DOWNHOLE DYNAMOMETER TOOL

Glenn D. Albert
ALBERT Engineering

The Downhole Dynamometer is a tool designed primarily for the acquisition of sucker-rod load and position data at any point in the rod string. The tool is completely sealed, battery-operated, and microprocessor-controlled to sample the various parameters at specific times and sampling rates and to store the data digitally in a non-volatile memory for later retrieval. Other parameters sampled are temperature and pressure and, with the present design, bending data is also collected. Axial position is derived from acceleration. At the time of this presentation two-dimensional lateral accelerations may also be available. While used predominantly for code validation the tool could be an effective well-diagnostic device as well.

Development

Much of what is stated in the opening paragraph can also be found, in some form, in SPE paper #17010 (Fall '87) and in the author's Master's thesis published one year before that. In the five years following 1987 little changed with the tool but in 1992 development resumed to meet the slowly-growing needs of the production industry. In the past two years steadily growing industry demand has been met with sweeping changes to meet today's needs and to make the tool practical for repeated field use. Figure 1 illustrates the main features of the present design.

Like most tools, this one was developed to meet a need. Most features of this tool are designed to meet the express needs of industry and the improvements that have occurred over the past two years reflect this. The history of the changes are depicted in Figure 2. There are also many changes that do not show up in the figure. An example is the concept of using multiple tools, together in the same string to determine simultaneous conditions at more than one point.

The most significant improvement lately is in the stabilizing of the load signal. Changing to transducer-class strain gages and installation techniques have elevated the load signal to an absolute signal which should eliminate the need for downhole calibration.

The advent of silicon-based sensors and a great deal of effort in minimizing power consumption have led to both the reduced physical length of the tool and extended operating time. The continuing trend in integrated circuits toward higher density storage devices has enabled the increased storage capacity in the same amount of physical space.

While many of these features have stabilized for the time being, the tool is designed, whenever possible, for flexibility. As each feature presently incorporated arose from a need, it is assumed that further needs may arise and the design will be adaptable. Within the present architecture, sampling rates, times and signal combinations are all programmable.

Application

The present mode of operation of the tool is of a lease nature that works as follows. The user's needs are listed in terms of which combination(s) of signals are to be sampled, how often, specifically which days and times, and at what sampling rates. Once these things are defined, the tools are programmed, prepared and shipped to the user at the prescribed beginning of the test. The user then installs the tool(s) in the string, much like any other section, and leaves them in the operating well the prescribed period of time. In the past a standing-valve check period has been coordinated with a calibration sampling period to determine static pressure and load points. If the load cells prove to be truly transducer class this step may be eliminated. When the test is finished the tool(s) are returned for retrieval of data and generation of graphs. Since the graphs and any other information that come out of a test are the sole properties of the user, no graphs are presented here, but there are likely to be other papers presented at this conference that reflect the graph format and quality.

The amount of data collected is limited by the total capacity of the digital memory. Tradeoffs can be made between the sampling rate, number of signals sampled, and total time of sampling to arrive at the best solution for a given application. As a rule, each signal sampled requires two bytes of storage per sample. Standard sampling rates are; once per minute, once per second, 10Hz, and 50Hz. If six channels were sampled at 50Hz there would be about seven minutes worth of space in a 256kByte memory. This seven minutes could be divided up as desired, and more total sampling time could be realized at lower sampling rates. A standard option is to maintain a once-per-minute account of the six main channels throughout the test. For a four-day test this adds up to about 70kBytes of overhead.

Other specifications required of the user are the expected peak loads, pressures, and temperatures of the specific test well. While there has been some discussion of designing for higher temperatures the present electronic components have an operating limit of 85 C.

Construction

The body of the tool is constructed of standard oil field components. Ultimate load capabilities are in excess of 20,000 pounds. The unit is completely sealed and the pressure is ported to the pressure sensor via a 3/16" diameter hole in one of the flats of the bottom connector. The present design weighs around 12 pounds and is 23.25" long by 1.75" in diameter.

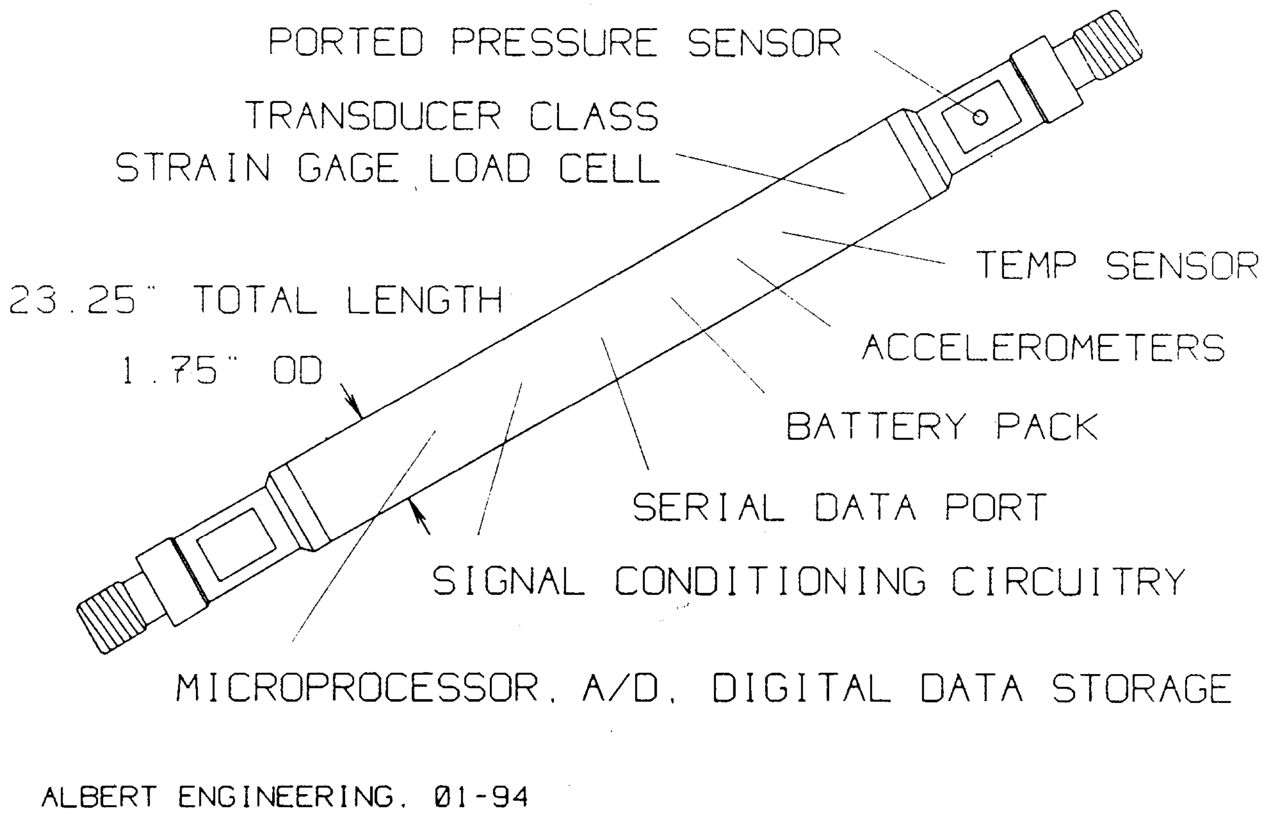

Figure 1 - Downhole dynamometer

	1986	1992	1994
SIGNAL			
LOAD	YES, PURE AXIAL	YES, PURE AXIAL	YES, AXIAL & BEND
POSITION	YES, PIEZO-ELEC	NO	YES, PIEZO-RESIST
PRESSURE	YES	YES	YES
TEMP.	YES	NO	YES
FEATURE			
STORAGE	32 kBytes	128 kBytes	256/512 kBytes
RESOLUT.	8-bit	12-bit	12-bit
RANGE	< 24 Hours	5 days	10+ days
LENGTH	> 6 feet	< 4 feet	< 2 feet

Figure 2 - Development stages of the downhole dynamometer tool