ASEE's 123rd Annual • Conference & Exposition • New Orleans, LA • June 26-29, 2016

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Paper ID #17334

A Non-Commercial Pneumatic Trainer with PLC Control

Dr. Maged Mikhail, Purdue University - Calumet

Dr. Maged B. Mikhail, Assistant Professor, Mechatronics Engineering Technology Ph.D., Electrical Engineering, Tennessee State University, Nashville, Tennessee, August 2013. Dissertation title: "Development of Integrated Decision Fusion Software System For Aircraft Structural Health Monitoring" M.S., Electrical Engineering, Tennessee State University, Nashville, Tennessee, May 2009. Thesis title: "Development of Software System for Control and Coordination of Tasks among Mobile Robot and Robotic Arm." B.S., Electrical Engineering University of El Mina Cairo, Egypt, May 2001.

Prof. Gregory P. Neff, Purdue University - Northwest

Gregory Neff is professor of mechanical engineering technology at Purdue University Northwest, Calumet campus. He is a Registered Professional Engineer, a Certified Manufacturing Engineer, and a Certified Manufacturing Technologist. Greg is active in ASEE where he won the Meryl K. Miller award in 1994 and in SME as faculty advisor for SME student chapter 161 and an advisor for Tau Alpha Pi. He is a member of ASHRAE and sponsor of student members. He is active in ASME, where he has served as chair in 2001-2002 for the Mechanical Engineering Technology Department Head Committee (METDHC) of the American Society of Mechanical Engineers (ASME). He also served the METDHC as as vice-chair responsible for METDHC technical sessions at the 2001 International Mechanical Engineering Congress and Exposition in New York and secretary in 1999-2000. Greg has represented ASME as an MET accreditation program evaluator or team chair visiting twelve schools between 1996 and 2006 and served as a member of the ASME Committee on Technology Accreditation from 2002 to 2006. He served on the Technology Accreditation Commission of the Accreditation Board for Engineering and Technology (now ETAC/ABET) as an ASME Commissioner with a term that started in summer 2003 and continued as an alternate member through 2006.

A Non-Commercial Pneumatic Trainer with PLC Control

In a mechanical engineering technology, mechatronics engineering technology, agricultural engineering, or instrumentation program, the fluid power course is a vitally important part of the curriculum. Purdue Northwest in Hammond, Indiana uses Vickers Hydraulic trainers for its hydraulics labs. This equipment and the hydraulic circuit experiments and documentation that accompanied the trainer gave students experiences that suited the needs of our manufacturing partners of the past.

With the recent rapid growth of our mechatronics engineering technology program, now larger than our EET program, we found our new automation and packaging industrial partners needed more pneumatics and PLC control than local manufacturing employers in the steel, automotive, and rail industries. The principles of pneumatics and control of pneumatic circuits lends itself particularly well to productive laboratory experiences in an instrumentation & control or mechatronics context to serve as a first introduction to PLC control.

Pneumatic actuators and solenoid valves are relatively inexpensive and can provide fast motion that catches the eye in lab when incorporated into an appropriate trainer. However commercial pneumatics trainers or PLC trainers are expensive and limited in what they can demonstrate.

Fig. 1 Final 80/20 Cart without Components Installed

We have prototyped a PLC controlled pneumatics trainer and are in the process of building 6 to 7 double sided stand-alone trainer carts. The carts are made from modular "Industrial Erector Set" parts from Fort Wayne Indiana-based 80/20 Inc.

80/20 makes industrial framing system parts with a catalog of over 1200 pages of components perfect to build custom professional looking racks, displays, carts, workbenches, or to build just about anything[1].

For this effort, senior project students[2], student manufacturing lab assistants, administrators, and faculty, together with world class industrial partners from the pneumatics and control industries who support our program collaborated.

One of our industrial partners, Bimba is a nationally-known pneumatics manufacturer with headquarters in the Chicago area. We are using their pneumatic actuators and circuit components, including some from the Mead and MFD subsidiaries of Bimba[3].

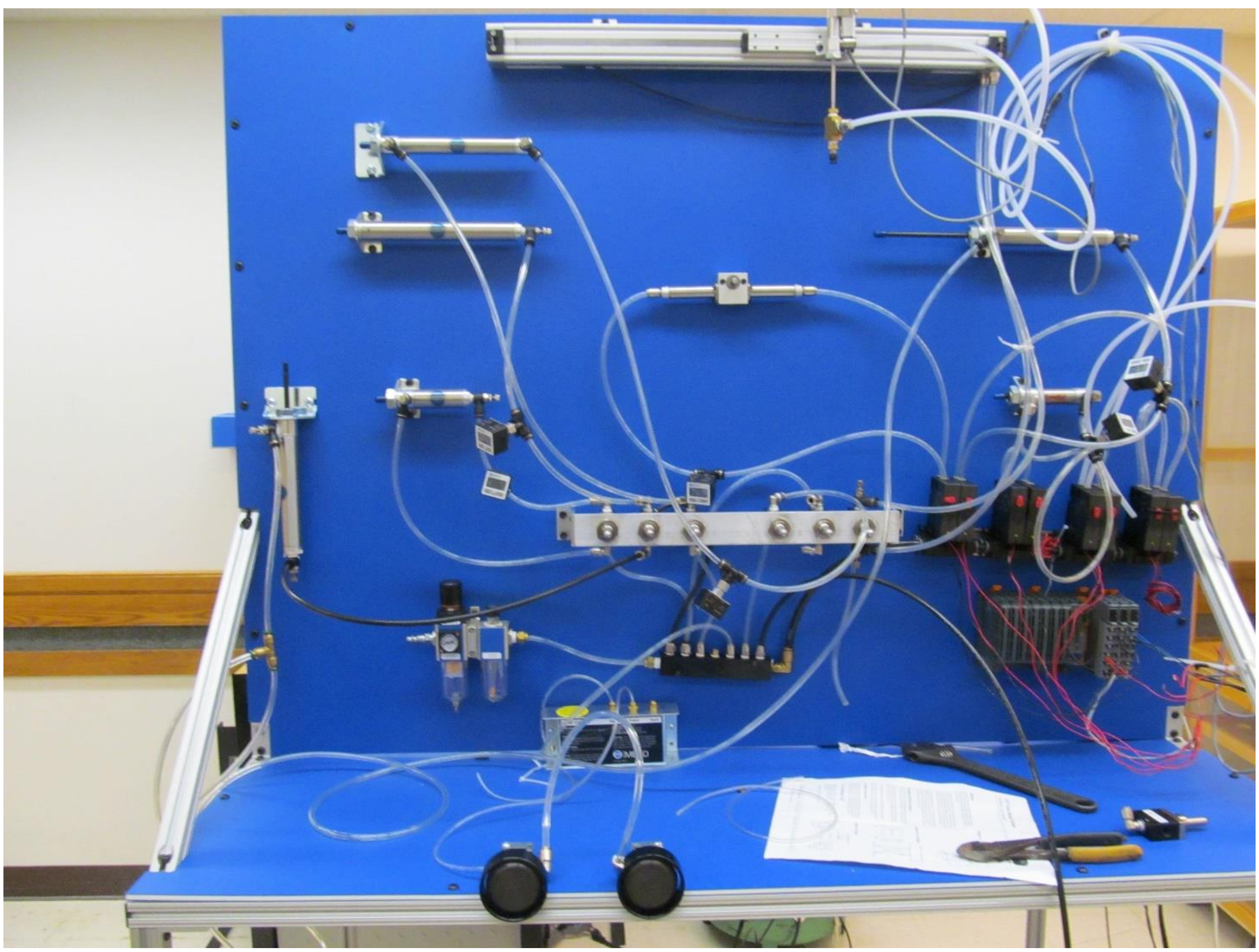


Fig. 2 Pneumatic and Control Component Prototype

Control components from B & R Automation have been used. B & R is an Austrian company with US headquarters in the Atlanta area. We are using 24 Volt DC X20CP1483 Pentium-level PLCs, I/O modules, Power supplies, B & R[4] Automation Studio control software, training hardware, and curriculum.

Our fluid power course uses the 7th Ed *Fluid Power with Applications* text by Anthony Esposito[4]. The pneumatic experiments that senior project students wrote and tested were mainly from those covered in the Esposito text. Two of these were simulated with Famitech Automation Studio software and included on a CD included with the text allowing the simulations to be compared to the experiment.

One of our goals is to perform some experiments done earlier in the semester with hydraulics equipment on the Vickers hydraulic trainers with the new pneumatic trainers to see how the different speed and characteristics of hydraulic motion compare to pneumatic motion in the case of meter-in, meter-out, and by-pass speed control. This demonstrates constant pressure air source driven motion rather than a constant flow hydraulic source driven motion.

Another experiment is see how well two cylinders can be moved in synchronization with manual control using series and parallel circuits with pneumatics compared to hydraulics.

The trainers will be used to teach how to control circuits with PLCs, utilizing ladder logic and structured text. Programming basics such as variable declaration, code structure, programming practices, and programmable actuation will be covered. Internal timers, external sensors, and position feedback cylinders will used. The Esposito text covers more than a dozen ladder logic automation controlled circuits with more than half simulated on the included CD.

An example of a PLC controlled circuit from Esposito's Chapter 15 that will be used as a lab with the ladder logic diagram:

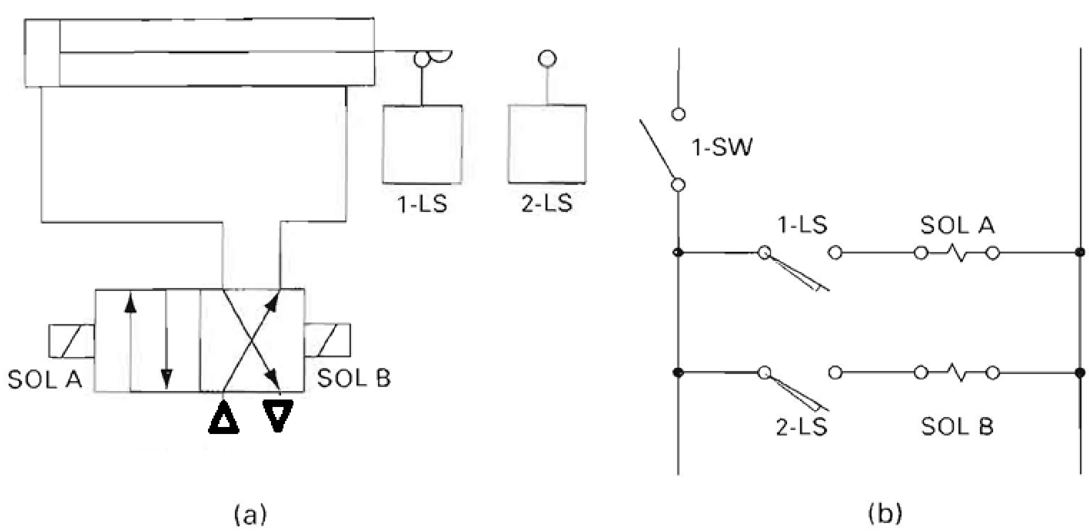


Fig. 3 Reciprocation of cylinder using limit switches

This experiment will employ a pneumatic cylinder with end of stroke switches or position feedback output. The cylinder will reciprocate back and forth. Then students will write an equivalent program using structured text. Then modify this program by putting delays at both ends of the stroke.

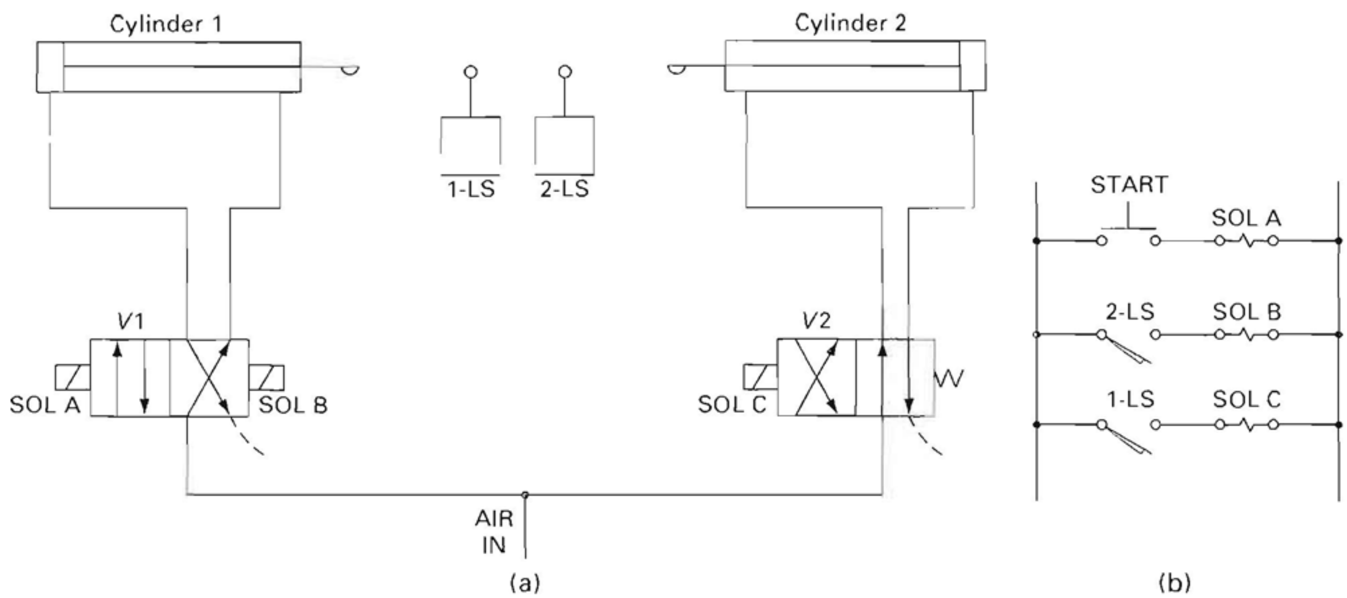


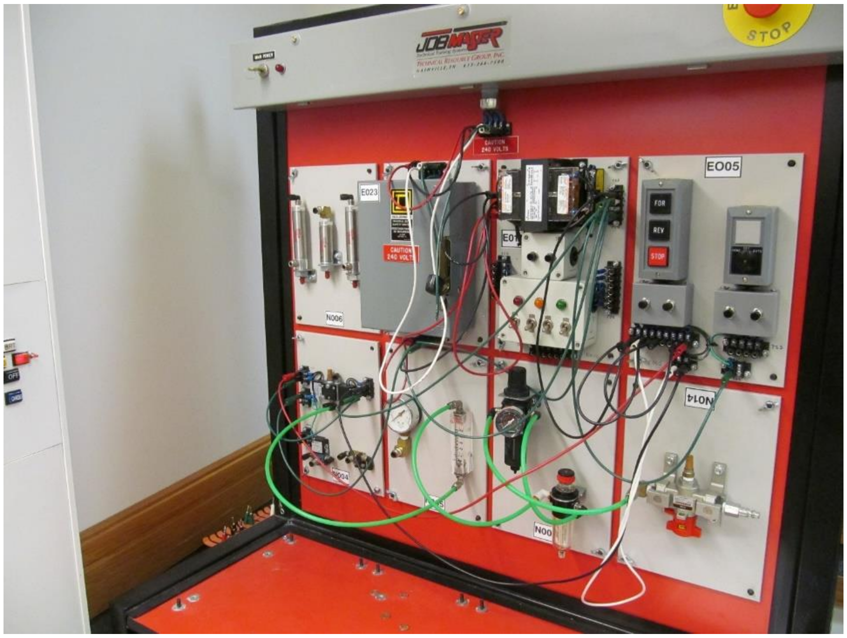
Fig. 4 Dual-cylinder sequencing circuit. ***(This circuit is simulated on the CD included with the textbook.)***

This circuit requires two limit switches, two double acting cylinders and two solenoid valves. The cylinder 1 starts to move when the start button is pushed. At the end of the stroke cylinder 2 extends. Then both cylinders retract together and the cycle is over.

Conclusion

These trainers will make it possible to introduce mechanical engineering technology and mechatronics engineering technology students to PLCs and introduce two of the IEC 61131-3 programming languages early in the curriculum since the fluid power course has only physics as a prerequisite. He, et al[6] have pointed out the usefulness of teaching students multiple IEC 61131-3 languages. The pneumatics projects provide a foundation for interfacing components into program projects like the one described by Kadir[7]. This first exposure to automation lays a good foundation for more advanced courses that will help qualify graduates to fill some of the estimated two million manufacturing jobs that are estimated will go unfilled due to a lack skills out of the three and a half million new jobs that manufacturing will need to fill over the next ten years[8]. Nine out of ten manufacturers are having difficulty finding skilled workers and they say this is directly hurting the bottom line, according to an SME survey[9]. Note that the Appendix shows a commercial pneumatics trainer used to demonstrate the use of electrical relays with pneumatics[10].

Appendix



JobMaster Pneumatics Trainer (Commercial uses 120 V Relay Automation) used for background knowledge.

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