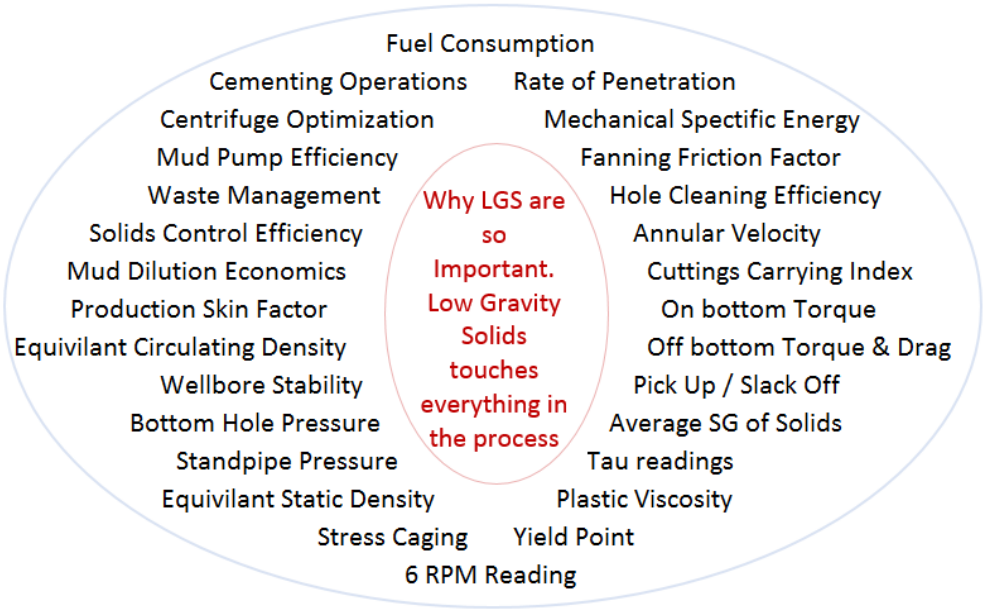
The Importance of Digitized Solids Removal

Why should we measure something that hardly has any significant impact to the overall well delivery process?

I'm being facetious of course…. the importance of solids removal efficiency goes far deeper than just the face value of a low gravity solids percentage. Drilled solids touches every part of the well delivery process, many of which can have huge consequences. When the solids removal process is not managed properly, it can lead to high-cost implications or worse, a well control incident that can turn into a health, safety, and environmental incident. No one wants to manage a preventable blowout, it certainly will not help with any ESG compliance initiatives.

Modern process control applications will help mitigate these incidents, we have the subject matter expertise, and we have the hardware to digitize the work flows so that we always maintain control of our process. This has been the greatest leap forward that we are experiencing right now with the modern digital transformation, we no longer must rely on once per day mud check data, we have access to once per second mud check data from multiple sample points throughout the rig streaming live all day, every day. Is there any doubt as to what the value of the data analytics is going to bring when you are measuring all your drilling fluid parameters from multiple locations in real time? AI/machine learning capabilities is how we get to the value, but first we must measure, without data there is no value.



Notably, the Operators have placed more emphasis on solids control equipment performance capabilities, while many drilling contractors are changing their rig design to incorporate adequate mixing capabilities utilizing equipment with high agitation/shear and unique tank design that leads to better KPI's. The entire drilling fluids management process is all interconnected to one another, from mixing the mud, to measuring the mud, to removing solids from the mud, to managing the waste generated from the process, it's all important, the digitization of the data collection process allows us to quantify the process efficiencies automatically. Quantifying process efficiencies, equipment efficiencies, as well as compositional analysis, leads us to a system of alarms, alerts & early warning indications of things that are trending out of spec, underperforming, or non-compliant.

While we are seeing advancements in back yard equipment and design changes, we are still relying on the conventional 1-4 mud checks per day to make decisions. The next natural progression is to measure in real time what needs to be measured to help optimize the process. For example, measure a "mixing index" to determine when a drilling fluid is adequately sheared and ready to be added to the active circulatory system. Quantify the compositional analysis of the drilling fluid returned to the active mud system from the centrifuge effluent and drying shakers, what LGS/HGS ratio split is being processed in real time? Measuring the % oil on cuttings of the waste stream being discharged. How much dilution is optimal for the current ROP & LGS spec? What is the total volume/mass of rock removed from the well? There are dozens of KPI's that can be monitored in real time that can provide the leading indicators to many problems and issues that are common to every drilling process.

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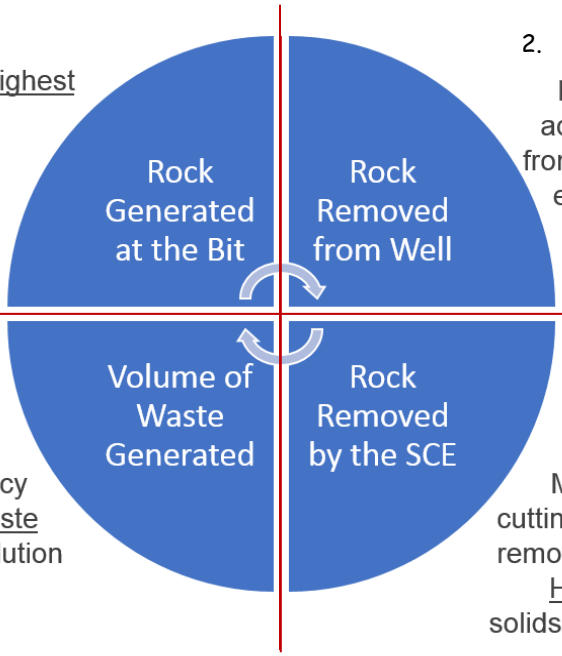
1.

The objective is to achieve the Highest ROP with the lowest energy consumption. Maximize drilling performance at the lowest cost

Highest Drilling Efficiency



2.

Maintain optimum fluid properties to adequately remove all drilled cuttings from the well. Use proper hydraulics to ensure Adequate Cuttings Transport

Highest Cuttings Removal Efficiency

Lowest Waste Volume

Highest Solids Removal Efficiency

4.

Maximum solids removal efficiency you can expect to see Lower Waste Volumes generated and lower dilution volumes required to deliver a productive well

3.

Must remove those unwanted drilled cuttings on the first pass using the solids removal equipment. Need to achieve the Highest SRE due to those unwanted solids being the culprit to increased costs if not managed properly

1. The advancements in bit design, downhole motors and software have led us to some of the highest rates of penetration in recorded history. The caveat is that the methods we use to manage our fluids is still conventional, meaning we run a mud check and by the time we get the results we have passed through 4 different formation types, whole new batches of challenges. Drilling fluids management is very much a reactive process in this modern-day drilling effort…..but it doesn't have to be, we can digitize the mud check.

2. Measuring the rheology of a mud system once per day that has an ROP of 400+ ft/hr is almost moot. The cuttings carrying index of the mud is stretched to the maximum. With the main objective being to adequately clean the hole, the only real way to maintain control of torque, drag, pickup, slack off, is to measure the hydraulics in real time, and start identifying trends in real time. Manual methods will continue to be problematic, not because there is anything wrong with the measurement quality but more of a measurement frequency issue, we just can't continue to keep up with the current ROP expectations and assume we will experience fewer problems. We don't have to assume anything, we can quantify and predict using real time data analytics.

3. To compound our problem, our solids control equipment is only capable of removing ~80% of those drilled cuttings generated. This means we circulate the remaining 20% solids back down the well where we then proceed to grind & pulverize into even smaller particles. This is where the problem starts to escalate, these ultrafine solids can't be removed by the solids control equipment and each time this fluid passes through the bit the particle size distribution is being grinded smaller. This is where the problem can get way out of control, especially when running barite recovery. The LGS/HGS split that you are recycling back into your active can have 15-20% LGS, this is the mud monster that can get away from us if not managed properly. There is a delicate balance between solids control efficiency and dilution economics. A seasoned mud engineer knows how to react, a junior hand may not. One way to maintain control of the fluid properties at all times is to measure all your fluid properties continuously in real time. Its really the only way to continue to drill fast and continue to provide proactive decision making.

4. Lastly, everyone is becoming more environmentally conscious, reducing ESG exposure (Environmental Social Governance) is an active part of nearly every corporate strategy. A big part of this initiative is reducing the volume of waste generated at the rig site. Our mantra has been that if we can measure it, we can control it. We can control it by optimizing the fluid properties to maximize the solids removal efficiency which helps reduce the volume of waste. This balance has so much upside and no downside. There is absolutely no reason why measuring all your fluid properties will increase the number of problems and issues experienced on any rig anywhere in the world.

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Typical scenarios we see in the field that has huge implications:

Scenario # 1: When the mud weight starts to drop, a common practice is to shut the centrifuge off allowing the density to climb using unwanted drilled solids (LGS) as opposed to dusting with barite (HGS).

Point: It has been well documented that unwanted drill solids (LGS) costs more than barite (HGS). We just need to examine drilling performance alone, increased ECD, increased T&D, slower ROP, etc. all due to excessive LGS in the system. An inline measuring instrument can tell us our density & LGS/HGS split at all times and we can provide alarms and alerts if/when things drift out of specification.

Scenario # 2: – Running the centrifuge discharge excessively "wet" to maintain the lowest possible LGS in the system.

Point: Achieving a balance between dilution volume added, solids removed, and waste volume discharged is one that requires subject matter expertise and is difficult to manage with only a couple of sample points in a 24-hour period. Running the discharge from a centrifuge excessively "wet" will result in large volumes of waste requiring disposal plus this volume of mud has to be replaced with new volume built. The inline instruments that can track LGS and % oil on cuttings in real time would dictate when/how the solids control equipment will be adjusted to minimize the dilution volume, maximize the solids removal efficiency, and minimize the amount of waste generated.

Scenario # 3: Excessive wear on pump parts & downhole motors due to high solids concentration

Point: High concentration of solids leads to excess wear on mud pump liners/swabs & down hole equipment that increases down time due to repairs and unnecessary trips. Inline instrumentation to monitor the drilled solids concentration in real time can mitigate many premature problems as well allows us to schedule preventative maintenance.

Scenario # 4: Pull the shaker screens to reuse/recycle the Loss Circulation Material (LCM)

Point: The mud system has been loaded up with LGS due to poor solids control efficiency and poor drilling fluids management. Both the PV and ECD have been steadily climbing due to the excessive LGS in the system until ultimately, loss circulation is induced. An LCM pill is pumped but to save money on LCM the shaker screens are pulled to allow the LCM return to the active tank suction. This action does help recover LCM but the additional solids that was also returned back to the active tank suction results in compounding the loss circulation problem. The inline instrumentation would allow for a real time monitoring of the solids determination vs PV/ECD. The data analytics will allow us to provide an alarm/alert when the data starts to trend undesirably.

Scenario # 5: It is not uncommon to cut costs by running one single centrifuge on a weighted mud system. Lets examine this scenario.

Point: The centrifuge will target the easiest particle to remove first (stokes law) which will be the heavier barite (HGS) resulting in returning massive amounts of LGS back into the mud system. On a weighted mud system, dilution volume and barite additions will ultimately cost more than running a dual centrifuge configuration for barite recovery while the polishing centrifuge targets the LGS. The inline measuring instrumentation can tell us our LGS/HGS split and average SG of the solids at all times and allows for real time data analysis to quantify the cost differences.

Scenario # 6: Formation Damage or "skin damage" can have a huge effect on production rates.

Point: In many cases the result of excessive solids infiltrating the formation causes unpredictable production rates, always measuring the HGS/LGS concentrations while drilling would provide a window into understanding the true effects of solids contamination on production rates.

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