USER SOLUTION

Education/Mechanical Engineering
- *DAQ*
- *LabVIEW™*

Automated System for Educational Training on Punching Process Characterization

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The Challenge: Efficiently studying the mechanical characteristics of solid materials during the punching process.
The Solution: Developing a Macintosh-based measurement system using analog and digital DAQ boards controlled by LabVIEW.

Introduction

Automation of both test and measurement and process monitoring and control is significant to university laboratories. Flexibility in the selection of parameters to be measured and a user-friendly interface are both important goals for experimental measurements. These aspects are essential in R&D activities where postgraduate students play an important role. Some of the work also can be adapted to train undergraduate students. LabVIEW graphical software is an important key in using personal computers to achieve our goal of integrating hardware into easy-to-use systems for the experimental study of scientific and engineering phenomena.

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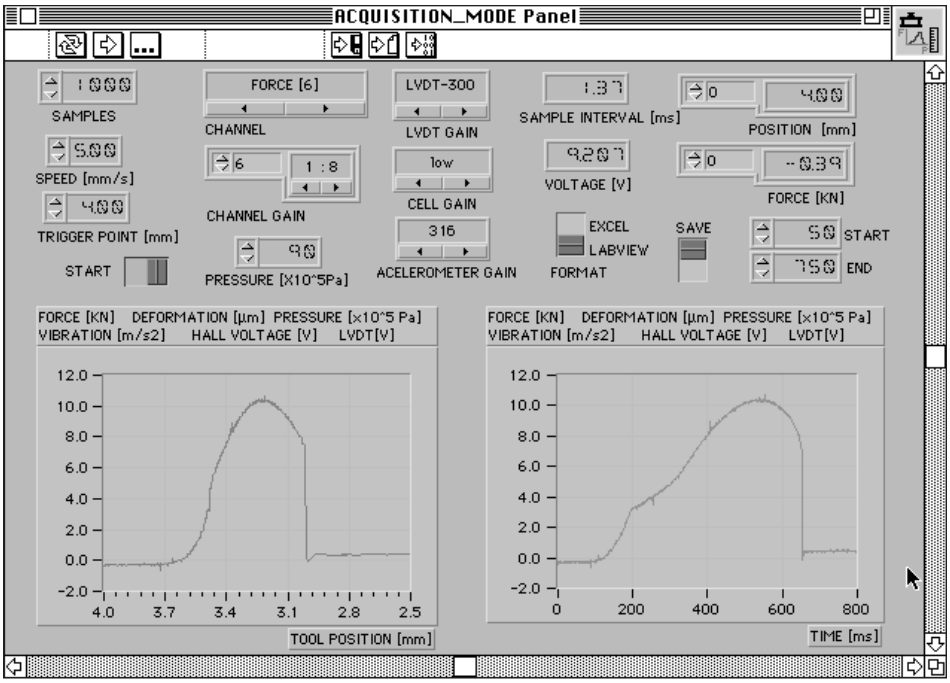
Experimental Overview

For our experiments with the punching process, we used a prototype hydraulic press with a C-shaped frame and a nominal range of 35 kN. It was equipped with a variety of transducers, detectors, and control actuators. With special control strategies, it was possible to reach a cutting frequency of 11 Hz. The main instrumentation and control actuators are summarized as follows:



Front Panel of the VI for Punching Process Studies

Transducers and Detectors

- 3 absolute pressure transducers that also measure temperature – one in each cylinder chamber and the third in the hydraulic power unit
- 1 accelerometer and charge amplifier measuring the effect on the press structure during the cutting process
- 1 load cell designed and built to fit the particular needs of this press and its load range, used for a direct measurement of force (special care was taken in an automatic sensing of its supply value and autocompensation actions are implemented)
- 1 LVDT displacement transducer for structure deformation measurements
- 1 incremental encoder for tool position measurement
- 1 Hall-effect sensor for fine tool position measurements
- 1 optical sensor (red beam) for metal sheet detection on the pneumatic metal sheet-feeder
- 3 digital Hall-effect sensors as top, bottom, and middle dead center detectors

Control Actuators

- 1 proportional pressure-limiting valve to set maximum force.
- 1 pneumatic valve to actuate the metal sheet feeding
- 1 on/off valve within the water cooling system for oil temperature control.
- 1 analog 4-port directional/proportional valve for commanding the change of the speed of the ram mounted on the top of the cylinder

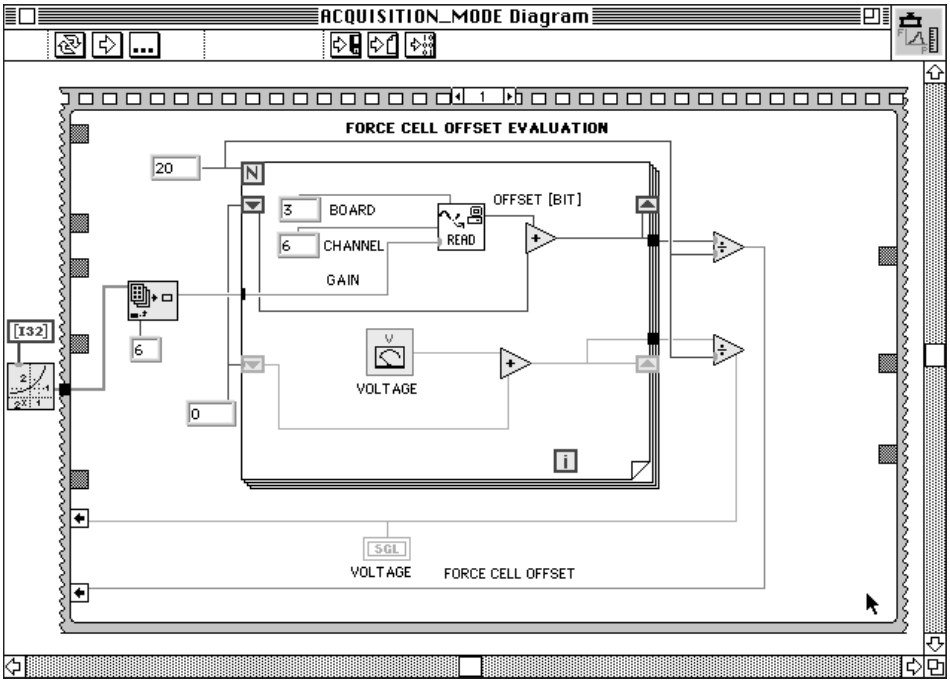
Hardware and Software Tools

The data acquisition and control system is based on an Apple Macintosh IIfx running LabVIEW, equipped with an NB-MIO-16 multifunction DAQ board, an NB-DIO-32F digital I/O board, and an NB-DMA-2800 DMA controller board from National Instruments. LabVIEW provides state-of-the-art graphical software tools for instrumentation programming and graphical user interface development.

The National Instruments products are aligned perfectly for the construction of virtual instrumentation systems, which rely heavily on the personal computer as

the host platform. We think of virtual instrumentation as a layer of software and hardware added to a general-purpose computer so that users can interact with the computer as though it were their own custom-designed traditional electronic instrument. The main point is that each user can construct his or her own instrument, as simple or as complex as needed, establishing simultaneously the specificity of the measurement methodology required.

Virtual instrumentation is ideal for university laboratories. Unlike industrial applications, where traditional turnkey solutions are often used, a university lab needs an open-architecture development environment to foster new creative approaches. We believe it is important at the educational level to allow students to be creative in building a measurement system to probe the phenomena under study, given that proper safety procedures are in place.



Block Diagram of the Punching Process Studies VI

This type of experimental training, using integrated teaching of experimental techniques and LabVIEW graphical software, gives the student excellent training through an open, interactive, flexible and friendly system.

The VI for Punching Studies

The virtual instrument (VI) for studying the punching process characterizes the cutting force pattern evolution in terms of tool position and time (during the punching process). We have acquired a large amount of data for later correlation studies by introducing changes in parameters such as punching speed, hydraulic pressure, type and thickness of material, and different tool parameters.

From the front panel, you can define parameters such as cutting speed, number of samples acquired, tool position trigger point, hydraulic pressure, gain selection (for the different transducers), width of the windows to be recorded, and the data format. The front panel displays a graph of the cutting force and the average time between samples. We can also select additional mechanical measurement quantities such as press structure deformation, hydraulic pressure evolution, and machine vibration level from the front panel of this VI.

Summary

This type of experimental training, using integrated teaching of experimental techniques and LabVIEW graphical software, gives students excellent training through an open, interactive, flexible, and friendly system. In this approach, the student is an active participant instead of a traditional passive observer. We believe this approach is an important goal in experimental science and engineering education.

The flexibility in choosing test parameters offers a wide variety of possible experiments. Students report their results after they are analyzed based on the syllabus of a mechanical engineering course. This procedure introduces students to the traditional methodology of R&D activities.

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