Automated Vehicle Cleansing System
A Laboratory Project in Fluid Power

Nikhil K. Kundu
Purdue University

Abstract
Fluid power plays a major role in the automation industry. Along with programmable logic controllers it belongs to the forefront of today's technology. The purpose of this project is to introduce the importance of this industry in the college level and train students of mechanical engineering for the challenge they are going to face in future.

Almost everybody is familiar with an automated vehicle cleansing system but the activities and equipment behind the scene are like black box to many. This project deals with the design and building of a seven ft. by three ft. table top model of an automated vehicle cleansing system operated by programmable logic controllers including almost all phases involved in a real car wash operation. The paper first describes the design and operation of the system and then explains the controls to run the processes and automating the entire operation.

Introduction
The first couple of years engineering courses deals with abstracts and isolated materials without much reference to real world applications. This project was assigned to a group of students in an attempt to introduce a number of systems by design and manufacturing approach.

First students learn basic engineering concepts in hydraulics in sophomore year, after which they were assigned this project in the junior year. as a partial requirement for a junior level course in fluid power. Students are highly motivated by the design and construction approach. This encourages students to work in teams and solve problems using engineering fundamentals. They learn to cooperate as team members and gain practical hands on experience. The objective of this project is to design a fully automated vehicle cleansing system using hydraulic and pneumatic systems operated by programmable logic controller.

Design
In the design phase students have the opportunity to use their knowledge of fluid power elements they learnt previously in a basic hydraulic course. Through a project they get more insight of the elements such as pumps, control valves, piping, fittings, and their installation including wiring for electrohydraulic and electropneumatic systems. Parts selection was based on design calculations followed by manufacturers catalog search. In the selection process students contact manufacturers and vendors, and in doing so they become familiar with various types of parts of different quality and costs. In most cases the manufacturers or vendors were very supportive of student projects and ended up donating the required parts for the project. In some cases compromises were made and somewhat comparable parts were used for the model system.

The automated vehicle cleansing system consist of nine major stations - Pre-soak water station, soap spray, curtain and rocker panel sprayer, side brushes, water rinse, wax station, and air dry station. Hydraulic systems (fig.1and fig. 2) operate the water rinse, soap spray, water spray, and wax spray. Pneumatic systems (fig.3) operate spinning curtains, and the rocking curtains. The entire system is controlled by an Allen Bradley SLC500 programmable logic controller. Couple of team members had some previous knowledge of ladder logic from coursework or industry experience which was very helpful in the successful completion of this project.

<u>Hydraulic System (fig. 1 and fig. 4)</u>
The first hydraulic system is used for overhead spray at four stations. It consist of a diaphragm pump P1 with 0-13 gpm capacity at 100 psi. and four solenoid valves V1, V2, V3, and V4. The second hydraulic system (fig.2) is used to pump and spray soap at two stations. It consist of two 3 gpm, 45 psi diaphragm pumps P2 and P3.

<u>Pneumatic System (fig. 3 and fig. 5)</u>

The pneumatic system consist of two air motors powered by a half horsepower air compressor and four solenoid valves V5, V6, V7, V8. The airline is divided into four branches, two goes to the air motors that operate the spinning curtains, and the other two are connected to the single acting, spring return air cylinders that operate the vertical rocking curtains.

The electropneumatic, the electrohydraulic, and the electromechanical systems along with pneumatic and hydraulic solenoid valves are powered by a 24 VAC power supply. The whole operation is controlled and sequenced by a programmable logic controller.

Operation (fig. 4, fig. 6 and fig. 7)
Step 1. The process cycle begins with the push start button on the PLC. A chain drive conveyor located under the table engages the wheel and pushes the vehicle into the first hoop H1 where it is rinsed with water from pump P1 through valve V1.
Step 2. The vehicle then moves to the second hoop H2 (fig. 6) which sprays a soap solution from pump P2 through valve V2 over the entire vehicle.
Step 3. The tires and wheels are then scrubbed by a rotating brush one on each side of hoop H2. The brushes are driven by a 12VDC motor with gear reducer. This unit has two flexible cords from motors to the brushes, and is located under the table.
Step 4. In this step the top of the vehicle is cleaned by rocking curtains hanging vertically at hoop H3. This rocking operation is performed by the air cylinder C1.
Step 5. The sides of the vehicle are then cleaned by two vertically rotating brushes, one on each side driven by an air motor M1 at hoop H4. At the same time the larger pump P1 goes on and rinses the vehicle.
Step 6. Now the vehicle is subjected to a second soap spray solution pumped by P3. A second oscillating curtain from above ensures that the top of the vehicle is free from debris. This operation is done by the second cylinder C2 at hoop H6.
Step 7. Next the sides of the vehicle is cleaned for the second time by two rotating brushes, one on each side. These brushes are driven by a second air motor M2 at hoop H7.
Step 8. This operation consists of two complete rinse cycles in hoops H8 and H9. This rinse water is pumped by P1 through valves V3 and V4.
Step 9. The final step is a complete blow dry by an electrically driven blower that blows through a manifold system all around the vehicle. The blower is installed under the table.

Controls
The whole operation is controlled and sequenced by a programmable logic controller. A chain conveyor CH (fig.6) under the table moves the vehicle through the whole cleansing process. It is driven by a 12VAC motor with a chain reduction CR to match the speed of the process.

All water spray applications are performed by an air actuated double diaphragm pump P1 through solenoid controlled valves V1, V2, V3, V4. The oscillating curtains are actuated by air cylinders C1 and C2, and the vertical brushes are driven by air motors M1 and M2. The air motors and air cylinders are controlled by solenoid valves V5, V6, V7, and V8 mounted on a manifold.The main air source for the entire system originates from a half horsepower air compressor. The whole vehicle cleansing system including the timing sequence to activate the solenoid valves, switches, pumps, and motors is controlled by an Allen Bradley SLC500 PLC which is the heartbeat of the whole system. A portion of the ladder logic diagram is shown in figure 8 as a sample.

Conclusions
This project serves as a valuable introduction to automation for mechanical and manufacturing engineering students. This offers a first hand knowledge and training in automation using hydraulics, pneumatics, mechanical, and electrical systems integrated in one. As a laboratory project in an advanced fluid power course the students had the opportunity to design and work with the elements they learnt in a fundamental course in fluid power. In this project students were required to contact a number of manufacturers of hydraulic and pneumatic components for parts selection. Through this exercise they had the opportunity to communicate with other professionals, investigate manufacturers catalogs, become familiar with specifications like capacity, pressure ratings, power limitation, operation characteristics, and the costs involved in building a system.

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NIKHIL K. KUNDU
Professor Kundu received his BS degree from Technical University, W. Berlin, Germany and MS degree from University of California, Berkeley both in Mechanical Engineering. Currently, he is an Associate Professor in the Department of Mechanical Engineering Technology of Purdue University in Elkhart, Indiana. Mr. Kundu has worked over ten years in the industry mostly in research and development.