SERBIATRIB`07
10th International Conference on Tribology
and
WORKSHOP`07
Sustainable Development in Industry by Apply Tribology Knowledge

PORTABLE DAQ EQUIPMENT WITH LABVIEW AS A TOOL FOR TRIBOLOGY EXPERIMENTS AND CONDITION MONITORING

[1]Aleksandar Marinković, [1]Aleksandar Vencl, [2] Peter Wallace
[1]University of Belgrade, Faculty of Mechanical Engineering,
Belgrade, Serbia, amarinkovic@mas.bg.ac.yu
[2]School of Engineering, Science & Design,
Glasgow Caledonian University, Glasgow, UK

Abstract: *Tribology experiments have a crucial importance in order to verify results of simulations and calculations and sometimes it is the only way to solve important problems and tasks. Numerous requirements in experimental investigations now days need a new approach in data acquisition (DAQ) tools and methods, where time and mobility are taking significant place. Last years LabVIEW software made a great expansion in industrial measurement applying and virtual instrumentation in data acquisition. The aim of this paper is to present some advantages of standard and portable DAQ Equipment with LabVIEW software and to show their application in some common tribology experiments. This equipment is also excellent tool in condition monitoring of mechanical systems from the aspect of tribological parameters. By comparing classical experimental techniques and simulations with Lab VIEW possibilities in combination with portable hardware modules, this paper will serve as a support for the development of new approach in tribology experimental investigations and their involving in general concept of condition monitoring. It is obvious, that the ambitious aims of this concept has a multidisciplinary approach by integrating this advance research and education tool of experimental design in mechanics, fluid dynamics, micromechanics etc.*

Key words: *data acquisition (DAQ), LabVIEW, tribology, condition monitoring*

1. INTRODUCTION

Tribology become more important in modern world because of energy saving, tendency of pollution reduction and trying to rich more efficiency systems, where for all those tasks experiments are taking significant place.
Experimental investigations in tribology actually started since the beginning of research in this field. Experiments were realised in order to test existing or try to find better characteristics of tribology investigation objects such are bearings, tools or for whole mechanical system. Besides, aim of tribology experiments is also to verify results geted by numeric calculations or various simulation methods. This aspect takes even more important place last years, as new simulation methods and tools are still in rapid progress.
Data acquisition (DAQ) comprise all elements in system for proper planning, realisation, acquire of relevant parameters and success in results analyse of experimental investigation. First of all it is necessary to have a proper test rig for experiment realisation, than for all measurements we could say that DAQ consists of several phases:

- Signal sampling
- Signal conditioning
- Analog to digital conversion
- Digital filtering and
- Data analysis.

2. DATA ACQUISITION (DAQ)

According to the above mentioned data acquisition phases, basic tasks of DAQ in general (as shown by Fig.1) are: acquisition of numerical values from physical systems, display of the data, storage (logging) of the data, analysis of the acquired data and presentation of the results.

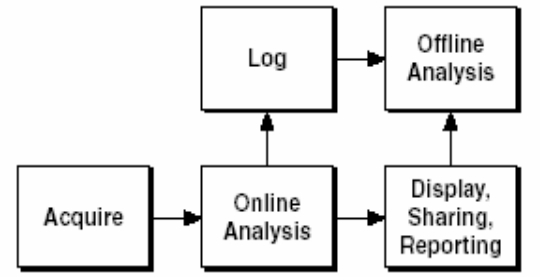

Figure 1. *Data Acquisition elements*

The computer controlled data acquisition system (DAQ) requires [1]:

- Analogue-digital conversion (ADC or digitizer) electronics,
- Signal conditioning electronics to produce signals suitable for presentation to the ADC,
- Terminal blocks, switching systems etc to bring the signals into the DAQ and
- Appropriate software to control the processes and display the results.

The issue of connectivity may appear trivial but therein lie many of the practical problems you may encounter when implementing DAQ systems. We must consider the issues of standardisation, reliability, noise, safety in our choice of connections.

As Fig.2 shows DAQ hardware options could be grouped as a classical desktop, PXI modular option or advanced such a portable option and distributed from remote sensors via network connections.

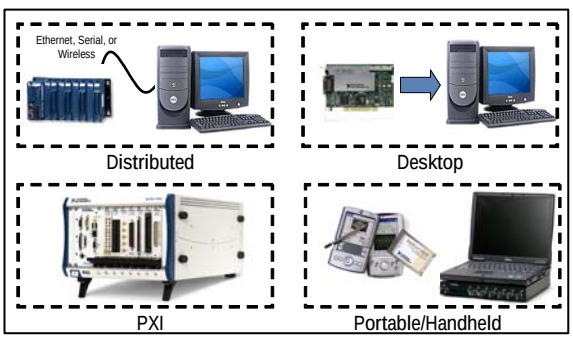

Figure 2. *DAQ Hardware options*

Choice of system depends on the requirements of your application and of course the depth of your pockets!

Modern DAQ systems vary from simple add-ons to notebook computers, providing low cost systems (offering portability, moderate performance and small number of channels) to modular chassis mounted systems (offering high speed, high channel count systems with dedicated buses for real time data transfer).

Fig.3 shows portable data acquisition system that includes a thermocouple and strain gage connected to an SCC signal conditioning carrier. SCC provides the sensor connectivity, excitation, amplification and filtering. The conditioned signals are output to a shielded cable and into a plug-in DAQ device. The DAQ device converts the analog signal into digital, enabling LabVIEW to acquire, analyze, and present the data.

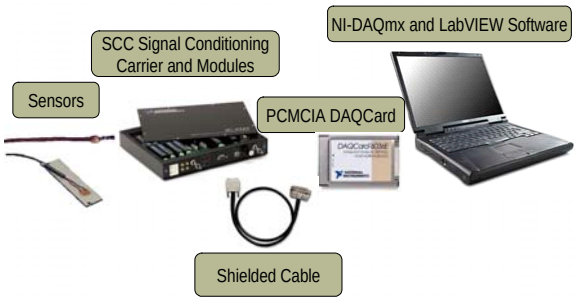

Figure 3. *Components of portable DAQ system*

Crucial importance for DAQ system applying is to chose qualitative, but also user friendly software that could acquire, analyse and present data from experiments. Common DAQ software solution is National Instruments (NI) LabVIEW graphical development environment. That is an example of a virtual instrument (VI) interface (stored in a .vi file) [2]. It uses the metaphor of a physical instrument front panel to bring together the interrogation and control of any signal sources or actuators available to the system.

Each VI contains three main parts:

- Front Panel – How the user interacts with the VI.
- Block Diagram – The code that controls the program.
- Icon/Connector – Means of connecting a VI to other VIs.
-

Every front panel control or indicator has a corresponding terminal on the block diagram (Fig.4). When a VI is run, values from controls

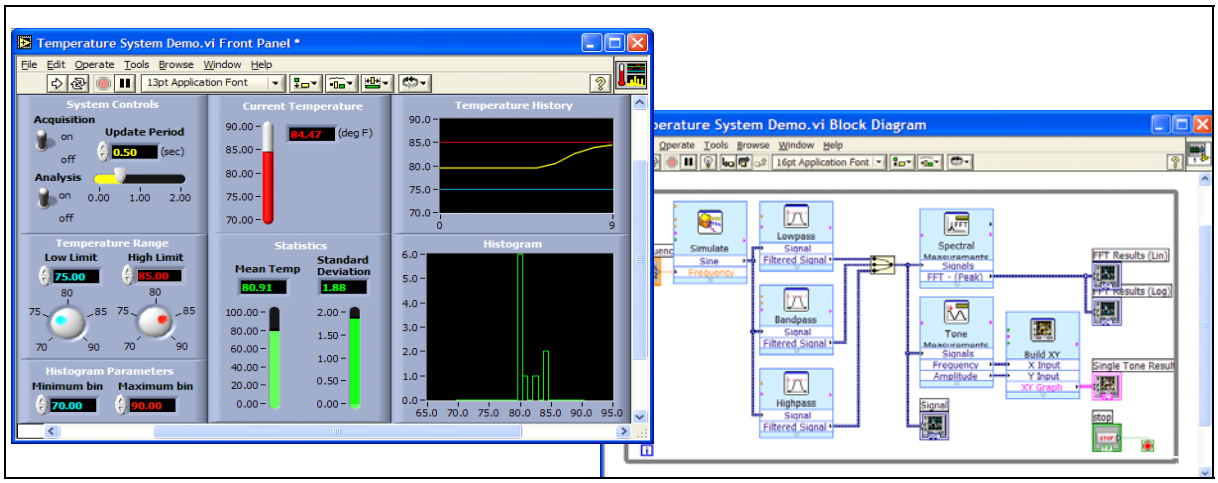

Figure 4. *Front panel and block diagram in LabVIEW virtual instrument interface*

flow through the block diagram, where they are used in the functions on the diagram, and the results are passed into other functions or indicators

Next chapter gives a few examples of experimental investigation in tribology, where proper choice of DAQ hardware option in combination with virtual instrument interface by LabVIEW could make numerous advantages.

3. APPLYING EXAMPLES OF EXPERIMENTS IN TRIBOLOGY

Different experimental investigations in tribology are carried out on Mechanical Engineering Faculty, University of Belgrade. Only couple of them is described here aimed to present possible advantages of proper DAQ system applying.

3.1 Experiments with porous sliding bearings

Experiments of sliding bearings are carried out in Machine Design Department laboratory, conducted on old testing rig USL1 [3] and new one USL 5-30 [4]. Measurement of operating temperature and coefficient of friction for bearings were worked out. The dependence of temperature from time has been done with parameters: radial load of F = 170 N and rotation speed of n = 4780 rpm (for boundary value of pv characteristics). Compared with old test rig [3], experimental investigations on new test rig system USL 5-30 (shown on Fig.5) are more efficient, much easier to realise and give results that better fit to real operating conditions.

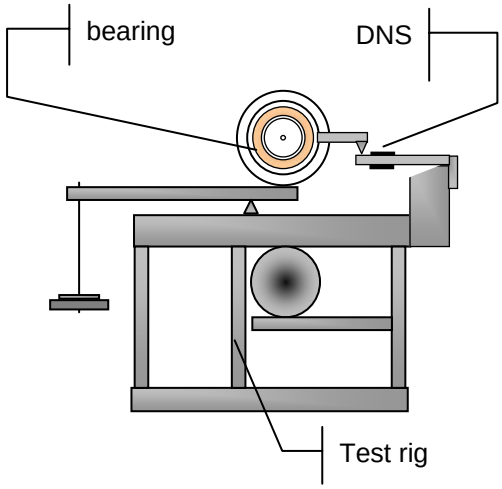

Figure 5. *USL 5-30 test rig system*

Using this test rig system for experiments it is possible to apply portable DAQ system (similar as shown by Fig. 3) with main components: SC-2345 Carrier, modules SCC-SG03 half bridge and SCC-SG24 for full bridge strain measurement and SCC-TC02 for temperature measurement (Fig.6).

Figure 6. *SCC Carrier and modules*

Besides this signal conditioning part, multifunction DAQ Card 6062E with 16 input/2

output channels is heart of the portable system, which allows signal transfer from transducers and conditioners to the computer with NI DAQ software.
Main reason for DAQ applying in this measurement is need of continually following two channels for friction torque by DNS and bearing temperature simultaneously. Even not necessary to have high sample rate for this kind of experiments, advantages of getting results and its disposal for further analyses is evident.

3.2 Experiments with composite materials

These experiments were carried out in Tribology laboratory, on standard pin-on-disc tribometer under dry and boundary lubrication conditions at different loads and sliding speeds (Fig. 7). Some of the results as well as description of tribometer are described elsewhere [5].

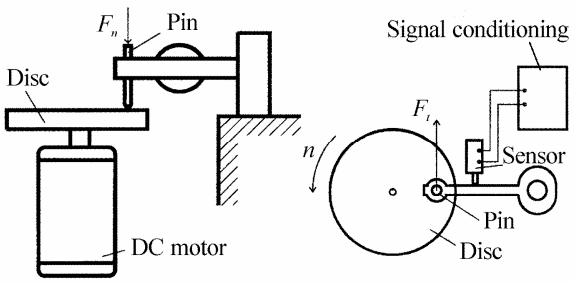

Figure 7. *Schematic diagram of pin-on-disc tribometer T-62*

During the test normal force was constant and friction force i.e. coefficient of friction as well as lubricant temperature were varying and monitored through DAQ system in classical desktop variant. Multifunction DAQ Card PCL-712 with 16 input / 2 output channels was used to transfer signal from transducers and conditioners to the computer with NI DAQ software.
Before applying this DAQ system test parameters were monitored through mechanical measuring system. By using DAQ system it was possible to get more accurate results and to monitor them continuously during the time. Any error during the experiment could be noticed instantly, preventing to have inconsequent results gain with averaging. For this kind of experiments advantages of having very high sample rate also wasn't necessary and wasn't used.

5. CONCLUSION

Compared with classical way of experimental investigation, main advantage of using DAQ with virtual instrumentation interface by LabVIEW software is in flexibility concerning requirements that could be also modify during experiments realisation.
A fundamental requirement of any DAQ system is the matching of the sampling rate to the frequency content of the signal. Undersampling results in aliasing, which produces irrecoverable errors in the reconstructed, sampled signal. Oversampling may introduce too much noise into the reconstructed signal and may, in some cases, saturate the ADC, again producing irrecoverable loss of data.
Finally, not only based on described examples, emphasis of explained portable DAQ approach in tribology experiments is magnified in condition monitoring. This is actually the way of control and diagnosis complete mechanical system only by following and measure vibrations and some of tribology parameters, such are temperature rate, wear rate and also oil content analyse in the system.

REFERENCES:

[1] Wallace P.: *Data Acquisition and Analysis*, Lectures for MSc Applied Instrumentation and Control, Glasgow Caledonian University, Glasgow, 2005.

[2] *LabVIEW Basics I Introduction*, Course software version 7.0, National Instruments Corporation, March 2004 edition.

[3] Marinković A., Maneski T., Milosević V.: *Porous metal bearing temperature problem*, 1st International Conference on Tribology in Environmental Design, Bournemouth UK, September 2000., Proceedings, pp.79-86.

[4] Marinković A: *Optimization of parameters for porous journal sliding bearings*, Ph.D. degree thesis, Mechanical Engineering Faculty, University of Belgrade, Belgrade, September 2004.

[5] Vencl A., Rac A., Bobić I., Mišković Z.: *Tribological properties of Al-Si alloy A356 reinforced with Al_2O_3 particles*, 4th Balkan Conference on Metallurgy, Zlatibor, Serbia, 27-29.09.2006, Proceedings, 527-534.