INTRODUCING STATE-OF-THE-ART TECHNOLOGY INTO FLUID POWER LABORATORY

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Abstract ? The Department of Mechanical Engineering Technology at Purdue University has recently upgraded its fluid power laboratory. The upgrades include Automation Studio software, which has the ability to interface the software program with fluid power test stands over an interface box, as well as new modular test stands. The stands are designed to interface with the computer, but their major characteristic is, however, the opportunity for students to build their own circuits. The existing traditional stands need to be set up before the laboratory exercises start, and students have a limited opportunity to change the hardware setup. The new stands are designed to offer such opportunity. Each laboratory exercise starts with an empty slate, so there is no need for preparing the stands ahead of time. Students do the setup themselves. At the end of the laboratory exercise, students disassemble their circuits from the test stands, and leave them ready for another class, which can be on a completely different topic. This greatly reduces the preparation time for the staff. Another benefit is a greater involvement of students, who take ownership of their work, as well as experience more challenge from many problems they encounter. As this development is at the introduction stage, only preliminary experiences will be presented about how the new technology affects students' learning of fluid power topics.

DEVELOPMENT OF A MOTION CONTROL LABORATORY FOR FLUID POWER EDUCATION

Fluid Power Laboratory in the Department of Mechanical Engineering Technology applied for funds to the Otto Maha Fund at Purdue University to develop a motion control laboratory and incorporate it into the delivery of the MET fluid power program. The requested funds were intended to purchase new and upgrade existing equipment, and to perform all the work necessary to include it into the courses. The goal was to facilitate students' involvement in the laboratory experiments. It was expected that students would gain invaluable hands-on experience in building and troubleshooting of industrial-grade motion control systems. Test stands of a modular design were proposed, equipped with modern motion control hardware and software, which would allow students to build their systems from scratch and test them.

The proposed equipment was intended to be primarily used for advanced courses in fluid power, which have not been funded in pace with the technology development in recent years. However, students enrolled in the basic fluid power course would be able to use the stands, too. The stands could be used by every course without any need to rebuild them. Industry offers modular stands at a very competitive price. The modular design of the stands seemed to provide the best instructional flexibility available. The design of the stands follows practices used in fluid power education in Germany. Since the cost of this undertaking was over $150,000, it was spread over a four-year period.

FLUID POWER COURSES OFFERED BY MET

The courses described below are three-credit-hour courses with a two-hour laboratory component. With so many diverse courses with heavy laboratory use, the equipment in the laboratory needs to be versatile and adaptable. In the past, dedicated stands were used for hydraulic, pneumatic, controls, and data acquisition exercises. The laboratory technician would set up the stands ahead of time. It was not practical to allow the students to build the circuits on their own as part of their assignments, as this would be too time consuming. As a result, students lacked the opportunity to build the circuits themselves, and thus had reduced opportunities of learning by doing. The MET Fluid Power Laboratory serves the following six courses, which are taken by approximately 300 students per year:

MET 230 Fluid Power is a required introductory course for MET students. Students in several other departments may take MET 230 as an elective course.

MET 334 Advanced Fluid Power is an elective course, which includes the study of circuits with steady state and dynamic loading.

MET 382 Controls and Instrumentation for Automation is a required instrumentation course utilizing the fluid power

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laboratory for one third of its content. It involves data acquisition from motion control circuits.

MET 432 Hydraulic Motion Control Systems. This advanced course studies control system response using simulation programs to predict system stability.

MET 436 Pneumatic Motion Control Systems. Another advanced course, which offers the study of moving-part logic control devices as used in typical industrial applications.

TECH 581F Advanced Topics in Fluid Power is a graduate course for the study of advanced aspects of fluid power design, test, and instrumentation. Additional topics include computer simulation of hydraulic controls systems, dynamic pressure and noise measurements in fluid power circuits, and start-up transients in hydraulic drives.

The laboratory upgrade aimed to support courses on the advanced level, but the MET 230 basic undergraduate fluid power course would also benefit greatly. The goal was to combine hands-on laboratory exercises with the new technology available today. This technology refers to electronic control of fluid power systems, computer simulation, data acquisition, programmable logic control, and new ways of data transfer. The most effective way to achieve this goal seemed to be a switch to a fluid power stand of modular design, capable to serve the six courses.

The modular stands would expand the existing capacity for training conventional hydraulics and pneumatics offered on traditional pre-assembled stands. Thanks to the modular design of the stands, they could be used in all of our fluid power courses. Students would pick the components from racks, install and test them, and put them back on the racks at the end of the laboratory session. The next group of students could then use the same stand for a completely different project during the following hour. In this way, students would be able to build, run, and test the fluid power systems by themselves. Students using the traditional stands often express their desire to have even more hands-on learning, which is exactly what the modular test stands would enable.

Potential users of the new stands would be the Purdue University School of Technology students taking courses in fluid power. Upgraded equipment in the fluid power laboratory would also be a good promotional tool in organizing workshops for industry, high school teachers, and for distance education.

In addition to implementing new test stands of modular design, several instrumentation upgrades to existing data acquisition system and fluid power simulation software would be needed. It would make it possible for students to build control systems and check their designs by using simulation software. A new interface kit offered by Famic Technologies 2000 of Montreal, Canada, would allow controlling the modular test stands by using the Automation Studio software. [1] The kit would greatly enhance hands-on opportunities for students. It would allow them to build circuits for electric controls and run the stands from the computer. The above kit requires an interface card to be installed in the computer. Another option would be a serial connection interfacing the stand with the FluidSIM software offered by Festo[2], Hauppauge, N.Y

The budget proposal included four training stands of a modern modular design. Each stand would be double-sided with two independent fluid power supplies. They would come with all the basic components for teaching hydraulics and pneumatics.

The new equipment would require an additional effort to implement it into the courses, as all of the courses would need to be modified to accommodate the new laboratory equipment. This would be an excellent opportunity for student projects during this transition period.

SOFTWARE SELECTION

At first, budget constraints allowed us to only buy one license of the Automation Studio 3.0 software, which included hydraulic, pneumatic, electric (relay) and programmable logic control (PLC) modules. This license was running from the School of Technology server, and thus was accessible to more students and faculty. To facilitate the student access to the software, a demo version of the software was also installed in the Fluid Power Laboratory. Students were encouraged to install the free demo version on their home computers. The demo version was as functional as the full version, but did not allow for saving of the circuits. This was a drawback because students needed to start each circuit from scratch. For the beginners in using the software, this was not a big problem, however, because they were forced to repeat the creation process of each circuit. Otherwise they would use old circuits and only modify them. While this saves time, it has no benefit when a student learns the software. "Practice makes perfect" would be a good justification for using the demo software without the option of saving the work. It's like learning to ride a bicycle from scratch when you do not have the option to "save" your achievements. To document their work, students could capture the monitor screen to the clipboard and paste it into Word to report their work, as the demo software did not allow printing, as well. Famic Technologies still does not offer a cheap student version of the Automation Studio software. Festo does offer a student version of its FluidSIM 3 software with some restrictions compared to the full version. For example, the student version does not allow one to display exact values for pressure, flow rate, speed etc. during simulation. Also, no more than two cylinders can be used in a circuit simulation. Printing functions are not available. Although the student version contains all the functions of the full version 3.5, they are not all enabled. Unavailable options are displayed dimmed. This allows you

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to see the additional functionality available in the full version [2].

Fluid power simulation software is an excellent tool for drawing schematics. The software usually offers an extensive library of symbols. For a student, it is a hard work to learn the fluid power symbols from a textbook. It is much easier learning them by creating circuits. This knowledge comes naturally as a by-product of creating circuits. Another great advantage of the software is its ability to animate the circuits. This feature allows seeing which parts of the circuit are exposed to high pressure, and the symbols actually move as they do in a real system. Such software is also an excellent tool for a lecture allowing saving time to explain the functions of a circuit. Before selecting the software, it is advised to evaluate all available packages. As fluid power education is not a big market, this software tends to be a product of activities that may not be a major commitment of a company. Expect the software to do less than advertised, or involve a lot of commitment on the part of the user to master the software glitches.

HARDWARE SELECTION

The hardware upgrades to the fluid power laboratory should satisfy several criteria. First, the current laboratory space is limited, and introducing the new upgrades would require removing some of the existing equipment to make space for the new equipment. Next, the new equipment should be universal in order to satisfy the requirements of the six courses. In addition, the new equipment should be upgradeable to accommodate new components if needed in the future. The ability of interfacing the hardware with the simulation software would be an important feature, as well.

The current fluid power stands are designed for hydraulics, or pneumatics. Not for both. If the new stands could be used for both pneumatics and hydraulics that would save space in the laboratory. Since currently the stands need to be prepared ahead of time, there could be no time for the preparation, depending on the laboratory schedule. The natural solution is a modular test stand. It allows adding components in the future, as well as assembling the circuits by the students themselves. In this way, the stands are never pre-assembled. However, students need to disassemble their circuits at the end of their laboratory period, to make the stand ready for another exercise.

The DS3 Synergy test stand [3], see Figure 1, made by Bosch Rexroth was selected for the Fluid Power Laboratory. Each stand comes with one double-pump hydraulic power unit to allow one group of students to work on each side of the stand at the same time. In this way, four students can comfortably work on this stand. In total, four stands are planned to accommodate up to 16 students in a laboratory group. The stands come equipped with electrical controls (push buttons, timers, relays, limit switches, pressure switches), that allow for easy interfacing with the simulation software.

FIGURE. 1
DS3 SYNERGY TEST STAND MADE BY BOSCH REXROTH. HYDRAULIC POWER UNIT AND MOST OF THE COMPONENTS ARE NOT SHOWN.

Two of the DS3 Synergy test stands arrived in fall 2002 and proved to be a good choice so far. Students like to work with them. Several laboratory assignments have already been reworked for the new stands. There was a need to reduce the workload for the students, however, as they now need time to create the circuits before testing them. Students build the circuits on the stands, and on the computers as well, by using the Automation Studio software. Understanding of the circuits, and fluid power in general, seems to be improved.

SUMMARY

The Department of Mechanical Engineering Technology offers several courses in fluid power. There was a need to upgrade the equipment for all of the courses, due to significant changes and technical advances which have taken place in fluid power industry in recent years. The proposed equipment, and procedures developed based on it, will be used in all other fluid power courses. This will give our students the opportunity to access recent technology in fluid power, and gain hands-on experience in this area. Until recently, our hydraulic motion control equipment did not provide for computer control and simulation. The new equipment has been found to be an excellent tool for teaching basic principles in motion control. In order to limit the cost of the modernization, the current equipment will be used whenever possible in new applications.

REFERENCES

[1] http://www.automationstudio.com for Automation Studio software.

[2] http://www.festo.com for FluidSIM software.

[3] http://www.boschrexroth.com/BoschRexroth/business_units/brs/en/leistungen/didactic_2/training_systems/index.jsp for Bosch training stands.