A New Method of Mechanical Gas (Methane) Extraction From Drilling Mud

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Published: January 2008

Prepared for
Southwest Section
American Association of Petroleum Geologists
Wichita Falls, Texas

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Abstract

iBall Instruments® has developed an improved mechanical method of extracting gas information written into mud during drilling operations. This new methodology implements the principals of inertial cavitation for highly efficient sample extraction. The cavitation methodology has proven to be a superior and more effective way to extract dissolved gasses, gasses trapped in powdered rock, gasses suspended in mud and gasses associated with small rock particles. Further, this new device and methodology provides an increased level of personal safety by incorporating a Direct Current isolated power supply. The equipment has been field tested and refined to a commercial product. This white paper describes (1) the evolutionary process of development, (2) the components utilized in the finished product and (3) explanations as to how the finished product works.

Contents

History

The process of mud logging has been in existence for decades. With the generalized oil bust resulting from the O.P.E.C. crisis of 1970s, the resulting depressed oil prices and the subsequent oil depression during 1982-1984, very few dollars have been invested to upgrade or improve the equipment and techniques utilized. There are mud-logging trailers in operation today that still use vacuum tube technology and thirty-plus year old paper chart recorders to divine methane shows in the mud during the drilling process.

The author was unable to establish a time line as to when it was first discerned that the drilling fluid used to lubricate and cool the drilling bit contained detectable gas content indigenous to the mud that is expelled from the hole. Most likely it was discovered due to an oil field accident involving some type of rapid combustion process of the drilling mud. While the history of the earliest on-site methane detection systems is unclear, there is evidence that some detection systems were built in the late 1950's and possibly earlier. The primary source of gas detection utilized "hot wire" technology.

The challenge iBall Technologies accepted was designing a reliable method to remove the sample gas out of the drilling mud and transport the sample to the hot wire detection system. It became evident that a new and improved mechanical device was required to provide consistent sample gas extraction.

For at least twenty-seven years, sample gas extraction has been accomplished using a mechanical method of mud agitation. This method worked well enough to become the industry's de facto standard, albeit it is not without significant asperities.

In 2006, iBall Instruments® began a study of agitation methods; the weaknesses of the mechanisms in general use and set out to improve not only the mechanical implementation, but the efficiency and safety aspects of the process.

Gas Sample Quality

The goal was to design a system capable of extracting a more exacting sample of the gas information that is "written" into the mud during drilling operations.

As drilling mud is forced under high pressure down the center of the drilling pipe, it lubricates and cools the drilling bit making it last longer. This mud must then travel up the sides of the hole being drilled. As the drilling mud travels up around the shaft or pipe, the mud is in direct contact with all the layers of strata including all gas bearing strata.

There are four (4) sources of gas information trapped within the drilling mud that exits to the surface.

1. If the drill bit is in direct contact with the gas bearing strata, this violent contact creates a large amount of rock dust which is then infused with gases and suspended into the drilling mud.

2. The mud may also contain gas impregnated rock particles: some smaller than 0.5mm, others larger than 1mm.

3. Additionally, if the gas bearing strata is under high pressure, the drilling mud may include dissolved gases.

    - By way of example, carbon dioxide is dissolved into soft drinks under pressure to create the “fizz” when opened under ambient atmospheric pressure.

4. Lastly, there are background gasses. These are the gases that are trapped in the drilling mud that are constantly re-circulated from the surface back down through the hole and then, to once again exit back to the surface.

Air Injection System

It was the author’s belief that through a more efficient gas extraction system, geologists and loggers would be able to detect and discern all four sources of trapped gasses instead of only the one or two types of gases that current extraction methods provide.

The Research and Development Process

Early research focused on exploring radical new designs for sample gas extraction based on numerous methodologies.

For comparison, testing of new designs was accomplished in parallel with standard hot wire systems that employed common induction motor sample extractors.

Pressurized Atmosphere System

The first radical design built and tested by iBall Instruments® utilized compressed atmospheric air, pumped into the base of a very light weight PVC tube/column. The compressed air forced fresh drilling mud from the bottom of the tube up to the middle section. The sample gasses were then extracted at the top.

This air injection system had limited success due to the dilution of the gas sample from the injected air. However, a benefit of this design was a reduction in water vapor infused into the sample extraction. This system also performed well when extracting samples from the middle of a drilling mud supply.

The next design of interest incorporated an air injection system. It used pressurized atmosphere to agitate the surface mud and recirculate the sample gasses back through the agitator thereby eliminating the dilution of sample gasses.

This design also showed limited success because of the limited agitation of the surface mud. But, it did prove recirculation of the agitation gasses reduced the dilution of the sample gasses.

Pressurized Atmosphere with Mechanical Vibrator

The third agitation system prototyped and tested also used compressed recirculated atmospheric air but incorporated a mechanical vibrator that vibrated the entire extraction mechanism.

This extractor proved very interesting. There was very little water extracted with the sample gasses and it pulled out much of the dissolved gasses. Unfortunately, the mechanism had little effect on any of the other sources of trapped gasses in the mud.

After about three hundred (300) hours of use, the external vibration exerted upon the PVC components proved too much and the unit broke at the upper cup joint.

The fourth prototype integrated some of methods used in previous agitator designs and it incorporated a motor to agitate the drilling mud. Additionally, the design employed a three (3) foot condensation tube. As sample gasses were passed up through the column that supports the mechanism, water vapor actually condensed on the inside of the column instead rather than within the vacuum lines. This design reduced the amount of water condensation in the sample tubing considerably. The reduction in weight of this design made it easier to assemble and clean. One of the obvious advantages of this PVC based design was the issue of cleaning. When the mud dried, it fell off without minimal intervention and there was no corrosion.

Agitator with Condenser Column

The drawback of this design was found to be in the mid-chamber placement of the connection to the main extraction chamber. It was concluded that placement into the mud pool was critical. If the mud level in the shaker was too high, then mud contamination seeping into the sample line was assured.

The Construction of the Final Design

Further design enhancements on the fourth prototype include a lightweight DC sealed motor, a stainless steel fork assembly and a quick hose clamp design to afford easier adjustments.

A final design is now in production. Extrapolating on past experiments/designs, it appears that this product provides a very good balance of both the pros and cons for sample gas extraction. The current design uses 0.100” thick 2.0” OD steel wall tubing for the supports, and a main 4.0” OD extraction tube. The lightweight motor and motor assembly weighs in at just less than 21 pounds making it easy to transport and install by a single technician.

Cavitation vs. Agitation

Through our research and prototyping, we have found that the cavitation methodology is superior to agitation and the most efficient way to extract (1) dissolved gasses, (2) gasses trapped in powdered rock suspended within mud, (3) in small rock particles and (4) background gases.

- A typical 120VAC Induction motor will not spin agitator devices fast enough to extract all the information trapped in the returning mud. Experimentation and testing proved that the drilling mud must be brought into inertial cavitation for proper sample extraction.

Cavitation is a general term used to describe the behavior of voids or bubbles in some form of liquid. Cavitation is usually divided into two classes of behavior: inertial, and non-inertial.

Inertial cavitation is the process where a void or bubble in a liquid rapidly grows and collapses, and can produce a shock wave. Such cavitation often occurs in pumps, propellers, and impellers.

When a given volume of liquid is subjected to a sufficiently low pressure caused by an outside stimulus, it may rupture and form a cavity. This phenomenon is termed cavitation. The phenomena can occur behind the blade of a rapidly rotating boat propeller or on any surface oscillating underwater with sufficient amplitude and acceleration.

By implementing the theories behind cavitation, the new iBall Instruments® cavitator extraction system reinvents the process.

The New iBall Cavitator and How it Works

Sample gases gasses evaporate or are drawn into the formed cavity from the surrounding medium; this cavity has a high vacuum. When the vacuum cavity is created, heat is lost into the surrounding media. Then, during the time the cavity is in existence, heat is re-absorbed from the surrounding mud. When the mechanical stimulus is removed or moves from one region to another, the low-pressure cavitation bubble will begin to collapse due to the higher pressure of the surrounding medium. As the bubble collapses, or compresses, the pressure and temperature of the vapor within will rapidly increase. The bubble will eventually collapse to a fraction of its original size, but still remains due to the heat energy absorbed during its static phase. This bubble will contain any and all percentages of trapped gas extractions from all media within the drilling mud. As cavitation is sustained, more bubbles are generated and more sample gas is produced.

The All-New iBall Cavitator Complete Assembly

The actual process of cavitation is similar to boiling. The major difference between boiling and cavitation is the thermodynamic paths which precede the formation of the vapor from the liquid. Boiling is when the local vapor pressure of the liquid rises above its local ambient pressure and sufficient energy is present to cause the phase change to a gas. Cavitation occurs when, through mechanical means, the local pressure falls sufficiently far below the saturated vapor pressure. This value is given by the tensile strength of the drilling mud, which has a relationship to the mud weight and viscosity. As mud weight and viscosity is increased, a higher fork velocity must be achieved to sustain proper cavitation. This is why AC induction motors fail in proper sample extraction. Most motors do not have the ability to sustain speeds high enough to produce the proper cavitation.

iBall Cavitator

In order for cavitation to occur, the cavitation "bubbles" generally need a surface on which they can nucleate. On the new cavitator design, this surface is primarily the cavitation forks and then by the very small solids in the drilling mud, followed by small un-dissolved micro-bubbles within the mud itself. These pre-existing bubbles (e.g., methane) start to grow in size unbounded when they are exposed to a pressure below the threshold pressure. For your further research, this pressure limit is known as “Blake's Threshold.”

The new iBall Instruments® Cavitator has further refinements. It still has the condensation tower that doubles as the vertical mounting tube. This tower draws out much of the condensation found to be a problem with other sample extractors. The cavitator also has a .750” vent hole that allows for atmosphere to be drawn in and for atmospheric pressure equalization. This vent is shielded from wind with a 4.0” tube welded to it at an angle of roughly twenty-five (25) degrees. A simple and inexpensive rubber cap blocks the upper and lower condensation tube orifices. The upper cap is pierced and the sample extraction tubing is inserted. Clean up is easily facilitated by just removing the rubber caps and rinsing with water.

Overcoming the Weight Problem

iBall Cavitator Clamping

The sample extraction systems that are in use today are generally over-built and much too heavy. The Cavitator system from iBall Instruments® weighs only twenty-one (21) pounds and can be disassembled into three (3) convenient sections. Typically the current systems average over eighty (80) pounds and some weigh well over one hundred (100) lbs. This has been proven to be unnecessary and potentially hazardous. Sample extraction is enhanced by the Cavitator’s smaller chamber design. This also helps eliminate sample dilution.

Cast Aluminum Clamps

The main tubing pieces are made from very robust 0.100” thick 2” OD tubing. This is the same material that racecar roll cages are made from. Anything bigger or thicker is overkill. The main chamber is constructed from 0.200” thick steel 4” OD tubing that should last for many years. The final criterion for this design was achieved as it is lightweight, flexible, and easy to adjust. The most significant improvement for the clamping system was the addition of the 1000lb-test cast aluminum clamps.

Simply Shocking

24 Volt DC Motor Assembly
(Stainless steel forks)

Typically sample extractors employed today use 120 Volt AC induction motors that are connected into the drilling rigs' AC power source. The iBall Instruments® Cavitator uses a low-voltage 24-volt Direct Current sealed motor powered from a simple AC to DC power supply. The supply is fully isolated and low-voltage eliminating the shock hazard to personnel. This accomplishes two things that make the system superior to any AC powered device. First, it permits the use of a low-cost, lightweight low-voltage electrical cable going out to the Cavitator. This common cable is safe, easy to run, and connect.

It also affords equipment the ability to monitor the DC current flow to the Cavitator. This constant current monitoring tells the iBall Instruments® computer the viscosity of the mud or alert the user to other potential problems.

Reliability

The Harsh Environment

The advantage of a sealed DC motor system became evident when it was discovered that one of the Cavitator Systems had spent a few hours running submersed in mud. The Cavitator system was quickly and safely pulled up and re-clamped to the side of the shaker without any service interruption. This picture shows a mud covered DC motor assembly with the addition of an iBall Instruments® mud-blocking filter at the extractor. The sample lines are virtually free of contamination or occlusions.

The heart of the Cavitator system is a very powerful 24VDC permanent magnet motor assembly provided with balanced cavitation forks. This inexpensive motor assembly is easily replaced in the event of end of life failure, or external damage.

Summary

The new iBall Instruments® Cavitation System design has significantly improved the sample extraction process. Geologists and mud loggers depend on drill sample gas for scientific interpretation. The better the sample, the better the results.

Related Links

See the following resources for further information:

- http://www.answers.com/topic/cavitation
- www.iballinstruments.com