Using LabVIEW to Teach Internal Combustion Engine

View of the System

"Using LabVIEW and the hands-on approach to the test operation has helped students understand important test functions."
- Rémy CANN, Lycée Vauban de Brest

The Challenge:
Teaching students with a range of technical backgrounds the basic concepts of automatic injector testing for applied ignition engines using compelling, hands-on materials.

The Solution:
Building an automated injector test using NI LabVIEW software and NI PCI-6251 multifunction data acquisition cards for a simple yet effective teaching tool.

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In the STS Internal Combustion Engines course at the Lycée Vauban in Brest, France, the curriculum focuses on the mechanics of engine injection systems and the experimental study of injectors. The class often includes students from a range of technical backgrounds, most of whom are not automation experts.

We developed an effective hands-on approach to teach injection systems concepts in the classroom. We wanted to build an automated injector tester that would give students programming experience to better understand the functions and concepts of ignition testing.

Building the Test System

We built the injector test system using LabVIEW graphical system design software because it is easy to use, which allows students to have their applications up and running fast, and offers immediate feedback during experiments. We also used an NI PCI-6221 data acquisition card because of its reliable performance and affordability. We used a serial port to communicate with the scale.

The injector test stand has two main functions. It generates an n-pulse train at the frequency of 50 or 100 Hz with a duty cycle rating that depends on the desired injection time (PWM control). After each pulse train, the system measures the fuel mass flow for the n injections and establishes calculation and graphic functions. LabVIEW records and displays the test results immediately after a test runs.

Implementation

The hardware includes the following elements:

- The fuel circuit (tank, pump, and injector train equipped with a pressure regulator)
- Two stabilized electric feeds for the fuel pump and the injector
- An electronic interface that converts meter pulses from the PCI-6221 card into an injector control signal
- A graduated measuring cylinder on the scale

The unit is contained in an enclosure where forced ventilation extracts the vapors. We used white spirit, a common organic solvent, as the fluid for the tests.

Running the Test

The test investigates the mass behavior by injection for a given control period. Typically, the control signal is a pulse train with a period of 10 ms. A series of sequences of n injections occurs, adjusting the injection time from 0.5 to 9.5 ms per set of 0.5 ms.

Using LabVIEW, the test automatically calculates the quantities injected per stroke by dividing the mass read on the scale by the number of injections. LabVIEW graphically displays the test results, and the test determines the regression line of the points obtained, which reveals the static gain or loss and the offset. Data on these two characteristics is essential for adjusting engine management using the injection calculator.

The injection behavior is a function of its physical configuration as well as operating conditions, especially the drive voltage and the pressure difference between the fuel and the air into which it is injected. This is why many tests may be conducted by adjusting the voltage by the stabilized feed and the pressure by a pressure/vacuum pump.

Control System

Using the main VI built in LabVIEW, we can control, calculate, and display test results. We also developed two subVIs to handle the primary testing tasks. The first subVI communicates with the scale and the second manages the n pulse train using a counter exit on the PCI-6221 card. To automate the test, we integrated the two subVIs into a shift register. We built all of the sequences (from 0.5 to 9.5 ms) on a for loop.

An important constraint is the level of liquid in the measuring cylinder. The quantities injected must be significant to reduce uncertainty, yet small enough to avoid overflow. To address this challenge, we determined an “estimated” calculation to adapt the number of pulses in each iteration and obtained a target mass sequence in the measuring cylinder.

Conclusion

The automated injector tests with LabVIEW are the leading instruction tool for the internal combustion engine course. The system implements principles that are in line with curriculum goals and serves as a simple and effective tool.

It is usually difficult to teach students who do not have an automation background. However, using LabVIEW and the hands-on approach to the test operation has helped students understand important test functions such as communication, pulse generation, and shift register in a compelling and fun way. Students are highly engaged during the experiments and can immediately verify the function of their VI on the machine.

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View of the System


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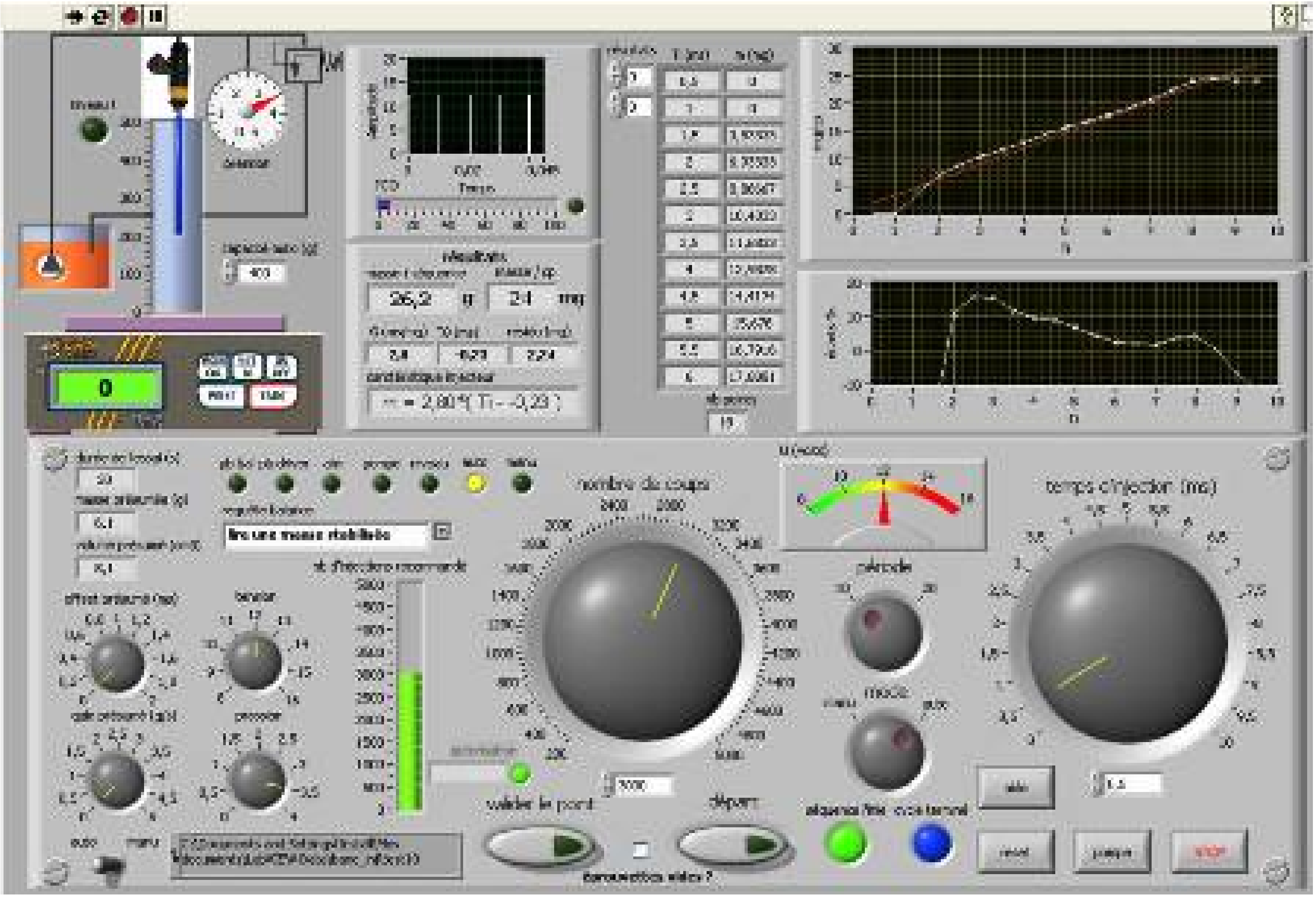
Measuring Cylinder



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