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Measurement and Analysis of Drilling Vibration Using Tracer DAQ and LABVIEW

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Abstract- This study presents a vibration measurement system using Micro-Electro-Mechanical Systems (MEMS) accelerometer design to measure the vibration of a vibration source. The LABVIEW program is developed to monitor and analyze measured data. The program first acquires the analogue input signal from the three different channels, and reads the data to be analyzed. The obtained measurement data during the measurement is illustrated graphically by means of Tracer DAQ and LABVIEW. Therefore, as a result of the analysis, vibration data obtained by means of two different programs are compared. Some preliminary results of this endeavor are presented. The error evaluation of these accelerometers has been performed according to the Mean Absolute Percentage Error (MAPE) method. In the conducted evaluation, Accelerometer (Acc) 1 is 0.033%, Acc 2 is 0.019% and Acc 3 is 0.055%. We have reached that findings of proposed study are similar.

Keywords- Data acquisition; vibration analysis; vibration monitoring; accelerometer.

1. Introduction

Developing technology, vibration reduction and insulation methods have been an integral part of the machine design and as a result, the need for accurate measurement and analysis of vibration is emerged. Years ago, this requirement could be met with simple optical instruments of experienced engineers, which measures listening touch senses and displacement. However, nowadays very fast and as result of vibration forces are too large for the machine, vibration measurement methods and tools have been developed and are being used.

This paper investigates the vibration on cutting tools, especially on the drill bits, during the cutting operation. As the importance of full automation in the industry has gained substantial importance, vibration monitoring during the cutting operation has been the subject of many investigators (Ertunç and Sevim, 2001; Ertunç, 1999; El-Wardany et al., 1999; Stein et. al., 2007; Fan and Qiao, 2011). Vibration, is the one of the most common and bothersome problems affecting drilling performance. Successful drilling processes requires the proper understanding of how to minimize vibration to efficiently maximize production, drill life, and production quality. Excessive vibrations interfere with production quality and may cause the mechanical and/or electronic drill equipment to malfunction. Hence, it is worthwhile to undertake technical efforts to minimize vibrations. It is necessary and valuable to be able to assess the importance of vibration abatement measures and to assess their effectiveness as a means for reliable measurement (Zou et al., 2000; Paddan and Griffin, 2002; Doebelin, 2003; Anon, 2011; Stein et. al., 2011).

2. The Measurement Compact System

To facilitate the single-axis vibration measurement in field conditions, a low-cost apparatus was developed from the commercially available MEMS acceleration sensors. The aim behind the project was to have the in-house facilities to perform the field measurements within reasonable costs without the need for specialized equipment and for a specialized test engineer. The purpose of this system is:

- To gather real-time field vibration data for future use in the drilling operation system simulation research.
- To have the means to analyze the drilling vibration concurrently.

In this way, the various interactions could be analyzed in each material. The research effort could then focus on vibration mitigation in the axis of the highest influence (acceleration value). This is not necessarily in the vertical axis.

This study designed and constructed a compact measuring system employing three single-axis MEMS accelerometers interfaced via a Measurement Computing's USB-1208FS data acquisition device to a laptop. The vibration signals generated in the process of drilling was measured using a MEMS accelerometer (ADXL103-CE, AD22280). The digitized data were then processed in Tracer DAQ® software and popular virtual instrument (VI) development workbench LABVIEW to analyze the vibration. The program first acquires the analogue input signal from the three different channels, and read the data to be analyzed. The obtained measurement data during the measurement was graphically illustrated by means of TRACER DAQ, LABVIEW. Therefore, as a result of the analysis, the vibration data obtained by three different programs are compared. Some preliminary results of this endeavor are presented. The error evaluation of these accelerometers was performed according to the Mean Absolute Percentage Error (MAPE) method. In the conducted evaluation, Accelerometer 1 (ACC 1) was 0.033%, Accelerometer 2 (ACC 2) was 0.019%, and Accelerometer 3 (ACC 3) was 0.055%.

The compact vibration measuring system consists of the following parts (see Fig. 1):

Fig.1. Photo of the sensors and DAQ device box with the laptop.

A/Three identical single-axis MEMS accelerometers; B/A Measurement Computing's USB-1208FS DAQ device; C/-A standard laptop with an acquisition program.

A/ The three-component MEMS accelerometer type ADXL103NE-CD and AD22280, are available in a 5 mm × 5 mm × 2 mm, 8-terminal ceramic LCC package. ADXL103NE-CD and AD22280 are low power, complete single-axis accelerometers with signal conditioned voltage outputs, all on a single, monolithic

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IC. They measure acceleration with a full-scale range of relatively ± 1.7g and ± 50g; the output voltage is approx. 3.5 V to 6 V for zero acceleration. Temperature range is relatively –40°C to +125 °C and –40°C to +105 °C. They can measure both dynamic acceleration (vibration) and static acceleration (gravity). The accelerometers are factory calibrated, hence no field calibration is needed.

The accelerometers are fixed to a 10 mm thick cold-drawn plain of 60×180 mm. The accelerometers are positioned both at the edges and center, and seen in Fig. 2.

Accelerometer (Acc) 1, type AD22280, is positioned at the center, and Acc 2 and Acc 3, type ADXL103, are positioned at the edges (Fig.2).

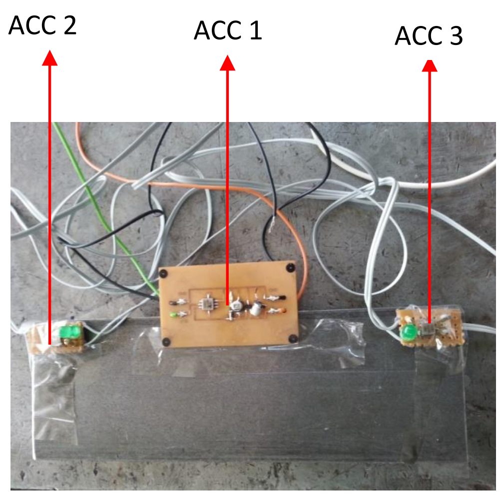

Fig. 2. Position of the accelerometers.

B/ USB-1208FS is a simple and low-cost multifunction I/O device from Measurement Computing. The device consists of eight analog inputs, two analog outputs, and 16 digital I/O connections. It can easily connect to a computer or external USB hub to create the application, and no extra power-supply is needed. To create the DAQ application, requires a programming development tool, such as Visual Studio/C#, or LABVIEW. DAQ applications include acquire data, display, trigger, control, analysis, math, statistics, alarming, save data, and more.

C/ A simple data logging software was designed and developed using Tracer DAQ and LABVIEW VI. The software can perform the following functions:

Acquire analog input signal from different channels.

- Display time domain signal.
- Study the effects of windows on the acquired data
- Display the signal spectra.

The program first acquires the analog input signal from the three different channels, and reads the data to be analyzed.

3. Measurement Vibration Using TRACERDAQ

Tracer DAQ is an out-of-the-box application that can generate, acquire, analyze, display, and export data within seconds of installing the Measurement Computing data acquisition hardware. Tracer DAQ includes a strip chart, an oscilloscope, a function generator, and a rate generator, all of which are accessed through a common, easy-to-use interface.

The vibration acceleration is obtained and displayed (Fig. 3).

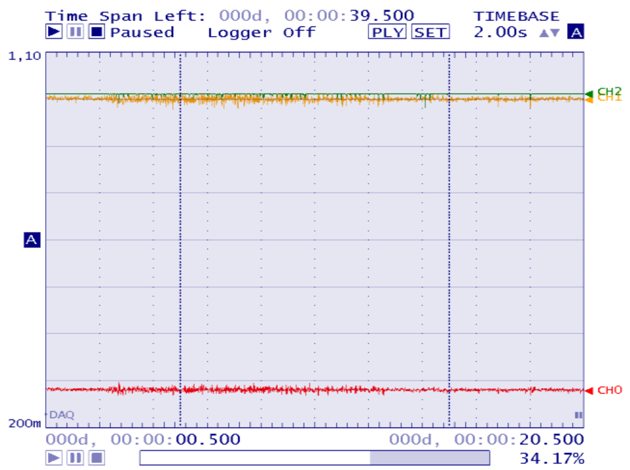

Fig.3. Vibration acceleration signals acquired with Tracer DAQ.

Table 1 illustrates the measured values acquired with the Tracer DAQ during drilling operation.

Yagimli, M., Kaya, A. (2016). Measurement and Analysis of Drilling Vibration Using Tracer DAQ and LABVIEW, Journal of Military and Information Science, Vol4(2),45-50.

Table 1. Measured values acquired with the Tracer DAQ during the drilling operation.

Acc 1	Acc 2	Acc 3
0,2918	0,9858	0,9858
0,2879	0,9912	0,998525
0,2889	0,9829	0,992660
0,286	0,9961	0,998541
0,2923	0,9805	0,968292
0,2876	0,9925	0,902168
0,3011	0,9893	1,011273
0,2908	0,9785	1,059067
0,2928	0,9907	0,973610
0,3006	0,9805	0,951203
0,2918	0,9888	0,981476
0,2781	0,9839	1,049818
0,2928	0,9897	1,026321
0,2908	0,9893	0,974652
0,2894	0,9844	1,011255
0,2884	0,9873	0,899409
0,2874	0,9863	0,993625

4. Measurement Vibration Using LABVIEW

LABVIEW is a software development platform that can be programmed with a graphic interface. LABVIEW software is ideal for any measurement or control system. LABVIEW is used in applications requiring data acquisition and it offers quite flexible choices to its users for data evaluation and monitoring.

In this study, data taken from the Measurement Computing's USB-1208FS DAQ device can be evaluated instantly on the computer, and graphs can be created and stored via LABVIEW in order to compare in the subsequent measurements. Fig. 4 presents the block diagram of program with LABVIEW.

Fig. 4. The block diagram of the program with LABVIEW.

Table 2 illustrates the measurements acquired with the LABVIEW values during the drilling operation.

Table 2. Measured values acquired with the LABVIEW during the cutting operation.

Acc 1	Acc 2	Acc 3
0,297852	0,98877	0,98877
0,29541	0,983887	0,976562
0,29541	0,983887	0,974121
0,29541	0,976562	0,974121
0,288086	0,976562	0,98877
0,26123	0,922852	1,013184
0,283203	0,97168	0,949707
0,307617	1,020508	0,939941
0,307617	0,983887	1,000977
0,290527	1,015625	1,044922
0,29541	0,966797	0,974121
0,283203	0,996094	0,930176
0,300293	1,032715	0,996094
0,290527	0,983887	0,998535
0,29541	0,976562	0,949707
0,300293	0,964355	1,052246
0,297852	0,983887	0,976562

5. Comparison of TracerDAQ with LABVIEW

Total error percentage of the measured values of Tracer DAQ and LABVIEW are carried out to the “Mean

Absolute Percentage Error (MAPE)" method. The Mean Absolute Percentage Error equation is (Nahmias, 1997; Lurgio, 1998):

$$\text{MAPE} = \left[\left(\frac{1}{n}\right)\sum_{i=1}^{n}\left|\frac{e_i}{D_i}\right|\right]\times 100 \qquad (1)$$

n = Measurement number
e_i = i'th error value

D_i= i'th measurement value

Measured values by means of Acc 1, which were acquired with LABVIEW and Tracer DAQ, are seen in Figure 5.

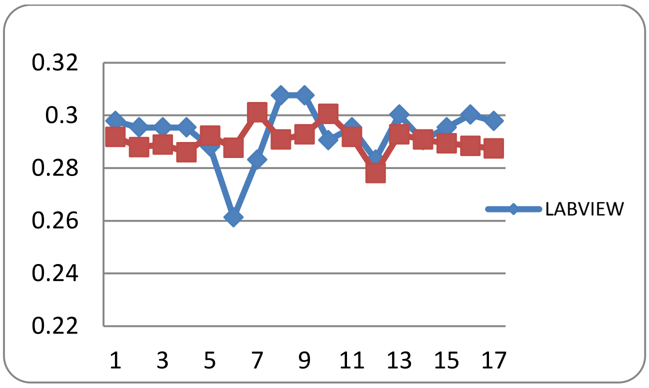

Fig. 5. Comparison of measured values via LABVIEW and Tracer DAQ for Acc 1.

As seen in the Figure 5, Mean Absolute Percentage Error for Acc 1 is 0.033 %. Measured values by means of Acc 2, which were acquired with LABVIEW and Tracer DAQ, are seen in Figure 6.

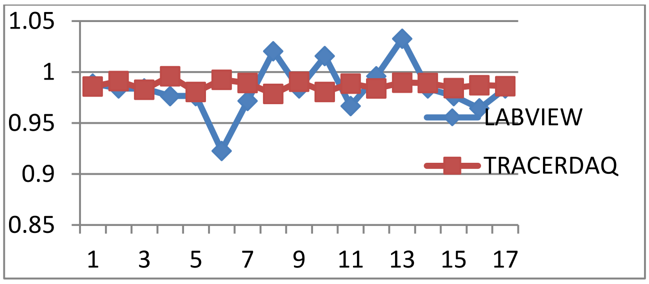

Fig. 6. Comparison of measured values via LABVIEW and Tracer DAQ for Acc 2.

As seen in Figure 6, Mean Absolute Percentage Error for Acc 2 was 0.019 %. The measured values by means of Acc 2, which were acquired with LABVIEW and Tracer DAQ, are seen at Figure 7.

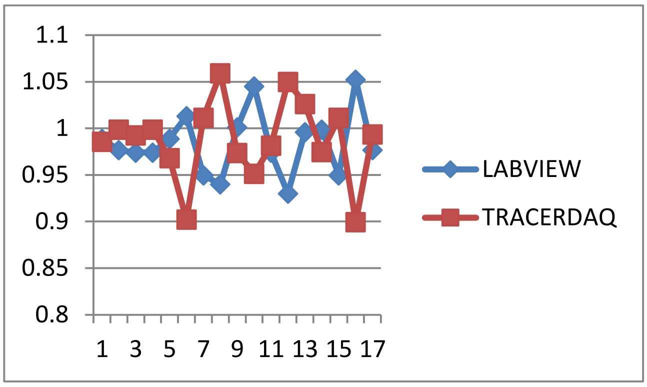

Fig. 7. Comparison of measured values via LABVIEW and TracerDAQ for Acc 3.

As seen in Figure 7, Mean Absolute Percentage Error for Acc 3 was 0.055 %.

6. Conclusion

Vibration measurement; both the maintenance-repair work and for the health of the employees a very important in the work places.

The vibration meter, depending on the machines if that machine vibrations outside of standard maintenance time has come. In a worker exposed to excessive vibration white finger and carpal tunnel disease occurs.

As a result of the analysis, vibration data obtained by the means of two different programs were compared.

Table 3. Mean Absolute Percentages Error for Acc 1, Acc 2 and Acc 3.

	Mean Absolute Percentage Error
Acc 1	0.033 %
Acc 2	0.019 %
Acc 3	0.055 %

The error evaluation of these accelerometers was performed according to the Mean Absolute Percentage Error (MAPE) method (Table 3). In the conducted evaluation, Accelerometer (Acc) 1 was 0.033%, Acc 2 was 0.019%, and Acc 3 was 0.055%. The results were similar.

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