed the system for our unique requirements. We have utilized graduate engineering students, literally rocket scientists, to help offset some of the cost that would have been required if we were forced to hire outside expertise.

I believe the application of this technology in our classes has had a very positive influence. Many students interviewing in the aviation manufacturing fields have reported being asked about their experience with data acquisition. Rather than the student muttering "data what" they were able to share their experiences with the interviewers. We are not trying to produce VI engineers. We are, however, trying to give our students a working vocabulary and some experience in this area. It seems that this was a natural evolution of our efforts to strengthen our applied research capability. The student benefits from the experience, the department benefits from the expanded capability related to research grants, and the instructor benefits from the technical training and professional growth.

