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Production test enhancement by the use of digital gauge

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ABSTRACT

Pressure monitoring and control using digital gauge as a tool, is one of the economical sources of obtaining valuable information about periodic production tests. It is actually a test to determine relative quantities of oil, gas and water produced under normal producing conditions. They facilitate well and reserves operations and also comply with legal and regulatory requirements. Every individual, in oil and gas well pressure and temperature monitoring and controlling team, require the knowledge of pressure and temperature(PT) behaviours in the annulus and tubing and at the wellhead, periodically, either during or after an operation. One of the most reliable ways through which these parameters (PT) can be monitored and controlled is through the use of one of the digital gauge known as “Keller (LoggerDCX4.11) Gauge”, which is capable of recording and storing PT data. Every operation carried out with this gauge is meant to achieve a specific goal, either to know the pressure build-up or the pressure drawdown, during and after annulus and tubing pressure bleed-off. When this purpose is achieved, effective well development and production is assured.PT, well development and production are closely related in the sense that, they are mutually dependent. For well development and production to succeed, pressure data, among other parameters must be known. This tool is one of the most advantageous gauges for PT well testing data. Its unique features make it easier to monitor and control oil and gas wells’ PT during development, production and maintenance.

Introduction

Pressures gauges are often used in plants or wellheads. As a result of the great number of them required, attention to maintenance could be compromised. It is therefore common for plants to be ordered to find out that many gauges and switches are out of service. This is unfortunate because, if a plant is operated with a failed pressure switch, the safety of the plant has been compromised. Conversely, if a plant is operated safely while a gauge is defective, it shows that the gauges were not needed in the first place. Therefore, one goal of good process instrumentation design is to install fewer but more reliable pressure gauges (Aston, 1984; Bourgoyne et al. 1986). One way to reduce the number of gauges in a plant is to stop installing them on the basis of habit (such as placing gauges on the discharge of every pump). Instead, review the need for each device individually. During the review, one should ask “what will be done with the reading” and install one only if there is a logical answer to the question. If a gauge only indicates that a pump is running, it is not needed since one can hear and see it. If the gauge indicates the pressure (or pressure drop) in the process, that information is only valuable only if one can do something about it (like cleaning a filter); otherwise it is useless (Brons and Martins 1972). If one approaches the specification of pressure gauges with this mentality, the number of gauges used will be reduced. If a plant uses fewer and better gauges, then the reliability will increase. It is a fact that the aim of running gauges at the wellhead is to achieve a particular objective of obtaining pressure rate of certain equipment and monitoring and controlling pressure in the tubing or annulus for possible oil and gas wells’ development and production, but there are constraints to that effect (Moore 1974). The question is do analog gauges really fulfilling the purpose of monitoring and controlling tubing and annulus pressures? It is also a known fact that the gauge ‘’Analog” plays a positive role in the development and production of oil and gas, but the question is, what are its advantages, in terms of data reading, recording ability, conveniences, etc. compared to digital (memory) gauge in monitoring and controlling pressures at wellheads for oil and gas production rate enhancement. It is on this basis that this research paper focuses deeply on how to make the best production test for oil and gas well with the use of digital pressure gauges.

Types of Pressure Gauges:

Commercial Gauges

(Perez-Tellez2003) analyzed the high reliability of the OMEGA ® commercial gauge line and observed the uniqueness of the OMEGA ® spring movement. The entire movement is suspended between two springs, the Bourdon tube above and the link below. Wearing parts have been reduced to a minimum. Furthermore, these movement parts are ultrasonically cleaned and lubricated with silicone oil to ensure long cycle life. The OMEGA ® spring suspended movement is largely resistant to the effects of shocks, pulsation and vibrations. The result of these features is a longer gauge life. The numerous applications for OMEGA ® commercial gauges include installation on pumps, portable compressors, industrial machines, hydraulic and pneumatic systems, instrumentation and pressurized vessels. For the user, this means greater resistance to mechanical shocks and vibrations. This increased resistance to the effects of rough usage contributes to its longer life.

Specifications (Type P and Type C Gauges)

Max Temp.: 66°C (150°F); | **Case:** Painted Steel; | **Window:** Polycarbonate Plastic;

Tube: Bronze; | **Connection:** Brass 1/4" NPT; | **Ranges:** Vacuum thru 600psi;

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Accuracy: 3-2-3% (3% over first & last 10% of range; 2% over remainder).

Liquid fillable utility gauges:

Figure 1: Liquid Fillable Utility gauge

The work done by Renault(1983) also showed that OMEGA PGUF series Liquid Fillable Utility gauges are designed for a wide range of applications on pumps, compressors, hydraulic systems, machine tools and petrochemical processing equipment. For high shocks and vibration applications, the PGUF can be liquid filled in the field to dampen the gauge pointer movement. The movement of PGUF series Liquid Filled gauges come in different ranges of (PSI/BAR) 0-30/2, 60/4, 100/7, 160/11, 300/20, 600/40 and 1000/70 and others. Their rated accuracy is ± 25% of span.

General service gauges:

Figure 2: General Service gauge

Scot (2002) observed that meeting the requirements of many industrial applications, the General Service Gauges can be used on steam boilers or other pressurized vessels; on pumps and compressors, on many type of industrial machinery; in the chemical, petroleum and allied process industries; in power plants; in pulp and paper mills. The pressure gauge actuation system in the OMEGA ® General Service Gauge line is the standard 316 SS Bourdon tube system, which is engineered to precise tolerances for consistent repeatability and response to pressure fluctuations. All gauge components should be chosen with an eye to the media and ambient operating conditions to which they are exposed, to prevent mis-application. Improper application can be detrimental to the gauge, cause failure and possibly personal injury or property damage.

Specifications (Type S Gauges):

Max Temp.:66°C/150°F; | **Case:** Polished Stainless Steel; | **Window:** Polycarbonate Plastic with Neoprene Sealing Gasket; | **Bourdon Tube:** 316 Stainless Steel; | **Connection:** Back or Lower; | **Fitting:** 316 SS, 1/4" NPT; Dial Size: 2-1/2" and 3-1/2" Mounting: Stem, Flange or "U" Bracket; Accuracy: 1% full scale.

Stainless steel industrial pressure gauges:

Figure 3: Stainless Steel Industrial Gauge

In the research work of Mathew and Russell (2004), it was observed hat, OMEGA's PGM Series are suitable for corrosive environment in Chemical, Petro-Chemical, refining, power, marine, food and pharmaceutical processing applications. The PGM series come in a 63 mm (212") or 100 mm (4") case and feature all stainless steel construction and is environmentally protected to IP65. The PGM series can also be liquid filled in the field. Liquid filled pressure gauges provide users with a number of advantages in certain applications. They are ideally suited for use on equipment where excessive vibrations and pulsations are encountered such as pumps, compressors and machine tools etc. The liquid fill minimizes the effect of these severe environments, protects, the gauge interiors and provides continuous lubrication in the mechanism, all adding up to extended service life. Liquid provides greater protection of the gauge interiors from corrosive environments. Gauges can be filled with a variety of fluids including glycerin, mineral oil and silicone oil.

Specifications (Type S Gauges):

Working Pressure: 75% of full scale; | **Over Range Protection:** 130% of full scale; | **Ambient Temp. Range:** -40 to 60°C (-40 to 140°F); | **Process Temp. Range:** -20 to 80°C (-4 to 176°F); | **Degree of Protection:** IP65; | **Element:** 316 Stainless Steel; | **Window:** 63 mm: polycarbonate, 100 mm: laminated safety glass; | **Case and Bezel Ring:** 304 stainless steel; | **Pressure Connection:** 316 stainless steel, 1/4" nptm on 63 mm, 1/2" nptm on 100 mm; | **Accuracy:** 63 mm ± 1.6% of span.

Industrial Process Gauges:

Figure 4: Industrial Process Gauge

(Perez-Tellez2003) pointed out in his work, that industrial pressures are very useful for the factory floor. Thousands are installed worldwide to monitor process pressures. These gauges are available in vacuum, compound, and ranges up to 20,000 psi (1380) bar. A hermetic seal provides greater protection and safety.

Speifications:

Dial Arc:270° | **Case:** Lower Connection: Black Phenol, Back Connection: Aluminum; | **Window:** Double-Strength Glass; | **Bourdon Tube:** 316 Stainless Steel | **Connection:** 1.2" NPT Male-316SS; | **Mounting:** Stem, Flush or Surface; | **Operating Temperature:** 121°C/250°F Max.

Pressure analysis in gas/condensate reservoir

(Maylor1989) established a systematic method for analyzing production well-test pressure data in gas/condensate reservoir. He stated that a three phase ID (Internal Diameter) model be used. Different systematic features are always needed to illustrate the build-up pressure response in gas/condensate reservoirs. The steady state method does not accurately predict the oil saturation values on the region in which oil is condensed from the gas and accumulated until it reaches the critical oil saturation. Applying the line fitting method in the two phase analysis, a zero-slope line can be fitted to the derivative data points in the middle time region. The procedures allow the gas relative permeability value at the connate-water saturation and the mechanical skin factor to be obtained, provided the pseudo pressure function has been estimated accurately.

Materials and Methodology

Material and Equipment: Keller memory gauge device, Logger DCX4.11, Portable Computer laptop, USB Cable

Adjustable Spanner, Christmas tree with hydraulically operated chokes and niddle valves.

Operational methods:

The operational method used in this research is Formation Evaluation method which includes: Well tubing surface pressure testing. Basically, the test was conducted, by rigging up the gauge at the well tubing-head niddle valve, selecting the recording button on the gauge, opening the choke and the niddle valve, allowing the flowing pressure recorded by the gauge to be stored at its configured interval as a function of time. At the end of the operation, the recording button of the gauge is turned-off, and then the niddle valve and the choke are closed.

Data Preparation

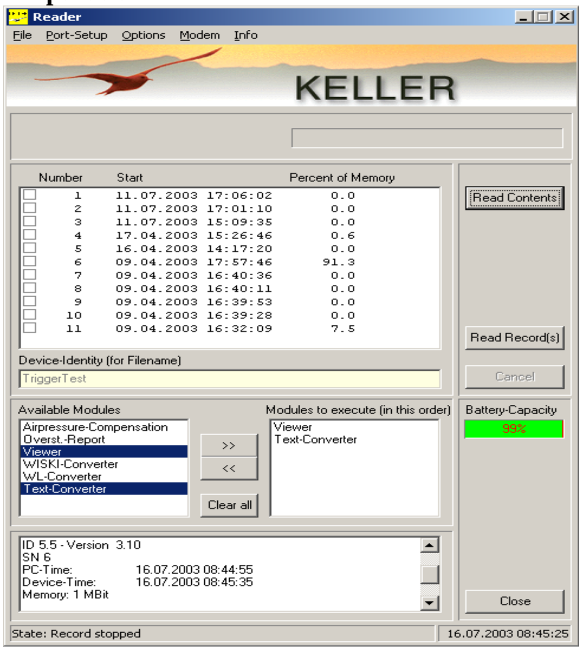

Figure 5: A Logger DCX Data-Reader Package

The Reader program (Reader)

All recordings available in the device are listed by means of this program. Each recording selected is read out of the device and stored in a separate file. Depending on the selection of executing modules, these files are either further processed or only displayed. The files can also be processed later with the help of the individual modules.

Figure 6: PC and configured Kelly Memory Gauge device

Initialization

The Data Logger DCX was initialized before communication was established with it. This is done by clicking Read Configuration. If a device is present, its settings are read in and displayed in Writer WL. The device type, serial number, device time and PC time as well as the (total) memory available in the device are listed in the status window. The status bar shows the current recording status as well as the current time.

File

Save configuration: The current configuration is backed up to a file (*.cfx)

Open configuration: A saved configuration file is opened and loaded.

Exit: Exit the program

Port-Setup

Port Selection of the serial interface

Modem: Upon activation, the communication protocol for data transfer via a modem is negotiated.

Settings

Editing the device identity:

On this screen you may enter a description (max. 63 characters) by which the device can be uniquely identified. This identification, along with the current date/time and index, is used to form the name of the file that the reader creates after reading in recorded data.

Table 1: Examination of constant wellhead pressure during oil-flow

Activity:		**Tubing surface pressure monitoring**	
Well Name:		**xxxxxxx**	
DAY	**TIME**	**P(psi)**	**T(°F)**
8/3/2014	10:46:40AM	167.57	85.71
8/3/2014	10:51:40AM	169.30	85.61
8/3/2014	10:56:40AM.	173.68	85.78
8/3/2014	11:36:40PM	192.41	79.01
8/3/2014	11:41:40PM	191.10	79.01
8/3/2014	11:46:40PM	191.08	78.97
8/3/2014	11:51:40PM	182.18	79.15
8/3/2014	11:56:40PM	194.85	79.22
8/4/2014	12:01:40AM	189.01	79.37
8/4/2014	12:06:40AM	191.92	78.79
8/4/2014	12:11:40AM	187.01	77.54
8/4/2014	12:16:40AM	177.82	77.43
8/4/2014	12:21:40AM	185:70	76.68
8/4/2014	12:26:40AM	184.28	76.21
8/4/2014	12:31:40AM	188.65	76.25
8/4/2014	12:36:40AM	189.09	76.32
8/4/2014	12:41:40AM	194.13	76.39
8/4/2014	12:46:40AM	203.75	76.43
8/4/2014	12:51:40AM	202.71	76.68
8/4/2014	11:41:40PM	204.55	79.51
8/4/2014	11:46:40PM	205.61	79.44
8/4/2014	11:51:40PM	195.55	79.37
8/9/2014	11:56:40PM	210.40	79.40
8/5/2014	12:01:40AM	202.2	79.44
8/5/2014	12:06:40AM	200.82	79.51
85/2014	12:11:40AM	194.75	79.61
8/5/2014	12:16:40AM	195.84	79.61
8/5/2014	12:21:40AM	206.93	79.47
8/5/2014	12:26:40AM	207.10	79.26
8/5/2014	12:31:40AM	204.22	79.12
8/5/2014	12:36:40AM	209.90	79.15
8/5/2014	12:41:40AM	193.75	79.15
8/5/2014	12:46:40AM	187.64	79.15
8/5/2014	12:51:40AM	207.72	79.15
8/5/2014	12:56:40AM	209.23	79.12
8/5/2014	1:01:40AM	203.35	79.15
8/5/2014	1:06:40AM	198.52	79.01
8/5/2014	1:11:40AM	199.35	78.87
8/5/2014	1:16;40AM	193.92	78.97
8/5/2014	1:21:40AM	203.97	79.04
8/5/2014	1:26:40AM	195.93	79.12
8/5/2014	10:16:40PM	193.10	88.77
8/5/2014	10:21:40PM	198.04	90.72
8/5/2014	10:26:40PM	190.10	91.89
8/5/2014	10:31:40PM	197.43	91.55
8/5/2014	10:36:40PM	189.80	91.61
8/5/2014	10:41:40PM	199.01	91.07
8/5/2014	10:46:40PM	190.03	90.93

Results And Discussion

Table 1 is available for the analysis of production test result, obtained during oil flow through Tubing at the Wellhead, to examine pressure behavior using Keller digital (memory) gauge. It was discovered, that Keller digital (memory) gauge communicates with Well's Pressure. Below are the results obtained from the test at the Wellhead to examine the advantages and major constraint(s) of this gauge over analog gauge(s).

Table 1 above shows the following:

(a) The date and time the gauge starts recording data with respect to Pressure and Temperature.

(b) Theconfiguredrecording interval.

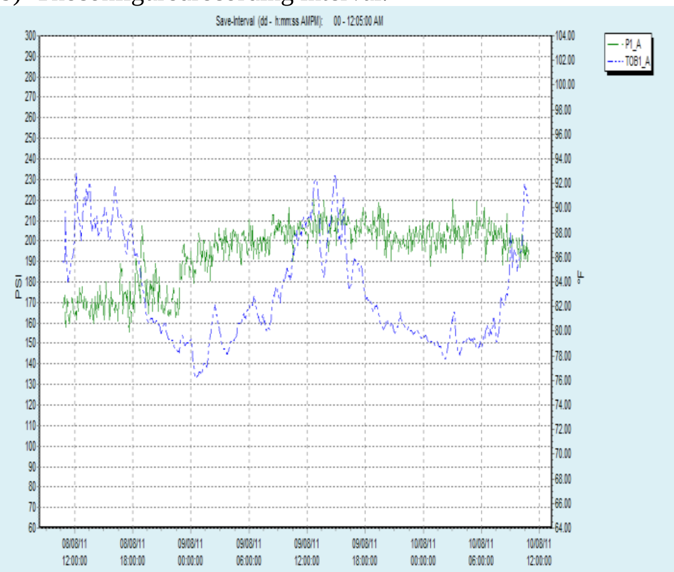

Figure 2: A typical Tubing pressure and Temperature chart prepared by the gauge

The following are extracted from Figure 2:

(a) Tubing Pressure/Temperature chart of Table 1 data.

(b) Green plotsindicate pressure plotting points while the blue plots indicate Temperature plotting points.

(c) Theconfigured interval (five minutes), indicating the Pressure and Temperature values in the tubing string.

(d) The result showed the pressure behavior at the wellhead and its effect on production rate.

It can be observed that at this period, the pressure was unstable, giving rise to unstable flow rate of production, because oil production wells are normally operated at constant bottom-hole pressure because of constant wellhead pressure imposed by constant choke size as that of Matthew and Russell, (2004).

Analyses Of Gross Liquid Flow Rate

A wellhead choke or bean was used on flowing wells to regulate the flowing rate. In order to properly interpret flowing well behavior, the effect of surface choke on production performance was evaluated.

Mathematically, Gilbert et al (2003) developed the following empirical equation relating oil flow, Gas Oil ratio (GOR), tubing pressure, and choke size.

$$P_{tf} = \frac{435\, R_{gl}^{0.346}\, q}{d^{1.89}} \quad (1)$$

$$q = \frac{P_{tf}\, d^{1.89}}{435\, R_{gl}^{0.346}} \quad (2)$$

Where P_{tf}= flowing tubing pressure

R_{gl} = gas-liquid ratio

q = Gross flow rate

d = Choke size in 1/64

From theresults (Table 1 and Figure 2), the wellhead flowing pressure values which ought to be constant is found to be unstable at different configuredintervals (5mins), making it difficult to estimate flowing rate of production with Equation 2.In order to estimate constant flow rate of production, the flowing pressure must be constant.From this information, it can be deduced that this oil-well requires maintenance.

All wells require a sound servicing program if production is to be maintained, restored or improved during the producing life of a well. These operations have one major purpose which is to keep a well producing at the desired level. The necessity for such a program is based on certain requirements that are essential to all wells, such as general maintenance and repair of equipment, and other requirements that may be necessary for some wells but not others. If a well produces less than expected, it is said to be "off" production. If it ceases to produce, it is "out" of production. In either case, it is classified as **"a Problem well".** There are six basic types of problems that may plague a well which are listed as follows:

- Deficient Hydrocarbon Production
- Excessive Gas Production
- Excessive Water Production
- Production of Formation Sand
- Equipment Failure
- Reservoir Depletion

One of the problems that were found on this well is **"Deficient Hydrocarbon Production."**Itproduced smaller quantity of hydrocarbon than expected. This condition exists when a well is producing below its full potential, or at a rate below an expected or required level. The problem may result from natural causes, man-made causes or a combination of the two.

Natural causes may be related to the physical characteristics of the reservoir and/or the composition of the formation fluid to be produced. This may include: poor natural reservoir permeability and porosity, the absence or limited presence of a natural drive condition or formation fluid having a high GOR, viscosity, etc.

In addition, a number of conditions may be created as a result of drilling, completing or producing a well that experiences formation damage resulting from an improper mud program during the drilling of the well. It may also include a well that produces water as a result of poor completion practices or loss of reservoir pressure because of improper pressure maintenance program.

Another suspected problem on this well is**"Equipment Failure".** One of the most common requirements for well services at a producing well is the maintenance and repair of any tool and/or mechanical equipment used at the well site. There are two basic types of tools and equipment failure: 1) Tool and equipment wear and 2) Equipment malfunction.

Wear generally occurs in all production tools, such as casing, tubing and packers, as well as all mechanical equipment. Most wear is caused by constant exposure of the tools and equipment to corrosive formation fluids during the production of the well. The wear in turn, causes equipment malfunction.

Equipment wear and malfunction may cause a number of other problems, including making the conditions for the crewdangerous, increased costs of produced fluids and loss of production.

Conclusion

The study has revealed the effective functions and potentials of Keller digital gauge, in monitoring and controlling well pressures and Temperatures, towards the development and production of oil and gas wells.

The analyses of the data obtained from this work revealed that Keller (memory) gauge, can monitor and control pressure in the tubing or in the annulus for possible oil and gas wells' development and production enhancement.Once a well is producing, it is important to maintain the production by a well-established well monitoring and servicing program.The following suggestions will assist in assessing well problems and finding solutions.

(a) Regular checks of surface pressure on production and surface casing strings.

(b) Routine observance of producing characteristics to observe unusual water or gas production increase.

(c) Regular checks of shut-in pressure to observe unusual pressure declines.

(d) Routine temperature survey which may be helpful in detecting large leaks

Keller (memory) digital gauge among other digital gauges, plays major role in detecting well's problems like Pressure and Temperature anomaly.

When a well goes "out" of production, it must be analyzed, the problem diagnosed and the necessary corrective action taken to restore the well to production status. The analysis includes a review of the well's mechanical history, geological data, and the condition of the reservoir, its production history, its well servicing and work-over history and a review of an offset well in the area.

Once an analysis and diagnosis are done, a plan of action is determined, a recommendation is made and a cost estimate prepared based on specific variables relevant to the well. The approved recommendation is translated into a field plan which specifies the required action, the service company equipment and crews and any other additional equipment or materials needed.

Recommendations

Based on the results and the discussion of this research, the following recommendations are made:

1. This tool should be used as a guide to those involves in well monitoring and operations.
2. Further investigation should be carried out at various conditions to see how "Analog Gauge(s)" couldbe considered as a preferred kind of gauge (tool) in monitoringand controlling wellhead pressures for possible detection of pressure behavior for the evaluation of production flow-rate.

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Nomenclature

d	=	depth
GOR	=	Gas Oil Ratio
Gp	=	Formation pressure gradient
P	=	Pressure
P_{bo}	=	Observes pressure drop
P_h	=	Hydraulic horse power
p_p	=	Pore pressure
P_{tf}	=	Tubing Flowing Pressure
PT	=	Pressure and Temperature
q	=	Gas flow Rate
R_{gl}	=	Gas liquid ratio

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