Software for Sonic Well-Logging Control Apparatus with Single-Sided Access

N.K. Andreev, A.S. Malatsion
Kazan State Power Engineering University, Kazan, Russia
Email: ngeikandreev@gmail.com

Abstract. *This report continues developments* of *a sonic testing technique aimed for the detection of defects of long pipes and bond of various materials to the surfaces of pipes in water and oil wells. The characteristic property of the proposed technique is that the longitudinal waves at 1 – 20 kHz are used for inspection and only single-sided access is needed for transducers located at a head of a pipe. The system was designed to be self-contained and easy to activate. Some characteristic features of a software made in the National Instruments LabVIEW environment and details of the construction of the sonic testing apparatus are considered.*

Keywords: Software, LabVIEW, Well-Logging, Defects of Cementation

1. Introduction

Recently results of developments of a sonic testing technique aimed for the detection of defects of long pipes and bond of various materials to the surfaces of pipes of oil and water wells were discussed [1, 2, 3, 4, 5]. The characteristic property of the proposed well-logging technique is that longitudinal waves at 1 – 20 kHz are used for inspection and only single-sided access is needed for transducers located at a head of a pipe. The method reduces to pulse exciting of longitudinal elastic waves in a body of a pipe coated by a cement slice and receiving of echo signals from defects of the pipe and bonding of a cement slice to the surfaces of pipes. The time of flight of a wave from the defect to the transmitter (receiver) can be converted through the velocity of propagation of sonic waves in a steel pipe to the value of the correspondent source-defect distance.

Sonic waves moving in a pipe are attenuated. Often amplitudes of detected signals are very small and comparable with the amplitudes of various types of noise. The detection, filtration and selection of the useful fraction of the signal are a complex problem.

Therefore the object of the paper is to report the results of the development of the software for the control and synchronization of the apparatus under consideration, signal detection, registration, data processing and displaying. Some characteristic features of a software made in the National Instruments LabVIEW environment and details of the construction of the sonic testing (ST) apparatus are also considered.

2. Subject and Methods

The software is one of the main parts of the single-sided well-logging system reported here.

The described inspection system (Fig.1) consists of several functional units, such as the pulser/receiver (home-made), transmitter and receiver transducers (home-made), display devices, analog-to-digital (ADC) and digital-to analog (DAC) converters produced by the Nationals Instruments, computer ASUS”EeePC1000H” and power supplier. The software is developed in the National Instruments LabVIEW environment.

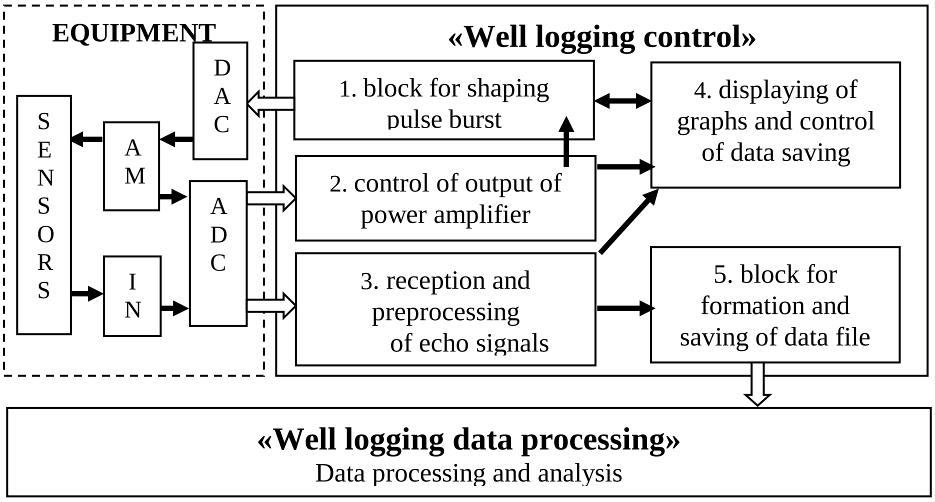

Fig. 1 Scheme of the well-logging measurement and control system:
AM – power amplifier, IN – interface, DAC – digital-to-analog converter, ADC – analog-to-digital converter

The sound energy is introduced into the pipe body through its head. When there is a crack or partial bond with cementation in the wave path, part of the energy will be reflected back from the flaw surface. Reflected signals are detected by a receiver transducer fastened also to the head of the pipe (well) near the transmitter transducer. If there is necessity in multifrequency measurements additional transducers can be fastened to the same head.

The generation of a carrier code is fulfilled by the computer. Then a DAC unit converts a carrier code to an analog form which is amplified in turn by the power amplifier. An ADC unit connected by an interface to a receiver transducer serves for conversion of received echo signals to a digital form and control of the output level of the power amplifier (AM).

The pulser used is an electronic device that can produce electrical pulses up to 3 kV of amplitude. Driven by the pulser, the transmitter transducer connected to a power amplifier through the electric transformer generates sonic energy at desired frequencies in the range of 1...20 kHz. The length of the exciting pulse can be changed from two to ten cycles of a carrier.

Let us consider methods and algorithms of data processing in acoustic cementometry (AC). There are two main blocks in the software: “Well logging control” [6] and “Well logging data processing” [7]. The “Well logging control” block consists of five programs which serve for: 1) shaping pulse burst; 2) control of output of power amplifier; 3) data acquisition and preprocessing of echo signals; 4) displaying of graphs and control of data saving and 5) formation and saving of data files. The “Well logging data processing” program attends to complete data processing.

The data of echo signals reflected from the defects and end of a pipe are saved in a computer memory in the text format “*.lmv*”. The graphing of diagrams such as “signal amplitude vs depth” can be fulfilled by using the table processors Microsoft Excel or Origin. The following data processing must be fulfilled in a correct order and by using additional programs.

Input of data from file is an operation that performs the insertion of the file containing data concerning the amplitudes and number of samples to the program of data processing. This insertion is organized as a semiautomatic procedure by a virtual button by which a user points the way to the file through the program envelope.

Signal detection is an operation of the signal module calculation that saves values of the signal amplitude and its frequency.

Signal filtration consists of two stages. The software incorporates blocks for spectral wavelet analysis. The signal contains noises at frequencies out and near of the spectrum of the response of a cemented steel pipe to the acoustic pulse excitation. At the first stage the part of a signal with a spectrum that differs from the spectrum of a well pipe response is removed. This procedure is used before the signal detection. The second procedure of the low frequency filtration allows select the information about the amplitude.
The essential part of the software is the exponential approximation and following normalization of an echo signal by point-by-point dividing of the signal to an exponential approximation function of its envelope.
The next step is the setting of the control level that determines what signal amplitude will be taken into account. The control level must be equal or greater than the noise level.
The essential part of the software is the procedure for localizing of defects (Fig.3). Calculation of the correlation functions for two signals measured at different frequencies or after a given time expiration is a basic operation of this procedure. The procedure includes also calculation of the value of the ratio of sites occupied by defects to the length of the whole pipe (in meters /meters). Using this procedure a user can detect such deviations in the structure of a well that indicate to serious cracks requiring to stop the process of production and start-up the process of repair.

3. Results

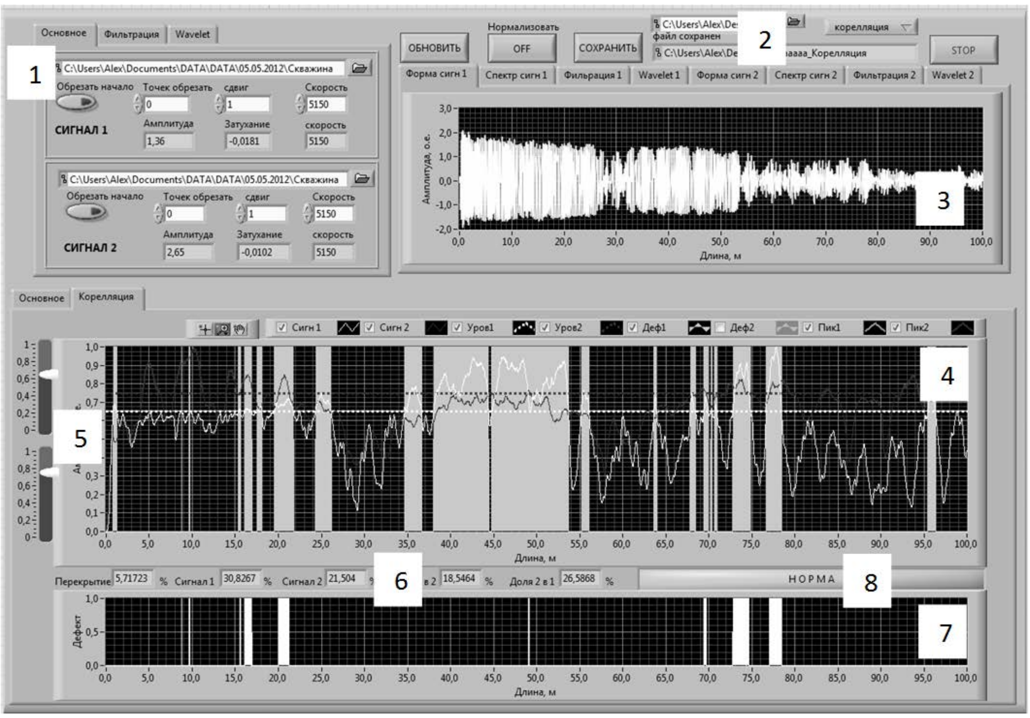

Fig.2. VI front panel of the program «Well logging data processing»

The image of the VI front panel of the program «Well logging data processing» is presented in Fig. 2. The front panel includes instruments for setting of parameters of testing (1), signal cut-off, filtration and wavelet analysis (2), image of signals (3), setting of a control level (5) and comparing of signals (4). The bright regions in the panels (4) and (7) indicate the places where the signal correlation is maximal. The experiment presented was fulfilled using the home-made laboratory equipment for testing of the developed single-sided well logging control system.

4. Discussion and Conclusions

Thus sophisticated routines are available for displaying results, and for preparing the data for spectral, statistical or correlation analysis in the software reported. The software is an integrated software package which contains all the necessary tools for the representation and evaluation of coordinates and dimensions of the defects, and evaluation of the degree of degradation of the structure quality of the tested well.

References

[1] Blizeyev A.B., Kozlov A.V., Smerkovich E.C. Acoustical diagnostics of the quality of the cement ring out of the well pipe. Russian patent 2055176, cl. IPC E 21 B 47/00. Claim 5029717 from 27.02.92, published 27.02.96. Bull. No 6.

[2] Andreev N.K., Malatsion A.S. Nondestructive acoustic monitoring and diagnostics of technical state of water and oil wells. *Russian News of Higher Educational Institutes. Energetic Problems.* No. 1-2: 107-115. 2014.

[3] Andreev N.K., Sadykov M.F., Malatsion A.S., Chernysheva M.G. Device for acoustic quality control cementing : Pat . Rus. Federation: MPK7 E21B47/00, applicant and patentee " KSPEU ." - № 133193 appl . 07.05.2013; publ . 10.10.2013, Bull.No. 28.

[4] Andreev N.K., Malatsion A.S., Chernyshova M.G. Sonic Testing of Long Pipes by Using Longitudinal Waves. In proceedings of the 9th International Conference on Measurement, 2013, 267-270.

[5] Andreev N.K., Malatsion A.S., Chernyshova M.G. Noninvasive Sonic Testing of Water Wells. In proceedings of the 1st International Global Virtual Conference GV-CONF 2013, 2013, 525-528.

[6] A.S. Malatsion, N.K. Andreev, M.F. Sadykov/ Certificate of state registration of the computer program No 2014613168 : WELL LOGGING CONTROL / application No. 2013661587 , DC . 12/12/2013 ; publ.20.04.2014, bull. No.4.

[7] A.S. Malatsion, N.K. Andreev. Certificate of state registration of the computer program No 2014611721: WELL LOGGING DATA PROCESSING / application No. 2013661584, DC . 12/12/2013; publ.20.03.2014, bull. No.3.