

Lathe Instrumentation utilizing LABVIEW

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Abstract

This paper presents an innovative instrumentation project that consists of instrumentation on a lathe using National Instruments Data Acquisition (NIDAQ) tools and display using Labview software. The aim was to carryout real-time measurement and display acquired waveforms on a PC screen and also store these waveforms for later use. This work is part of a NSF funded Greenfield Coalition's New Manufacturing Engineering curriculum project. Sensing and display of the motor torque and power of the lathe with respect to the depth of cut in real time and study of these for different materials and different tools are goals of the Labview application.

The development of the project is described and the results from the Lathe instrumentation are enclosed and discussed. Inquiry based and advanced features associated with the project that could enable examining student understanding of data acquisition, interfacing, sensing and programming at the end of the project are highlighted. Utilization of the project as part of the ET and Manufacturing curriculum is highlighted. The scope of future work is presented.

1. Introduction

PC based instrumentation has been widely accepted as a very effective means of measuring data in all areas of engineering. While utilizing computers as their centerpiece, these instrumentation systems are powerful avenues for data analysis and presentation. Being programmable, virtual instruments provide the advantages of multiple functionality over traditional analog instruments. Several companies manufacture data acquisition boards (DAQ) that housed within computers allow the acquisition of real time data for display, analysis, control and storage.

Amongst data acquisition hardware tools, most widely used and reported are made by National Instruments (NI), Datel, Keithley Metrabyte, Data Translation, Industrial Computer Source etc. The most popular data display tools likewise are the NI Labview and DADISP. Integrated data acquisition systems such as LabTech/Control and LabTech/Notebook from LabTech, TestPoint and Easiest from Keithley Metrabyte, DT VEE from Data Translation have been in use for several years. Due to the excellent academic programs, the NI tools have instilled interest amongst academic users more than any other tool. Our previous paper provides an exhaustive list of references that have dealt with Labview and NIDAQ tools is provided at the end of the paper [1]. Recent reports of Labview utilization for electric machines and power electronics are available [2, 3]. Availability of the student edition of Labview 5.0 from Addison Wesley at a

very reasonable price (~\$70 per copy), this fall, must meet the instrumentation requirements of most academic laboratories [www.natinst.com].

Properly sensed and conditioned signals determine the quality of display, analysis, and control of data from real time systems. Study of a lathe instrumentation system, whose discussion is the subject of this paper, provides students with hands-on experience and an environment to compare data from laboratory experiments. Here the NI Labview instrumentation and analysis software along with its DAQ board, has been utilized to interface signals from an actual lathe system set up to a PC. Required initial preparation and the details of NIDAQ and Labview in an electric dc M-G set implementation are discussed in a previous paper. The capabilities of student edition version 3.1 of Labview 3.1 instrumentation tool have been experimented with successful results.

2. Instrumentation Setup

The block diagram of the machine tool system along with the instrumentation system components is shown in Fig. 1. The system comprised of a three-phase induction motor coupled with reduction gears to the dead center of a lathe. The PC instrumentation consists of motor power, torque and depth of cut sensing and signal conditioning circuits and NIDAQ and Labview tools. Brief description of interfacing of the individual signals to the DAQ board are discussed below:

(a) Torque

The motor torque was measured using a Hampden model SM 50 Load cell unit with an analog signal conditioner unit. The load cell used has a range of 0 - 50 lbf or N-m. The signal conditioner gives the output to an accuracy of 0.1V per lbf or N-m with the maximum value of 5 V.

(b) Power

The motor power was measured using a Load Controls Inc. UPC model Universal Power Cell. The power cell has three phase power measuring capacity. It works on both fixed and variable frequencies and provides two analog outputs. It operates on single phase, DC or brushless DC supply. The universal power cell has three balanced Hall effect devices, each with a flux concentrator. Each phase wire that carries current passes through an individual hole. The magnetic flux around the wire is proportional to the current passing through the cable. A voltage sample for each phase is also provided. The Hall effect semiconductor does a vector multiplication of the current and voltage and also calculates the power factor. The output is proportional to the power consumed. Since the power cell is direction sensitive, the terminal side of the cell is made to face the supply. The response is adjusted to measure the average value of the power. The full-scale range is adjusted to match the motor capacity. The full-scale resistance is adjusted to 15 ohms to match the motor capacity of 15HP. This cell is capable of measuring up to 150HP.

(c) Depth of Cut

The depth of cut information was provided to the system by mounting an encoder on the rotary tool wheel with a gear mechanism. The encoder utilized was a H2 series U.S. Digital make

encoder that produces 256 pulses of 2V amplitude for its every 360-degree rotation. A linear to rotary conversion of the depth of cut was obtained and fed to the NIDAQ. The encoder pulses that were produced any time the tool was not in contact with the work piece were ignored in the calculations by means of a software switch in the Labview block diagram.

With a linear-rotary conversion gear ratio of 1:100, for every rotation of the hand wheel, the encoder rotates 100 times. For every rotation of the hand wheel, the linear motion is 0.5 inches. For every 0.5 inch movement of the tool, the encoder produces $256 \times 100 = 25,600$ pulses. Hence, for every inch movement of the tool, the encoder produces 51,200 pulses. The computer through the DAQ board reads the number of pulses produced. The ratio of the number of pulses to 51,200 gives the tool movement in inches.

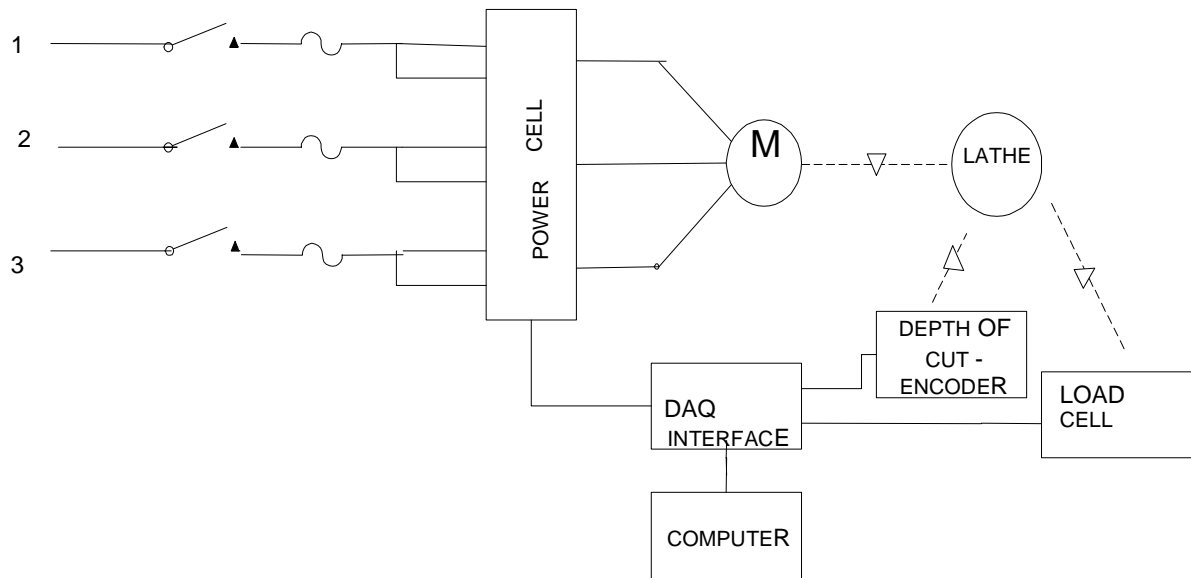


Fig. 1. Lathe instrumentation system setup

(d) NIDAQ hardware configuration

The DAQ board utilized in this application is the AT-MIO-16DE-10 that has two 24-bit timers and 32 TTL/CMOS compatible input/output channels and 16 single ended (0-10V output) or 8 differential channels (-5 to +5 V output) of 12 bit analog input/output channels. The hardware configuration of the NIDAQ board was studied and the required channels were configured. The sensed torque and power signals were tied to two separate analog input channels of the board. The pulses that represented the depth of cut were directly connected to a digital counter input.

(e) Labview Student Edition

The version of Labview that was utilized in the current project was 3.1. The front panel of the display was designed by utilizing the graphic programming capabilities of student edition. The displays of the variables in digital values were also added. The block diagrams devised for this application are shown in Fig. 2a and Fig. 2b. whereas the corresponding Labview front panel diagram with the real time data on screens is included in the experimentation section.

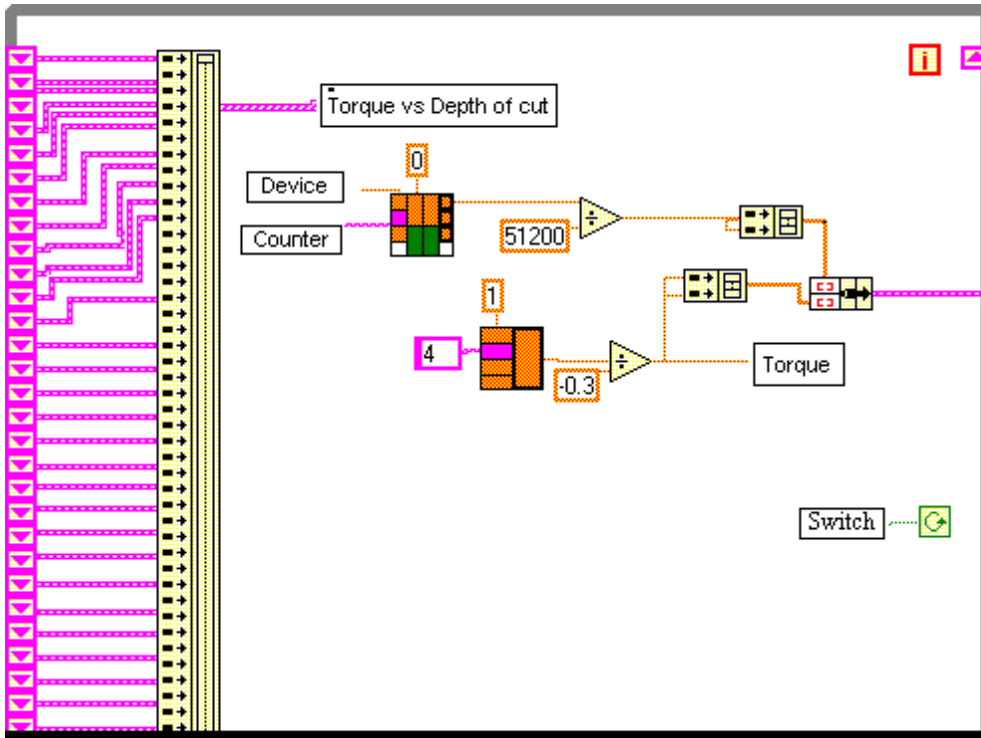


Fig. 2a. Block Diagram for Torque vs. Depth of Cut.

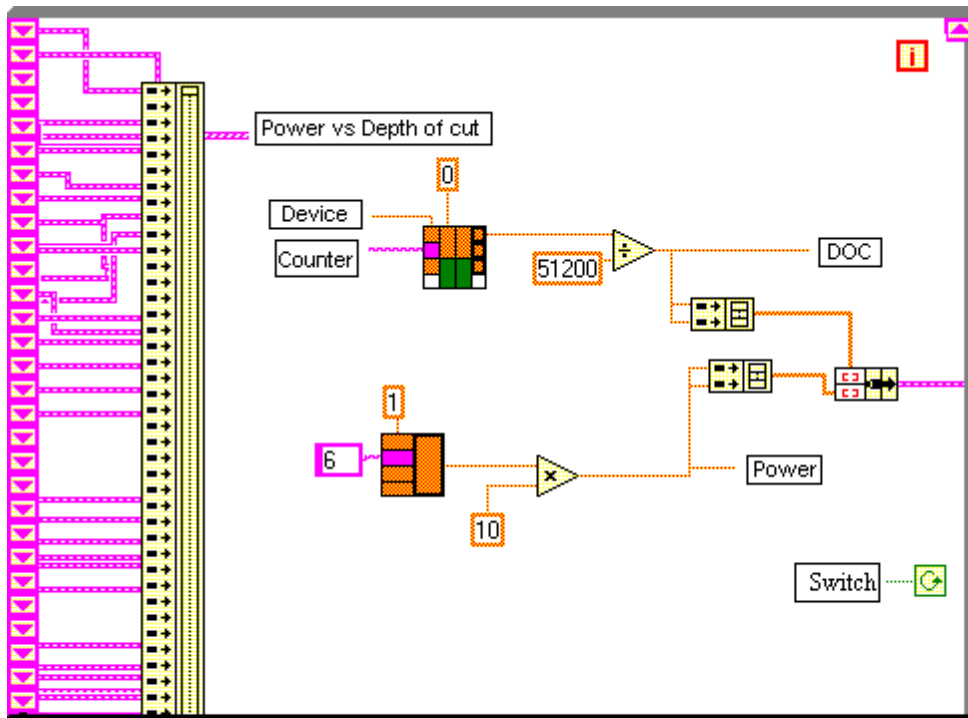


Fig. 2b. Block diagram for Power vs. Depth of Cut.

3. Experimentation

Many aspects of data acquisition, instrumentation, interfacing, programming, were made possible in this project. Initially, the display is set to show no readings until the tool touches the workpiece. The enabling switches in the Labview front panel are switched on to run Labview and make data available for display. As the tool starts loading the lathe, both the power consumed and the torque exerted will increase. The readings of torque, power and depth of cut are displayed individually and the torque and power with respect to the depth of cut are also displayed by devising the X-Y chart commands of Labview block diagram. A screen capture of the Labview front panel showing the real time data is shown in Fig. 3. Variation in the values of power and torque when the tool engages/disengages from the workpiece can be observed. When required, the Labview programs are stopped to freeze the signal displays. Several runs are conducted with different depth of cuts of the material.

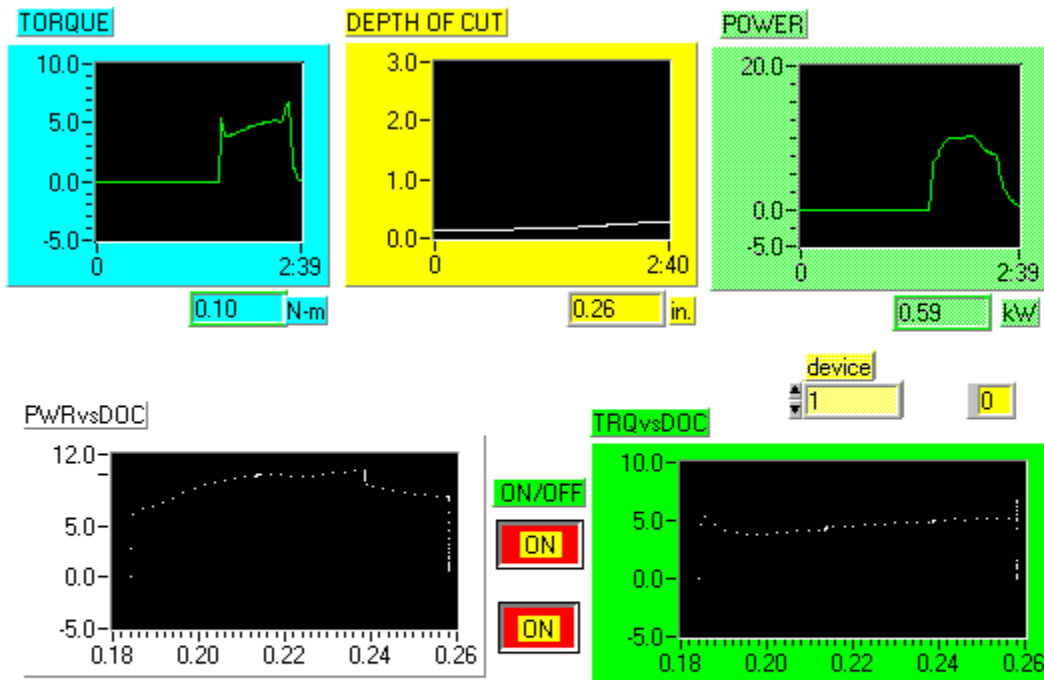


Fig. 3. Experimental results shown on Front panel

4. Scope of Project

The project was a component of the electric machine knowledge area development for the NSF funded Greenfield Coalition for New Manufacturing Education. This project is of extensive use for the focus: HOPE students in Manufacturing Engineering and Technology. After learning about this system, the students will come to know the importance of measuring the parameters in real time. They will also come to know about the issues involved in measuring, interfacing and

reading the parameters in real time. The following exercises are planned for inclusion in the course delivery.

1. In order to measure the torque in either lbf. or N-m, what settings are required? How to keep the corresponding setting by configuring the Labview block diagram and front panel?
2. In order to measure the instantaneous or average power, what adjustments are to be made?
3. How will you change the range of the power cell according to your motor's power capacity? What is the adjustment to be made?
4. Compare the torque and power quantities with various metal tools and work pieces.
5. Compare torque and power quantities with the amount of depth of cut and rate of depth of cut.
6. Increase the rate of depth of cut and analyze the torque and power quantities.
7. Plot torque and power on X-Y graph
8. What are all the steps involved in assigning different channels for input in the DAQ? Where are these changes to be made?
9. What is the device no? Find out its significance.
10. Find out how many rotations the rotary encoder has made using the index terminal? Which connections are to be made? Calibrate the instrument accordingly.
11. Repeat the same with any one of the channels of the rotary encoder.
12. Change the type of graph in the Labview from strip chart to flow chart or otherwise.
13. Explore the different possibilities of configuring the graphs.
14. Find what would be the effect if the loop in the diagram panel of Labview were removed?

This project introduces the importance of real time measurement. It also makes students aware of the facilities available to make real time measurements.

5. Future Work

The students can develop several other components with any additional facilities available. The students can configure the system to see the comparative values of parameters by changing the configuration of the graphs. The student is capable of modeling and configuring any measurement of a control system. It is possible to save the data corresponding to different tool material and different tool types as Excel files. This will enable plotting more than one of these curves for comparison.

6. Conclusion

A lathe instrumentation system that employs NI data acquisition tools to conduct load-monitoring studies is discussed. Essential features of signal conditioning, sensing units, NIDAQ hardware and Labview tool and its usage are detailed. Experimental studies are summarized and the results are discussed. The project continues to serve as a real-time application for the students of the EET program at Wayne State University while serving as the prototype for the Greenfield Coalition development. The development of the Labview based instrumentation for regular EET electric machine course is being explored with Labview version 5.0 and latest data acquisition boards.

7. References

1. S. Chickamenahalli, V. Nallaperumal, V. Waheed, "Electric machines instrumentation using Labview", ASEE Annual Conference, 1998
2. G. G. Karady and D. Tylavsky, 'Use of animation for improvement of student understanding of energy conversion', ASEE Annual Conference Proceedings, 1998
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