EMPLOYING A VIRTUAL INSTRUMENTATION AS A TEACHING TOOL FOR A CUTTING FORCES MONITORING SYSTEM IN DRILLING

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ABSTRACT
In the teaching of metal cutting theory the experimentally based approach has many advantages. Process monitoring is the manipulation of sensor measurements to determine the state of the processes. Measuring cutting forces in drilling (thrust force and torque) is one of the most common used techniques for monitoring because of their sensitivity to tool condition (drill wear, drill failure). The need for reliable and simultaneous prediction of thrust force and torque in drilling operations is highlighted.
It is ordinary to acquire measured data utilizing computer technology in cutting experiments. In this paper the well-established model of cutting force monitoring system in drilling through virtual instrumentation is presented. Virtual instrument technology gives more operability, functionality and flexibility. Virtual instrumentation is ideal for university laboratories because each user can construct their own instrument with the help of an open, interactive, flexible and friendly system.
The use of this model of monitoring system in drilling as a teaching tool is available to most universities and colleges. This will also give the student a more meaning-ful educational experience.
Keywords: drilling, virtual instrumentation, cutting force, monitoring

1. INTRODUCTION

Thrust force and torque are two important state parameters in a drilling process. The implement of measurement for these two parameters will be favourable for studying cutting mechanics, calculating power consumption, optimizing cutting parameters and checking accuracy of developed cutting force models. On the other hand we can estimate drill wear or drill failure according to the variation of thrust force and torque. The idea behind monitoring torque and thrust force is very clear, i.e. it is expected that these forces change as tool gradually wears. Drill wear has a strong effect on the hole quality and dimensional accuracy during drilling. Excess drill wear causes high forces and can damage the part, fixture and machine tool. Also, thrust force and torque enable choice correcting cutting condition. This paper is to construct a cutting forces monitoring system in drilling through virtual instrumentation.

2. VIRTUAL INSTRUMENTATION

It is ordinary to acquire measured data utilizing computer technology in cutting experiments. "Traditional" or "natural" instrumentation systems are made up of pre-defined hardware components. Because of their hard-coded function, these systems are more limited in their versatility than virtual

instrumentation systems. The primary difference between "natural" instrumentation and virtual instrumentation is the software component of a virtual instrument. There are many definitions of virtual instruments (VI). In the following, we report the definition of the National Physic Laboratory [2]: "Virtual Instrument is a reusable measurement instrument created adding hardware and software to a general purpose computer, and which uses a computer screen to provide the visual interface to the instrument".

Virtual instrument technology gives more operability, functionality and flexibility. Virtual instrumentation is ideal for university laboratories because each user can construct their own instrument with the help of an open, interactive, flexible and friendly system. Flexibility in the selection of parameters to be measured and a user-friendly interface are both important goals for experimental measurements.

Every virtual instrument consists of two parts – software and hardware. A virtual instrument typically has a sticker price comparable to and many times less than a similar traditional instrument for the current measurement task. However, the savings compound over time, because virtual instruments are much more flexible when changing measurement tasks.

LabVIEW (short for Laboratory Virtual Instrumentation Engineering Workbench) is a platform and development environment for a visual programming language from National Instruments. The programming language used in LabVIEW, called G, is a dataflow programming language. LabVIEW programs/subroutines are called virtual instruments (VIs). Each VI has three components: a block diagram, a front panel and a connector panel. Software takes the raw data and presents it in a form the user can understand. Software manipulates the data so it can appear in a graph or a chart or in a file report.

3. A MODEL OF CUTTING FORCES MONITORING SYSTEM IN DRILLING

Details of the drilling experimental setup can be seen in figure 1 [3]. The machine tool chosen is model of INDEX GU600. Thrust force and torque during drilling are measured by KISTLER quartz 2-component dynamometer (type 9271A). The dynamometer signals are then processed to make them suitable for computer capture. This is achieved via charge amplifier and an analogue to digital (A/D) converter. Dynamometer receives force signals and transmits them to multi-channel charge amplifier through connecting cable. The output electric charges (in pC) delivered from the measuring platform are converted by KISTLER multi-channel charge amplifier (type 5001) into proportional voltages. Simultaneously, data acquisition and A/D conversion depend on ED 428 card. The ED 428 multifunction board can be used for analogue input, analogue output, digital input/output and counting applications.

The software was developed in LabVIEW programming environment for data acquisition, instrument control and process monitoring (National Instruments, version 6.0), on PC with Pentium processor. The acquisition software completely controls the measurement process. It can measure thrust force and torque. LabVIEW program includes all of the tools needed for data acquisition, presentation, storage and analysis and it provides state-of-the-art graphical software tools for instrumentation programming and graphical user interface development. Diagrams are drawn in a graphical programming language that has the same power as conventional textual languages.

The program is divided in two main parts: a front panel where the inputs the acquisition from the instrument are specified and block diagram that, graphically, shows the program codes created using terminal nodes and wires. Therefore, by wiring together objects that perform different functions it is possible to create specific virtual instruments. There is, in addition, an icon/connector that allows using VI as a subVI. The program is quite flexible since it can be modified at any time by the operator, according to particular needs. The collected data, which appear in the graph of the front panel, can be stored to hard disk and retrieved for further calculation or exported to other applications such as spreadsheets (Microsoft Excel and MicroCal Origin). The front panel and block diagram VI is shown in figure 2. Every control or indicator on the front panel has a corresponding terminal on the block diagram. The front panel is the user interface of the VI and the user of VI needs not to know the graphical programming language.

During measurement the front panel displays graphs of thrust force and torque, and their peak values.

When the operator presses a button STOP, measurement will finish. After that, generate table will be on the front panel (with columns for time, thrust force and torque). These data can be stored an Excel file.
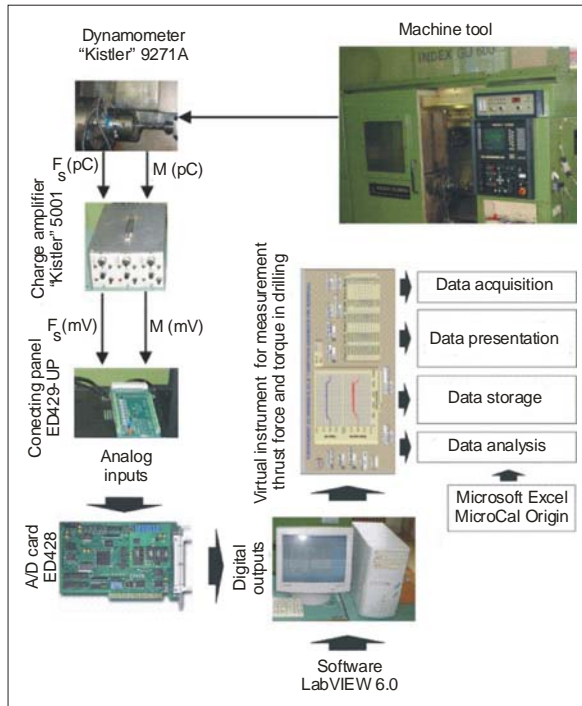
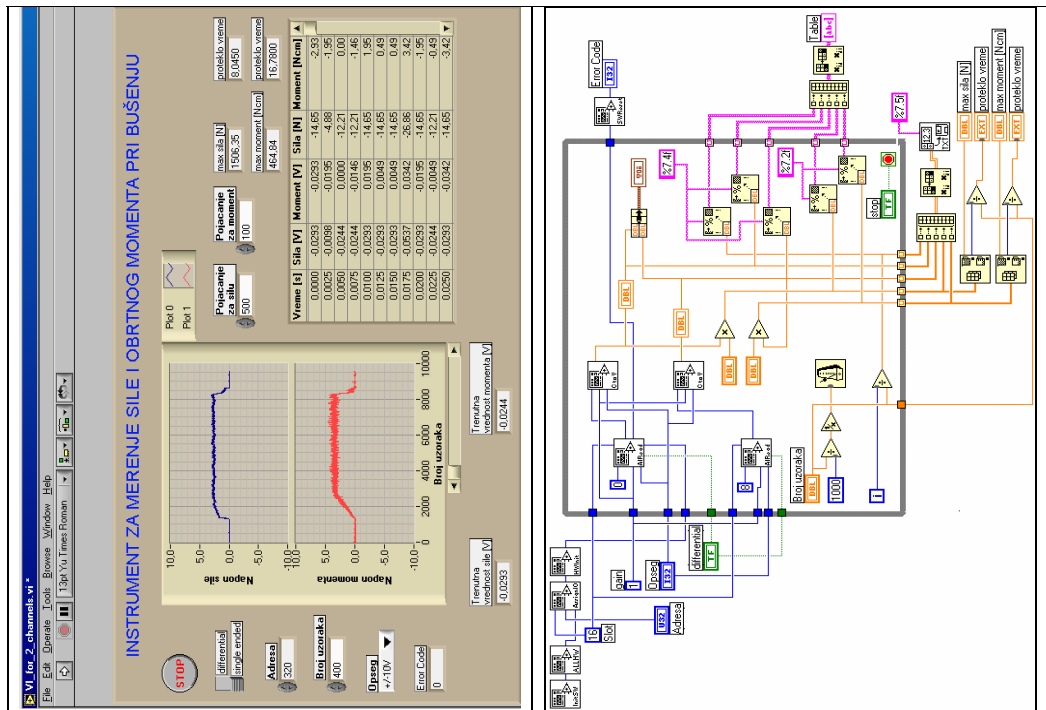*Figure 1. Block diagram for the measuring system [3]*

Figure 2. Front panel and block diagram the VI for the drilling process [3]

4. RESULTS

In this section the results of the experiments will be given. The experimental configuration corresponds to that shown in figure 1 in which thrust force and torque are measured. The experiments consisted of cutting tests. The typical thrust force and torque signals are shown in figure 3.
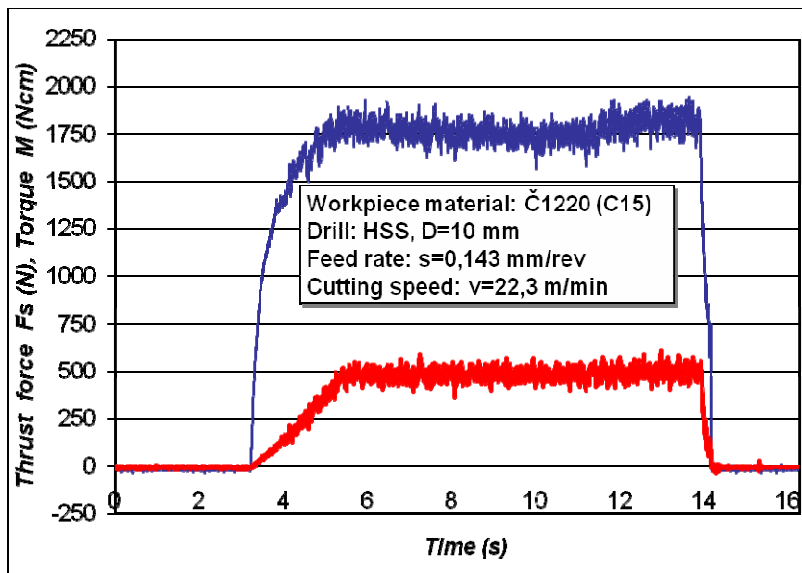

Figure 3. A typical thrust force and torque signal [3]

5. CONCLUSION

The need for reliable and simultaneous prediction of thrust force and torque in drilling operations is highlighted. In this paper the well-established model of cutting force monitoring system in drilling through virtual instrumentation is presented. This model can be employed as well as teaching tool. It is said that practice is the best „teacher" for beginner. The VI carries out a mission. It is tested with different cutting conditions and showed excellent measuring capability. This type of experimental investigations, using virtual instrumentation, gives the explorer   excellent conditions through an open, interactive, flexible and friendly system.

6. REFERENCES

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