PARKER HANNIFIN TEST STAND

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Abstract – *This paper will review a partnership between Parker-Hannifin Mobile Cylinders and Youngstown State University (YSU). The Mobile Cylinders Group makes hydraulic cylinders for municipal trash trucks and large mining equipment. Their mechanical design team needed a way to cycle the cylinders continuously in a laboratory environment for failure analysis. Parker-Hannifin had all of the necessary mechanical and hydraulic equipment necessary for testing but lacked experience in automation. The Electrical Engineering Technology Department at YSU was able to design a Programmable Logic Controller (PLC) based control system for Parker-Hannifin to order. A YSU undergraduate student worked under the guidance of a faculty advisor to fully install, wire, PLC-program, Human Machine Interface (HMI) program, and commission the test stand over the course of a single semester. A complete set of CAD drawings and documentation was also provided by the YSU student. This hands-on experience allowed the student to apply her basic knowledge of PLC's to a working process and learn more about sensors, industrial wiring practices, and programmable interfaces than can be taught in a classroom. It also provided an opportunity for the engineering technology department to become familiar with the latest Rockwell Automation PLCs and HMI's.*

Index Terms – PLC Programming, HMI Programming

INTRODUCTION

Parker-Hannifin Needs

Parker Hannifin Mobile Cylinders supplies hydraulic cylinders for demanding applications such as municipal trash trucks or mining equipment. The harsh environments where these cylinders operate lead to some unique design challenges. The cylinders must be very rugged, handle extremes in temperature and humidity, and operate hundreds of times a day.

Parker Hannifin opened a test laboratory in Mineral Ridge, Ohio where new cylinder designs could be tested. The goal was to cycle a set of cylinders over a million times and examine wear patterns and failure points. The information garnered from these tests could help Parker Hannifin refine the manufacturing process to make a longer lasting cylinder.

The mechanical design engineers at Parker Hannifin came up with a hydraulic control scheme for testing the cylinders. This design is shown on the following page in Figure 1. Custom Hydronics of North Lima, Ohio was able to modify a previously built test stand using parts supplied by Parker Hannifin and connect the piping and hoses. This test stand uses 4 solenoids to control the hydraulic system: one to charge the accumulator, two to extend and retract the cylinders being tested, and one accumulator safety solenoid. Two adjustable pressure switches were installed to monitor system pressure. A low oil switch was also installed in the oil reservoir. A thermocouple in the reservoir also provided oil temperature information while 2 cooling fans were mounted above the pump motor for system cooling. The thermocouple was wired to a ¼ DIN PID controller for temperature readout and relay control.

The engineers wanted to create an automatic test to cycle the cylinders up to 1,000,000 operations at a time. The auto test also required an adjustable time setting for the cylinder to remain extended or retracted and an adjustable time setting for bleeding the system between cycles. In addition, appropriate safety functions were required to abort the test automatically if the system was unattended.

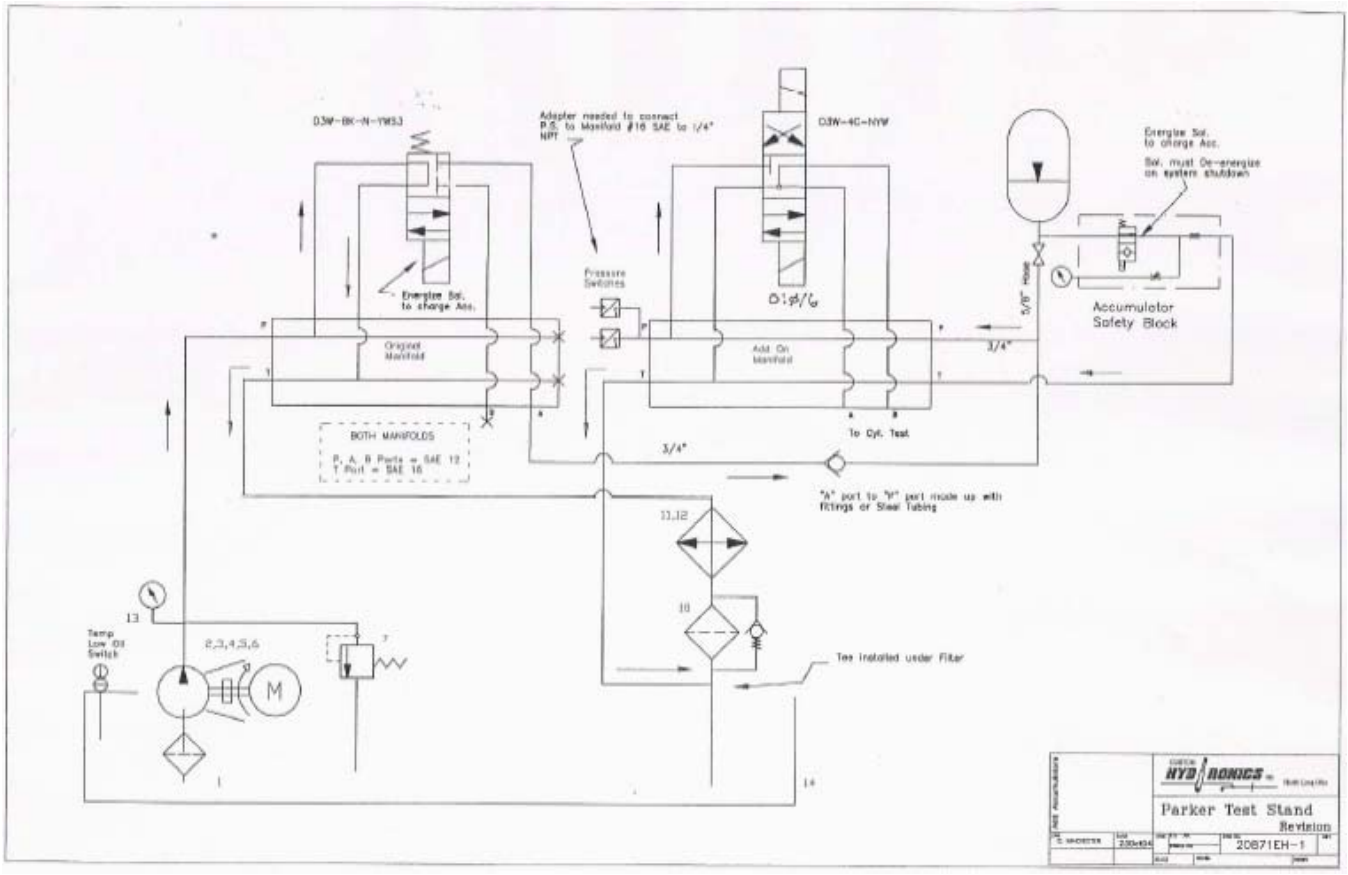

Figure 1 – Hydraulic Test Stand

YSU Commitment

The labor agreement between Youngstown State University (YSU) and the Youngstown State University Chapter of the Ohio Education Association allows the Administration to grant release time from teaching duties to faculty members pursuing professional development. This release time is based on competitive proposals submitted by interested faculty members. After speaking with the design engineers at Parker Hannifin regarding their test stand, I submitted an application to YSU for 4 hours of release time spread over two semesters to help them design and commission their automatic test system. The goal of this project from the perspective of professional development was to learn how to program Allen-Bradley's latest generation of PLC processors and HMI's using ControlLogix and RSView. Based on that experience, suitable PLC and HMI equipment would be purchased for YSU's Fundamentals of PLC's Lab (EET 3712) and new laboratories written. Parker Hannifin agreed to purchase all materials while YSU would supply the necessary engineering to develop the system.

In addition, a sophomore EET student, Denisha Crockett, had won a scholarship for undergraduate research in applied engineering. The requirements for this scholarship included work with a faculty advisor to perform an engineering project over a single year and write a detailed report on the experience. Using her background in EET and with guidance, Denisha was able to perform basic programming changes to the PLC and HMI, create wiring schematics, perform start-up and commissioning assistance, and make a detailed user manual for the hydraulic test stand. This hands-on experience far exceeded anything that could be done in a classroom setting.

TEST STAND DEVELOPMENT

Equipment Specification and Wiring

The existing test stand had an electrical control panel with hardwired relays and pushbuttons. This panel was re-used for the new test stand but a new backplane was installed. Some of the existing pushbuttons were retained for manual operation of the solenoids, system on/off control, and emergency stops. The YSU faculty member developed a list of required parts for Parker Hannifin to order from the

local electrical distributor. This included the appropriate PLC, HMI, fuses, starters, software, and programming cables.

The YSU faculty member then worked with Denisha Crockett to demonstrate how inputs and outputs are selected from mechanical prints and converted into a wiring scheme. These hand sketches were then used by Denisha to create AutoCAD drawings which include wire numbers. A simplified sketch of the electrical system that was later used as a final exam in EET 3712 is shown below in Figures 2.

Figure 2 – Hydraulic Test Stand I/O Schematics

Denisha also assisted the YSU faculty member in installing and wiring the panel at Parker Hannifin's Mineral Ridge Laboratory. This allowed her to gain some practical experience using power tools and hand tools as well as good wiring practices. It also gave her some familiarity with the National Electric Code regarding control panels and wiring practices.

PLC Programming

The design engineers at Parker Hannifin were able to make a brief step-by-step procedure of how the auto test was to function. They also laid out the safety criteria and interlocks required for the system. The YSU faculty advisor wrote the PLC code with Denisha observing since she had not yet taken EET 3712. By the end of the project, Denisha was proficient in understanding the basic relay, timer, and counter instructions covered in EET 3712.

In addition to the basic instructions, Denisha was also exposed to the process of moving data between a PLC and a higher level controller like an HMI. This type of instruction is beyond the scope of EET 3712 in its present form. She was also

aware of the documentation required in rung comments, instruction labeling, and reports required for future engineers to understand a PLC program. Since she put together the operating manual for the test stand, she appreciated the value of good program commenting.

HMI Programming

Figure 3 shows the HMI screens for this process. Animation was included to show the status of the key inputs and all 4 solenoids. These screens were designed by the YSU faculty member based on input from the Parker Hannifin design engineers.

Figure 3 - Hydraulic Test Stand HMI Screens

Denisha was able duplicate existing items on the HMI and link them with the appropriate tags in the database. Several iterations of changes occurred due to requests by the Parker Hannifin design engineers. This allowed Denisha to become comfortable maneuvering in the HMI software.

Test Stand Commissioning

Prior to startup, a complete wiring checkout was performed. The YSU faculty advisor used this opportunity to stress the importance of pre-energized and energized checking during startup. Denisha assisted in the I/O checkout, pressure switch calibration, E-Stop testing, and functionality testing. This gave her hands-on exposure to common input and output devices as well as the systematic approach required for commissioning electrical systems.

Once the Parker-Hannifin design team was satisfied with the operation, several sets of cylinders were tested for failure analysis. Small changes were made to the PLC and HMI programs as the design team changed some criteria. Once these changes were installed, Denisha created an operator's user manual for the test stand. This test stand and all supporting documentation were then sent to a Parker Hannifin production facility in Arkansas.

BRINGING THE EXPERIENCE BACK TO THE CLASSROOM

EET 3712 – Fundamentals of PLC's

As noted previously, this course provides EET students with a basic understanding of PLC's and programming. The course also covers industrial control strategies such as hydraulic, pneumatic, and motor speed control systems. The final exam for 2005 was based on the Parker Hannifin Test Stand. Students were taught how to read the hydraulic print during the last week of class and how the wiring schematic was developed. The students were also shown the HMI screens and taught how I/O from the HMI resides in PLC memory.

The final exam then brought together all of the previously covered material by asking the students how to program timers, counters, relays, and move commands to control the hydraulic system. Samples of the actual code were also given to the students so that they could explain what part of the process they were controlling. This system is small enough for students to understand but includes all of the major elements taught in this fundamental course.

EET 3725 – Electromechanical Systems

This course is taken exclusively by MET students. They have a foundation in hydraulic systems through their fluid power courses. The MET students are not taught how to program PLC's but learn how to read electrical prints, select I/O devices from mechanical processes, and wire PLC's. They also learn how to read simple ladder logic programs.

The final exam in this gives the MET students the hydraulic print and a completely hard-wired control system. The students are then asked to sketch an I/O elementary based on the hard-wired system. They are also given simple rungs of ladder logic and asked how

they relate to controlling the hydraulic system. This is very popular with the MET students since they often find themselves troubleshooting hydraulic systems controlled via PLC.

Future Work

The existing EET 3712 class teaches students how to wire, program, and troubleshoot both Allen-Bradley and GE PLC's. As these processors have become out of date and the popularity of HMI's has increased, it became obvious that changes were required. The EET department has recently purchased new CompactLogix PLC's and PanelView Plus 700 HMI's from Allen-Bradley. The class will be altered to teach the students programming on a single processor but also include HMI programming as part of the course. New test panels are currently being constructed for this purpose. In addition, new laboratories and lectures for this course are being developed. It is anticipated that this revised course will be fully operational for Spring Semester 2007.

CONCLUSION

Effectiveness of Partnership

Several objectives were met as a result of this partnership. Parker Hannifin was able to receive free engineering services for automating their hydraulic test stand during a time of lean budgeting. YSU was able to provide faculty development on the latest version of Rockwell Automation products. This faculty development was then used to supplement the classroom experience of EET and MET students and paved the way for future course upgrades. Denisha Crockett, a sophomore EET student, was also able to conduct meaningful applied engineering as part of her scholarship criteria. This experience went well beyond what could be gained in a normal classroom environment.