USING DATA ACQUISITION in the FLUID POWER LABORATORY

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ABSTRACT:

The fluid power laboratory provides many opportunities for automatic measurement of data. This paper discusses an experiment where data was acquired both manually and automatically. LabView[2] software and a data acquisition card were used to collect the data automatically. Methods for collecting the data are discussed for both the manual and automatic modes. Graphs are shown for both. The results are discussed briefly. Conclusions are made on the validity of the experiment.

MET 230 FLUID POWER, the COURSE[1]:

In the Mechanical Engineering Technology curriculum at Purdue University, sophomores take their first course in fluid power – MET 230. In the Ball State University Manufacturing Engineering Technology curriculum, this same course is ITMfg 340, which is the only fluid power course these students take.

Some of the topics covered include the following:

1. Fluid properties – pressure, head, viscosity, density, specific weight, specific gravity, bulk modulus, Pascal's principle
2. Continuity and Energy equations – steady state development and use of the conservation of mass and conservation of energy as it applies to liquids.
3. Conduit sizing and head loss – development of the equations for sizing the conduits for the hydraulic system and use of the Reynolds number and the Darcy equation for computing headloss in the system.
4. Pumps – study of various kinds of pumps from a geometry and performance perspective.
5. Actuators – study of both linear and rotary actuators. This includes the study of hydraulic motors from a geometry and performance perspective.
6. Valves – study of directional control valves, pressure control valves, flow control valves.
7. Measurement devices – study of various means of measuring the fluid parameters, as well as converting these fluid parameters into measurable signals.
8. Electrical controls and circuits – study of electrical components and how these control a hydraulic system.
9. Miscellaneous – study of seals, reservoirs and other components of a hydraulic system.
10. Introduction to pneumatic systems – an introduction to pneumatic systems is done in the last 3 weeks of the course.

Homework problems are assigned weekly pertaining to the topic of the week. In addition, problems centered around the energy equation are offered for extra credit. These optional problems are increasingly more difficult from the first to the last assigned. The students that choose to solve these problems become adept at solving Bernoulli's equation.

Report writing is a major part of MET 230 Fluid Power. The students write four formal and five informal reports in the course of 15 weeks. By the end of the semester, the students have not only learned how to collect data for the experiments described, but how to assimilate and present the data in an understandable manner.

A design project is assigned about week 12 of the semester. These projects involve sizing, selecting and configuring hydraulic components to solve a design problem. Some problems solved are a log splitter, tubing bender, can compactor, regenerative circuit, clamp and press fixture. At the conclusion of the project, each individual completes a formal design report and the team makes an oral presentation of the results.

MET 230 FLUID POWER EXPERIMENTS:

A total of nine different experiments and/or exercises are performed during the semester. These begin with symbols and drawing schematics and end with an exercise in sizing and selecting of hydraulic components. Some of the experiments are as follows:

1. Fluid viscosity – In this experiment, the students measure viscosity and other fluid properties and write a formal report on the findings.
2. Pump performance – efficiencies of the pump are computed from measurements made on a pump.
3. Motor performance – loading on a motor is simulated and from that efficiencies are computed or an attempt is made to compute these efficiencies. This experiment is being redesigned to make the measurements actual and the computation of the efficiencies realistic.
4. Cylinder circuits – a study of both a normal cylinder circuit and a regenerative cylinder circuit.
5. Pressure drop through a directional control valve – This experiment involves reading pressures on both sides of a DCV while the flow rate through the valve varies. This is done both with manual data acquisition and using LabView as described below.
6. Miscellaneous – Other exercises are, symbols and drawing schematics, using catalogs, fluid conductors and relief valve study.

PRESSURE DROP EXPERIMENT:

Computation of head loss is accomplished using Darcy's equation for straight pipes. Computing losses for fittings, valves, bends, etc. is done by use of constant factors (K factors). The students are allowed to believe that the K factor is constant and not a function of the velocity through the valve. However, when it comes to directional control valves, the students are shown that some manufacturers provide charts for the pressure drop as a function of the flow rate through the valve.

One of the experiments done in MET 230 Fluid Power is to measure the pressure drop through a directional control valve and compare the findings to the data presented by the manufacturer. In the past, the data collection for this experiment has been done manually. That is, a flow rate was set by moving the system flow control valve until the digital flow meter read a certain value, then record the pressure at the P port, A or B port (depending on valve position), and T port of the valve. Depending on the number of data points, this approach can take a considerable amount of time. In addition, it's not likely that this would be done in a real world setting. Notice the schematic in Figure 1, the flow is read from the flow meter labeled Flow, while, the pressure at the P port is P1, T port is P3 and the pressure at A and B are read at P2. A photograph of this stand is shown in Figure 4.

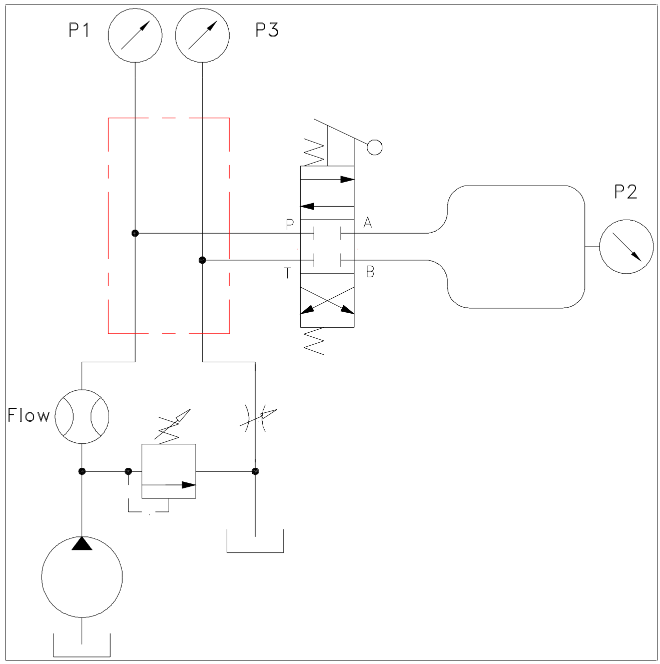

Figure 1 Schematic for the Experiment

In recent years, this experiment has been modified at Purdue-Muncie to collect the data both manually and using LabView and Excel. There are a number of reasons for this. Namely:

1. Provide an exposure to automatic data acquisition utilizing a computer.
2. Provide an opportunity for the students to examine the transients in the fluid power system.
3. Provide a challenge in manipulating and presenting the data in an understandable form using a computer and a spreadsheet.
4. Provide an exposure to electronic devices that have not been available to this point in their education.
5. To expose the students to how pressure and flow are measured using electronic devices and how that data is transformed so it can be read into a computer.
6. Provide an opportunity for the students to compare real world data to "sanitized" data.

Each of the hydraulic stands has one digital pressure meter with its pressure transducer. The experiment requires a simultaneous reading of three pressures for one flow reading. To accomplish this, one stand provides the valve and one pressure transducer/meter, while two others provide the other pressure transducers/meters. The pressure meters used have a 0-10 V analog output on the back of the meters. The flow meter is provided by the stand that also has the valve being measured. It too is a meter with a 0-10 V analog output.

The data acquisition board is a National Instruments[4] AT-MIO-16E-10[3]. The 16E-10 has 16 single ended analog inputs or it can be configured for 8 differential inputs. The maximum sample rate is 100 khz with a 12 A/D converter. Eight digital channels and two counter/timers are also available. A lower priced board could be used as long as there are enough inputs available and the sample rate is high enough for the signals being recorded. A sample rate that is ten times as fast as any signal you expect to see should be used. Hydraulic transients are interesting to see and challenging for the students to explain. The experiment described, used a sampling rate of 20 samples per second/channel. This experiment requires four simultaneous inputs. However, it could be modified to allow for automatic triggering of the data collection from an input on the fluid power stand; say, a beginning pressure value or some other input. Of course this would require an additional port. In our case, data collection is begun from a software toggle switch on the VI (Virtual Instrument) front panel.

The software being used is Labview for Windows Version 4.01. LabView uses a graphics language and control method to show what looks like an instrument panel. This VI has controls for start/stop, sample rate values, graphs and indicators for each channel being measured. The data streams to a file on the computer's hard drive while it is being displayed on the graphs and indicators on the VI. After the data collection is complete, the data is read into Excel for manipulation and presentation.

Some examples of the Labview collected data and the hand-collected data are shown in figures 2 and 3 respectively.

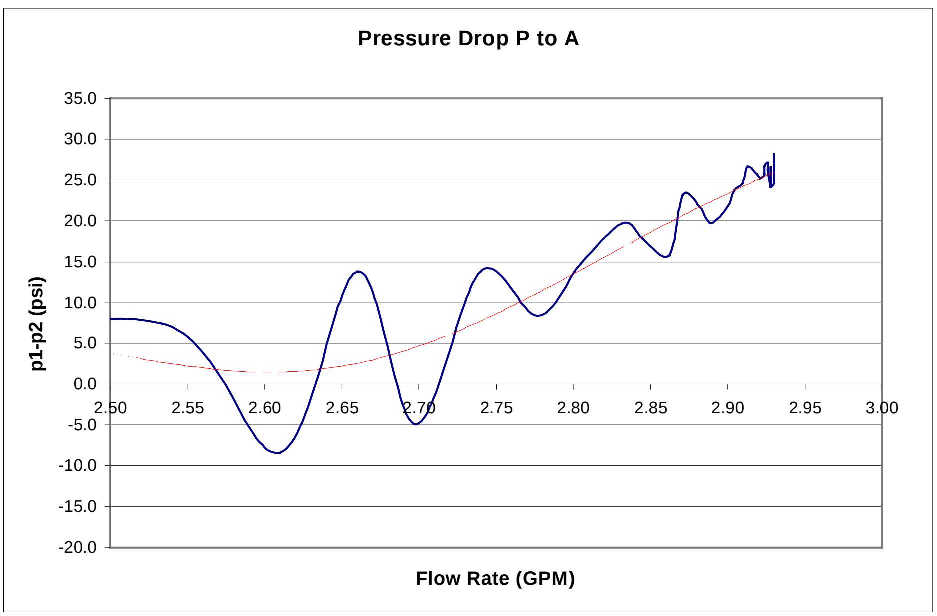

Figure 2 Data from LabView

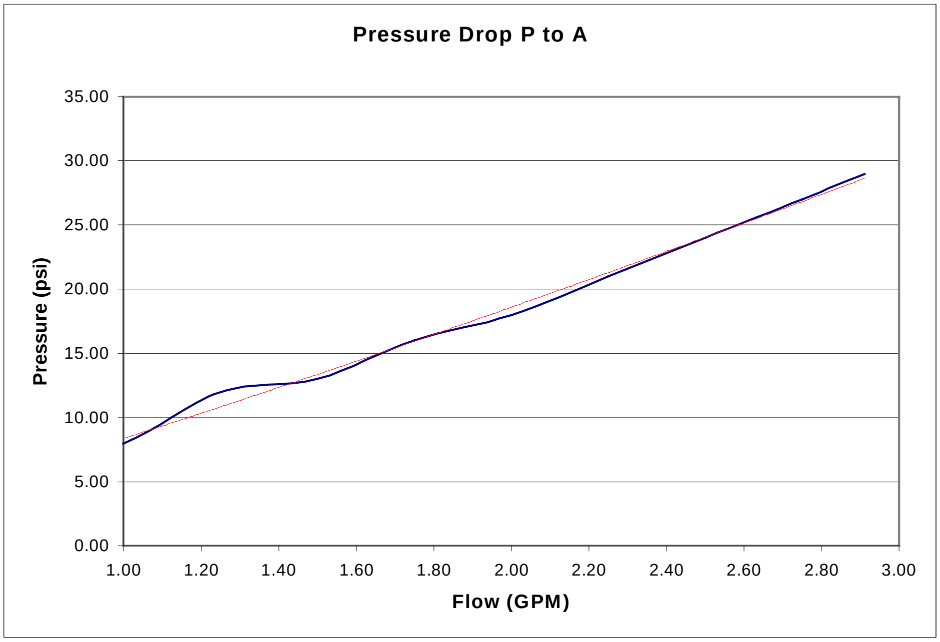

Figure 3 Hand Collected Data

As can be seen from the LabView graph, there are challenges for the student to determine the validity of the data collected and how to interpret the data. Some questions that can be asked are:

1. Why the difference in the graphs?
2. Why are there such large fluctuations in the DAQ graph?
3. What can be changed in the DAQ system or method of collection to make the data more reasonable?
4. How can an equation be obtained for the data?
5. How can the equation(s) obtained be used to predict values?

CONCLUSIONS and RECOMMENDATIONS:

This experiment is pushing the envelope for students in the second year of a mechanical engineering technology curriculum. The students do not have a good background in electronics or electrical technology. However, exposure to computer data acquisition and data manipulation using Excel can be introduced at this juncture in the curriculum.

The understanding of phenomena observed and how to interpret the results is quite a challenge for the students. Again this is pushing the envelope somewhat. It is clear, however, that the challenge is good for the students and something will be gained for them in their future studies because of the experience.

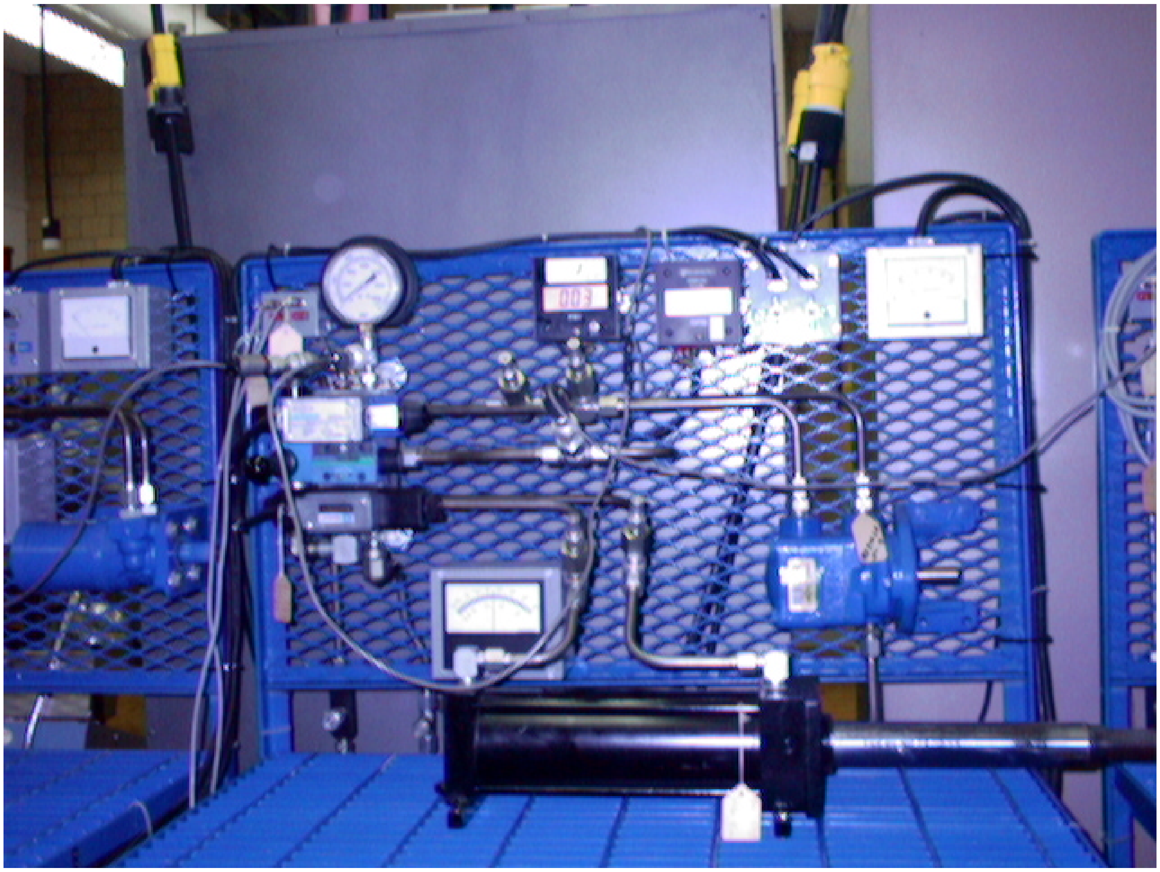

Figure 4 Photo of the Hydraulic Stand

REFERENCES:

1. Esposito, Anthony, *Fluid Power with Applications*, 4th ed. Upper Saddle River, NJ: Prentice Hall, 1997
2. LabView is a software product of National Instruments, Austin, TX
3. *AT-MIO-16E User Manual*, National Instruments, Austin, TX
4. National Instruments, Austin, TX 800-433-3488

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