

USING REXROTH BOSCH TEST STANDS FOR TEACHING PNEUMATIC CONTROL CIRCUITS

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1. INTRODUCTION

The Department of Mechanical Engineering Technology has recently upgraded its fluid power laboratory. The upgrade includes new pneumatic components to Rexroth Bosch fluid power test stands. The stands are designed for both hydraulic and pneumatic systems. They can also be interfaced with the computer software and electrical controls, as well as with data acquisition. The major characteristic of the stands is the opportunity for students to build their own circuits.

The traditional stands needed to be set up by the laboratory technician before the laboratory exercise started, and students had a limited opportunity to change the hardware. The new Rexroth Bosch stands are designed to offer such an opportunity. Each laboratory exercise starts with an empty slate, so there is no need for a set up. 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 the many problems they encounter.

Two new laboratory exercises presented in the following were developed for the fall 2004 semester of the MET 334 Advanced Fluid Power course to be completed on the Rexroth Bosch test stands with the pneumatic components. They are presented in an outline form to show the basic goals of the laboratory assignments. On the old pneumatic stands, it was not possible to assign similar exercises as the old stands were not equipped with the pilot-controlled pneumatic valves. They allowed only for building simple cylinder-control circuits, with one solenoid-operated pneumatic valve. Students were required to assemble the pneumatic circuit, but they had only very limited options as there were only a few components to be connected. As a result, students faced little challenge in the assignments on the old stands. The new test stands offer a multitude of pneumatic components, including five pneumatic cylinders (one with attached mass), 16 directional control valves (DCVs), logic elements, amplifiers, gauges, and much more. Currently the fluid power laboratory has four sets pneumatic components for the new test stands. We are considering purchasing four more due to their ease of use and great educational values, and much lower price than the hydraulic components. Students can learn building and troubleshooting fluid power circuits by starting with using pneumatic components, and only later

apply the knowledge to the hydraulic components. One other advantage of using pneumatic components first is that there is no need to run the hydraulic power units which generate noise and heat.

2. EXERCISE: CONTROL OF A DOUBLE-ACTING PNEUMATIC CYLINDER

Students receive a complete list of all pneumatics components currently available on four test stands, see Table 1. The four basic kits of pneumatic components do not include any electrical control, so we limit our assigned circuits to manual, mechanical, and pneumatic-pilot control. Students use a double-acting pneumatic cylinder, a pilot-operated 5/2 directional control valve, and two 3/2 manually-operated directional control valves. The 3/2 valves are three-way, two-position valves, which means they have three ports (pressure, cylinder or other output, and exhaust), and two positions, one of them is usually sustained by an offset spring.

2.1 Control of a double-acting cylinder in a press

Before assembling the circuit on the test stands, students develop a pneumatic circuit in Automation Studio software (www.automationstudio.com) to complete a task described below. Bosch (2001) developed a praxis-oriented approach which can easily be adapted to fit the competency level of students. Since our junior-level students already have some knowledge of pneumatics, more advanced exercises 7 and 9 were used as a starting point. They were adapted to also fit the Automation Studio software and components available on our new test stands. The pneumatic press setup is shown in Figure 1. There are a few pneumatic components already given, as in Figure 2, so that students only need to finish the symbols for the valves, and connect all components, as well as complete all port identifiers.

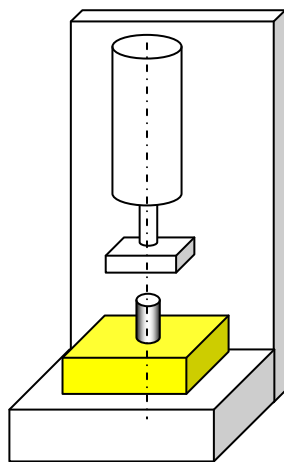


Figure 1: Pneumatic press setup.

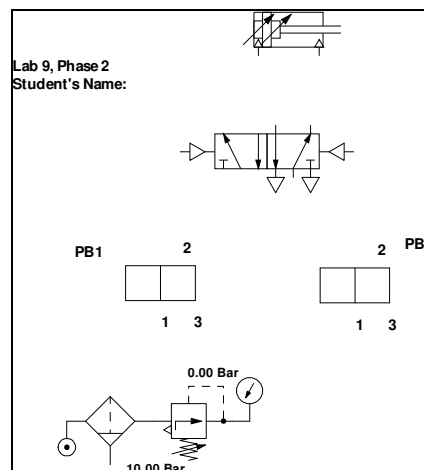


Figure 2: Circuit diagram to be completed.

To complete this and the other assignment presented in this paper, students needed some assistance from the instructor. Since this was their first encounter with the pneumatic components on the new stands, they were given a short introduction and demonstration. A comprehensive list of all available components, see sample in Table 1, is part of the laboratory manual. This table design was developed following students' feedback. Its purpose was to allow each student to quickly locate the needed component, and store it back at the end of the exercise in the correct location. The table provides all basic data of each component, its symbol, part number, as well as the physical location on the shelf.

2.1.1 Task to be completed: A pin is to be inserted into a hole in a square aluminum block (see setup schematic in Figure 1).

1. The pin and work piece are placed in position by hand.
2. A small pushbutton PB1 (which is to be located a short distance away from the press) is pressed and causes the piston rod of a large-area, short-stroke cylinder to extend and press in the pin.
3. When pushbutton PB1 is released, the cylinder is to complete its job, with the piston extending until the pin is inserted and piston stops there.
4. When push button PB2 is pressed, the piston fully retracts.
5. Complete/draw the circuit diagram in Automation Studio. Assign numbers for port designations to all connections on the valves. Run the simulation in Automation Studio.
6. Assemble and run the circuit on Rexroth Bosch stand.

2.2 Position control of a stamping press

Students develop a pneumatic circuit in Automation Studio to complete a task described below, and to be assembled on a pneumatic press, as shown in Figure 3. There are a few pneumatic components already given in Figure 4, so that students only need to finish the symbols for the valves, and connect all components, as well as complete all port identifiers. This task is a little more complex than the previous one.

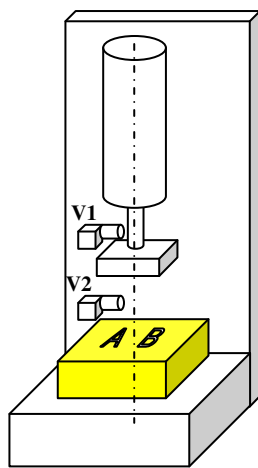


Figure 3: Pneumatic press setup.

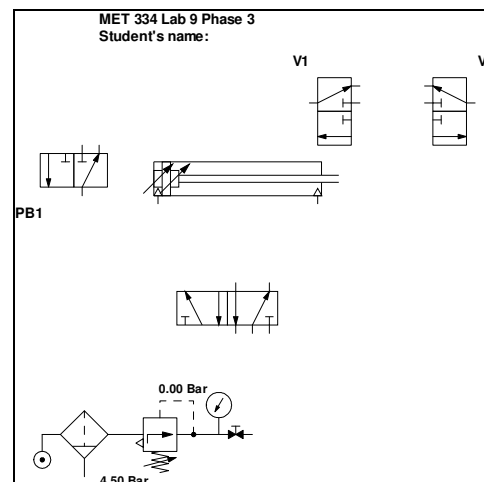


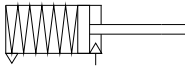
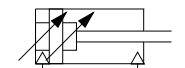
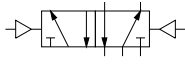
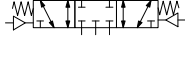




Figure 4: Circuit diagram.

A great help is obtained from using Automation Studio first before engaging in building the circuit on the test stand. This software allows students to experiment with various configurations and run the simulation to verify if they work. They can watch the animation on the computer monitor and learn the operation of the circuit even before they build it. This approach saves time by allowing the preparation to happen before the actual construction of the circuit is completed. Additional benefit is that students work on the circuit twice, once with Automation Studio, and then on the Rexroth Bosch stands, see Figure 5. This reinforces their understanding of the circuits.

2.2.1 Task to be completed: A stamping tool is used to stamp letters into plastic valve housings (see setup schematic in Figure 3).

1. The plastic valve housing is inserted by hand, and then the pushbutton PB1 is pressed to initiate the stamping process.
2. After the die has stamped the valve housing (roller-operated valve V2 is actuated), the cylinder automatically retracts to position 1 set by roller-operated valve V1.
3. The cylinder extension and retraction speeds are to be adjustable.
4. Include in the schematic a hand-operated valve to shut-off the pressure supply (integral part of air service unit, as shown in Figure 4).
7. Complete/draw the circuit diagram in Automation Studio. Use dashed lines for pilot lines. Assign numbers for port designations to all connections on the valves. Run the simulation in Automation Studio.
8. Assemble and run the circuit on the Rexroth Bosch stand.

Table 1: List of available pneumatic components (samples).

Pneumatic components	Bosch part number 1827003xxx	QTY per stand	Symbol
Cylinder single action with spring return, d = 25, s = 50 mm	371	1	
Cylinder double action with end-position cushioning, for proximity switching, d = 25, s = 100 mm	372	3	
5/2-DCV G1/8 impulse valve, pneumatic pilot operated. Ports; 1=Pressure, 2&4=Actuator, 3&5=Exhaust	377	3	
5/3-DCV G1/8 closed-center valve, pneumatic pilot operated. Ports; 1=Pressure, 2&4=Actuator, 3&5=Exhaust	378	1	
Throttle check valve G1/8 d = 1 mm	379	2	
Quick exhaust valve G1/4	381	1	
Shuttle valve (OR), G1/8	382	2	
Double pressure valve (AND), G1/8	383	5	

3/2-directional pilot-operated w/ time delay (0.15-5 s) valve, G1/8, spring return, (NC)	385	1	
Pressure regulator valve w/manometer 0.5-10 bar, G1/8	386	1	
Adjustable pressure switch w/3/2 DCV, 2-8 bar, Ports; 1=Pressure, 2=Actuator, 3=Exhaust	388	1	
3/2-amplifier, 2-stage, G1/8, 12-500 mbar	389	2	
3/2-directional control valve M5, roller lever, NC	399	4	
3/2-directional control valve M5, spring-return roller lever, NC	401	2	
Reflex nozzle d = 1 mm, min. pressure 0.4 bar	403	2	
Pressure gauge 0-10 bar	406	3	
Pressure indicator, red, min. pressure 1.2 bar	409	1	
Air service unit, with 3/2 ball valve, 0.5-10 bar, G1/8 – large box on bottom shelf	410	1	
Distributor block	411	1	
Double-acting cylinder, 25/10 mm Dia, 100 mm stroke, with pulling weight ; m= 3.4 kg (mount vertically), 5-mm allen wrench needed – large box on bottom shelf	373	1	
Low-pressure regulator with filter G1/8, 0-1 bar – large box on bottom shelf	387	1	

LOCATION OF COMPONENTS

372 Cylinder 	377 5/2-DCV 	379 Throttle 	383 AND 	383 AND 	389 Amplifier 	393 3/2-DCV
372 Cylinder 	377 5/2-DCV 	379 Throttle 	382 Shuttle 	383 AND 	388 Adj. switch 	392 3/2-DCV
372 Cylinder 	376 5/2-DCV 	378 5/3-DCV 	382 Shuttle 	383 AND 	386 Regulator 	392 3/2-DCV
371 Cylinder 	374 3/2-DCV 	377 5/2-DCV 	381 Quick E 	383 AND 	385 Time delay 	389 Amp.



Figure 5: Students working on the Rexroth Bosch DS3 Synergy test stands.

3. SUMMARY AND CONCLUSIONS

The approach presented above is possible thanks to the versatility of the new test stands. The main feature of these stands is that the components are stored outside of the stands. Students start their work with an empty board, and leave it empty when they finish their assignment. Student teams arrive at different, and their own, solutions. They readily take ownership of their design, engage vigorously in improving and troubleshooting it and thus learn more in-depth. The guidance provided to students, presented above for one two-hour laboratory exercise, was just enough to create a challenge, as well to provide all the necessary information. Students are asked to provide feedback in their laboratory reports about encountered problems, what they found worth keeping, and what they recommend for improvement. We have had a very positive experience and student feedback from using our new four double-sided test stands, which can be used for building hydraulic, pneumatic, and electric circuits, as well for teaching data acquisition from those circuits. The stands can be used for different courses back-to-back because they do not need to be prepared ahead of time.

So far the experience taught us that the components for the new test stands need to be very well organized to avoid problems. Students could spend a lot of time looking for a needed component. The storage system needs to be self-sustaining and self-correcting: It should be obvious to any student where a given component belongs. If out of place, students would bring the misplaced component to its original location. The layout presented in Table 1 has worked well thanks to the many inputs from students.

REFERENCES

Bosch Pneumatics (2001). *Trainer documents and exercise solutions for seminars PN/S1 and PN/K1*. Robert Bosch GmbH, Stuttgart, Germany. Part No. 1987764043.