LCM GENERATING STABILIZER

R&D –Modeling and Prototype testing

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SUMMARY

An LCM Generating Stabilizer tool is designed to slurrify cuttings into LCM size material during drilling, and treat lost circulation, strengthen the wellbore, shear drilling fluids, and aid cuttings removal. This proposal examines various phases for developing our patented tool, from the designing of a CAD model to software analysis, machining, building, and testing a prototype. A time schedule is presented, which could change based upon the various findings that could arise during development. These results will guide the tool refinement or re-design.

THE PRIZE

Stabilizers are used in all drill strings and LCM generation causes no harm to drilling operations, the potential prize is reducing drilling lost circulation problems by placing an LCM generating stabilizer in the majority of drill strings worldwide.

Lost Circulation (see http://petrowiki.org/Lost_circulation) comprises a major drilling cost, whereby Wang, et al, report[1] that, globally, 45% of wells use casing strings to isolate lost circulation and 19% to 20% of wells encounter lost circulation after applying extra casing strings. In addition to the well safety issues, the cost of combating the loss/losses of circulating fluids are associated rig time/dayrate, and loss of valuable drilling fluids. Last year in Norway, the combined losses of fluid in Water Based Mud (WBM), was between 8-12%, and Oil Based Mud reached 30-35% of the total amount used. Regardless of the depth/section being drilled, or the mud being used, the consequences of lost circulation are significant.

The potential prize is reducing or eliminated lost circulation through the inclusion of an LCM generating stabilizer in +/-45% of the drill strings used every day worldwide, which is significant regardless of whether you are in a boom or bust cycle.

LOST CIRCULATION

Since rock is an inelastic material, all wellbores fracture, or crack, and yield to some extent. As illustrated in Figure 1 on the next page, lost circulation material (LCM) sized particles can be used to bridge fractures close to the point of propagation so that gelatinous filter-cake becomes stuck between LCM particles and, thus, seals the fracture to prevent pressure from reaching the point of fracture propagation.

All wellbores have at least small fractures caused by drilling a borehole and moving stresses, formerly supported by the removed rock, to a hoop-stress cage formed by the circumference of the well bore. If these small fractures are not immediately sealed, the fractures can propagate and enlarge to allow larger particles larger within the fractures that prevent filter cake bridging and associated sealing. When larger material becomes lodged within the fractures, creating permeability that the gelatinous filter cake cannot bridge, it will allow pressure to reach the point of fracture propagation, and further enlarge the fracture, to cause lost circulation of drilling fluids.

An additional problem with current practice is that the surface addition of sand size LCM particles in large quantities can interfere and prevent operation of downhole drillstring tools. Whereas downhole generation of sand size LCM particles does not interfere with downhole tools and can prevent or inhibit fracture propagation and associated lost circulation.

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[1] H. Wang, R. Sweatman, B. Engelman, W. Deeg, D. Whitfill, M. Soliman and B. Towler, Best Practice in Understanding and Managing Lost Circulation Challenges, June 2008 SPE Drilling & Completion.

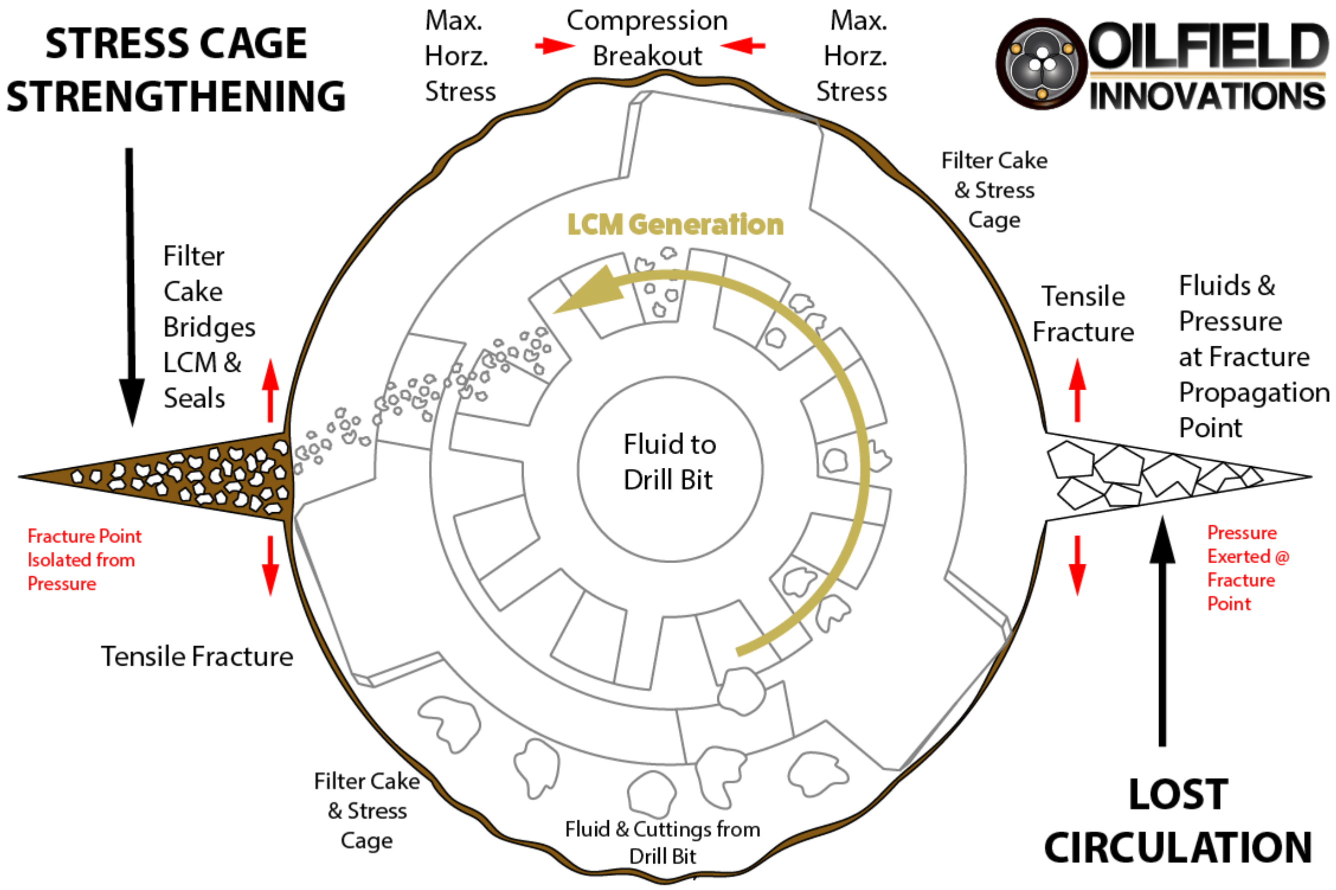

Figure 1 - Lost Circulation and LCM Generation Explanation

The value of stopping the problem of lost circulation, before it happens, cannot be over emphasized because once the problem starts it is difficult to stop as shown in Figure 1 above.

Once downhole LCM generation technology becomes recognized, any driller stating that they have encountered lost circulation will be asked: “did you put an LCM generating stabilizer in the string?”

Ultimately, depending upon pricing, the LCM generator may become viewed as cheap insurance and included as a matter of best practice, even though it is not absolutely necessary.

MAIN OBJECTIVE

The main objective is to design a tool that will generate LCM sized particles that are immediately applied to virgin wellbore during drilling operation, to prevent or inhibit the propagation of fractures that cause lost circulation. Thereafter, applied effective circulating density (ECD) will pack LCM and sealing filter cake deposited by the drilling fluids into any small fractures before the fractures propagate, to strengthen the wellbore and increase its pressure bearing capacity. Additionally the wellbore cleaning will improve, as the mud is sheared passing through the LCM Stab.

Nowadays, cuttings reinjection is considered proven technology[2] that uses centrifugal pumps to slurrify cuttings as shown in Figure 2.

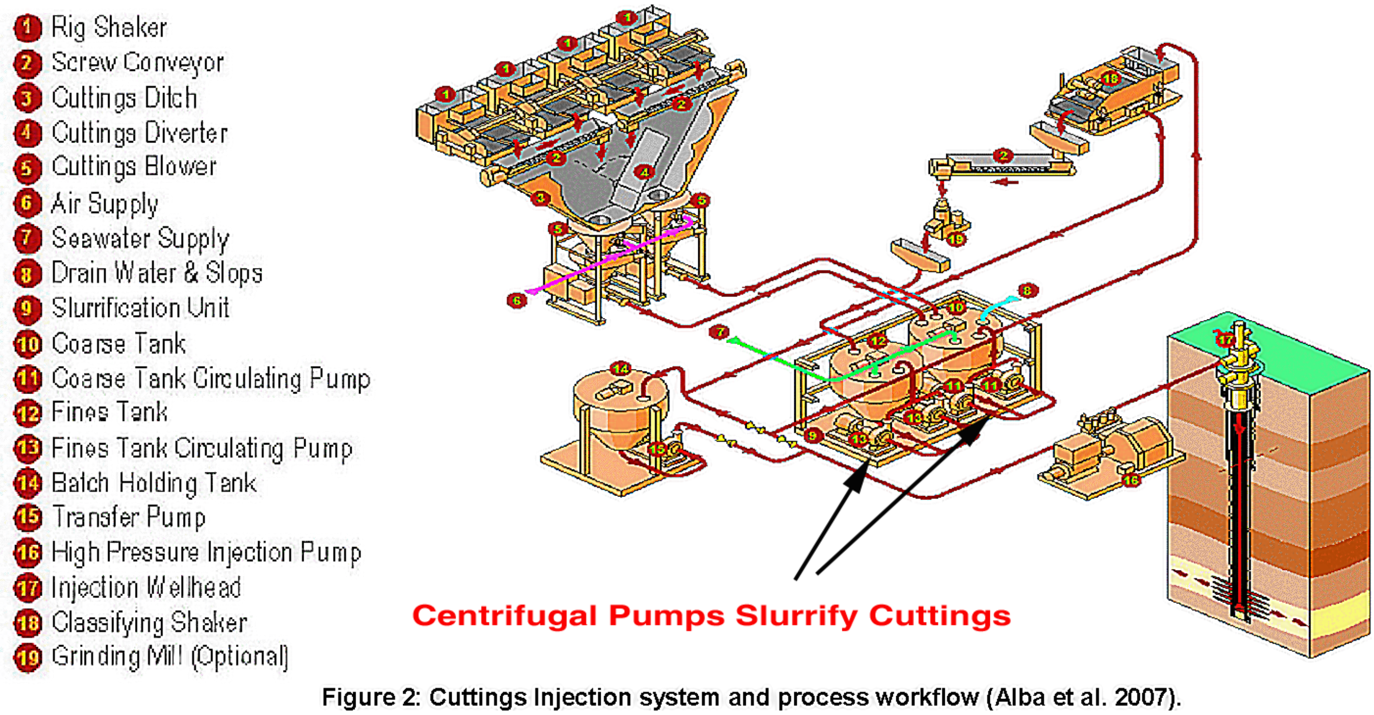

Figure 2 – Proven Technology of Cutting Slurrification[2]

Given that the slurrification of cuttings is a proven technology, the objective becomes how to package a centrifugal pump within a drilling stabilizer.

GOAL

The goal is to develop a fully tested and certified tool that is ready for downhole use within a live well. Subsequent to demonstrating the value of downhole LCM generation, this new technology can be sold to a larger companies like NOV, Halliburton, Schlumberger, or a business can be built around the tool and then sell it to a larger company.

Lost circulation is expensive because expensive drilling fluids are lost and it threatens the primary fluid column barrier. It is therefore a safety concern that cannot be ignored. Literally, billions are spent every year on lost rig time, LCM materials, and fluids in attempt to cure lost circulation.

We propose adapting a drillstring stabilizer to cure the problem before it happens, to ensure faster, cheaper, with a safer result.

Once proven, there will be no shortage of companies wanting to acquire our patent rights, because lost circulation market is measured in billions each year.

[2] A. Maliardi, et. al., "*Subsurface Cuttings Injection: Technical Challenges and Opportunities,*" IPTC 17565, presented at PTC in Doha, Qatar, 20-22 January 2014

OILFIELD INNOVATIONS

Oilfield Innovations is a company that brings new and innovative technology to the Oil and Gas market via the experience of its founders and employees. We are a technology driven company with a solid technical engineering base. Our knowledge of drilling and completion problems drives our innovation to deliver solutions that solve common problems using a holistic approach. Our LCM stab, will ultimately lead to a phase shift in the methods of drilling to reduce cost and increase productivity and safety.

IP OWNERSHIP

Oilfield Innovations Ltd. owns and controls all the Patent rights worldwide for the downhole LCM Generation Stabilizer.

RESEARCH AND DEVELOPMENT PARTNERS

We believe that many service companies have the experience and technology to bring such a new and profitable technology to the market. Sintef's personnel, software and laboratory facilities may be an ideal place to begin developing our LCM Generating Stabilizer.

We are asking for Joint Industry Project (JIP) financial funding (20 MNOK) for the LCM Generating Stabilizer project. This Research and Development project will also benefit from the expertise/experience with NCS operations. The cost illustrated in Figure 7, page 12 is an early estimate and is likely to be changed.

VERIFICATION

With regard to development of this innovative solution, Oilfield Innovations is underfunded and too small.

Since our patented solution has enormous potential, our primary concern is working with qualified companies who have the expertise to develop the tooling.

If a Joint industry Project is interested in discussing opportunities, we would like to discuss how we could verify the product for production development within, for example, Norway, the North Sea and/or a larger region.

LCM GENERATING STABILIZER

The proposed tool length, diameter, and weight will be similar to typical rotating stabilizers with the exception that the bypass around the stabilizer blades is reduced. This provides room for impellors to pump drilling fluids through the rotor/stator's (grinding mill) inside the stabilizer and slurrify the drill cuttings into LCM or sand sized particles.

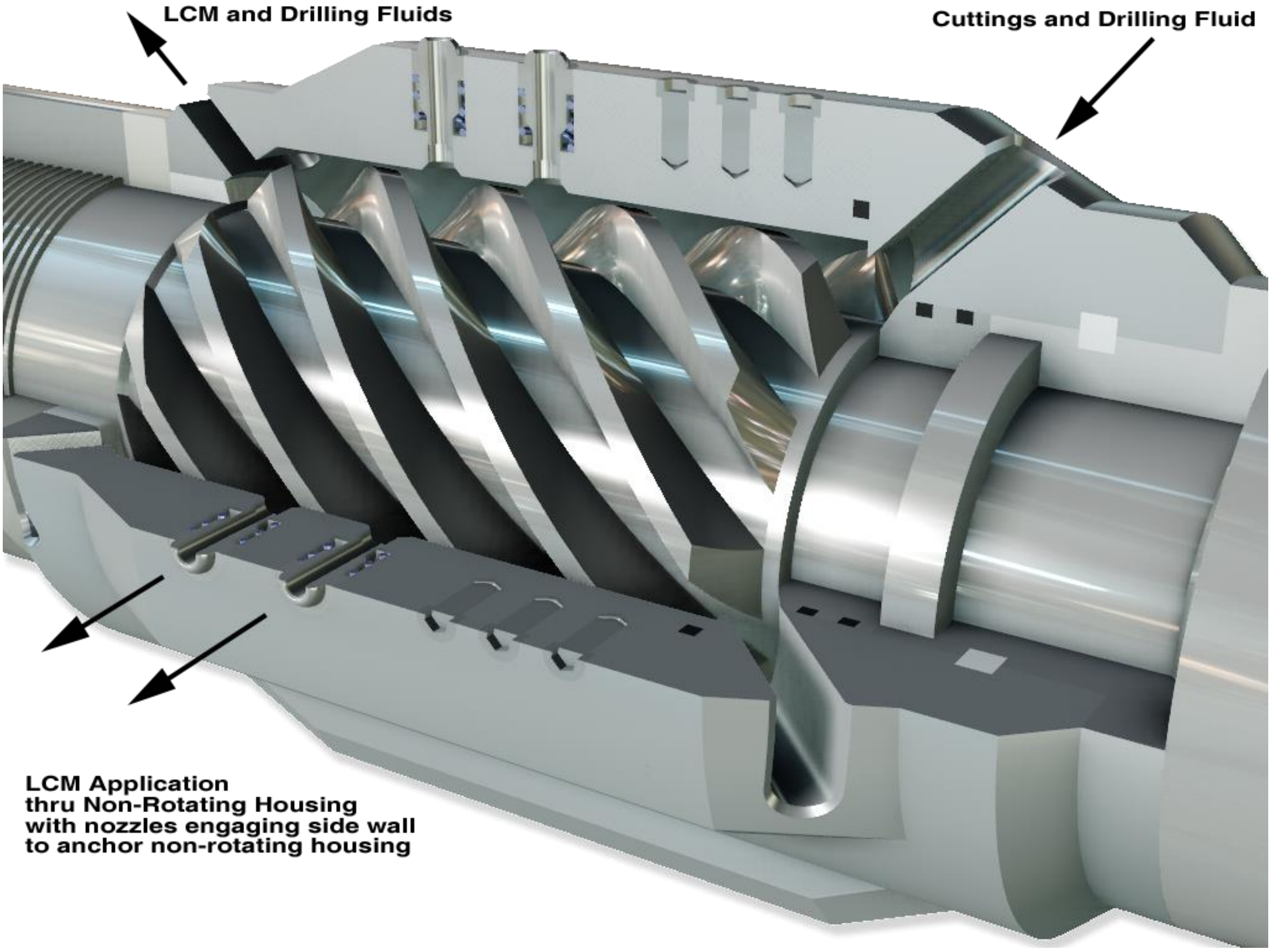

Figure 3 - Internal Slurrification Pump

The impellors of the internal pump are part of the rotating drill string, while the stabilizer blades form a part of the substantially non-rotating housing. The non-rotational aspect is achieved with nozzles and/or grips within the stabilizer blade that substantially anchor to the sidewall. These nozzles and/or grips extending from the stabilizer blades to engage the sidewall, and prevent or restrict rotation of the housing. This will drive the grinding mechanism and start pumping drilling fluids and slurrify cuttings. The generated LCM is readily available and can seal the fractures, and provide wellbore strengthening.

This LCM generator has no ID restrictions or interference with the inside of the pipe. However various models can be developed to balance the bypass area between stabilizer blades with (any) internal ID restrictions.

Single or multiple LCM generation tools can be placed in the string, whereby the placement of the LCM generating stabilizer(s) would be the same as any conventional placement of stabilizers, and would not interfere with the conventional practice of drill string design.

With regard to placement of a single LCM generator, it is most beneficial when it is in close proximity to the drill bit, so to immediately treat virgin wellbore fractures with LCM.

Lost circulation is not a problem if it is prevented from occurring; however, while our LCM generator can, conventional technology cannot immediately treat the fractures that always occur during typical drilling operation. Conventional LCM strategies that use topside addition of LCM, or large quantities of sand sized particles, suffer from clogging /erosion of the internal diameter of the drill string and can damage the downhole tools.

While the LCM generator can be designed to provide, more or less, rock fragment particles sized from 250 to 600 micron, treating fractures before they propagate, even with limited LCM generation, can be used to stop lost circulation before it occures. Thus, our target would be to slurrify and break, for example, 8-15 % of the cuttings down to sand sized particles as close to the bit as possible.

APPLICATIONS

The LCM generator is applicable to all drilling operations regardless of hole size, but initially we believe that it is best to begin development in larger hole sizes, for example 17 ½" and/or 12 ¼" hole sizes, to minimize development costs when proving the technology.

LOST DRILLING TIME & MUD

The loss of drilling fluids can range from minor losses to a critical loss that threatens well control. The most severe case of lost circulation is often described as a catastrophic or total losses. This occurs when fluid is pumped into the wellbore, but virtually no fluid returns from the wellbore. Unless the catastrophic (or total) losses were caused by drilling into a fault, these fluid losses could have been reduced or prevented through early treatment.

Once- well integrity is lost, for safety reasons drilling must stop, and fluid losses must be treated to regain well control.

Alternatively, minor to intermediate drilling fluid losses can be remedied by adding more drilling mud into the circulation system. Once fractures have propagated sufficiently, adding suitable sized particles can slow the loss of drilling fluids to fractures, but expensive drilling mud can continue to be lost.

Once the problem has occurred, typically, drilling speeds and ECD must be limited to reduce drilling fluid losses until the casing can be run and cemented in place. The optimal solution is to eliminate the problem by, for example, using our proposed downhole LCM generator.

While surface added LCM and mud properties have improved over time, the significant challenges (as shown in the following charts) of lost circulation still exist. As shown, the key performance indicators (KPIs) of lost Oil Based Mud (OBM) and Water Based Mud (WBM) can be used to substantiate the value of our patents.

Additionally, the drilling rate of penetration (ROP) must be reduced to limit ECD and mud loses or, alternatively, to wait until more mud is mixed or delivered.

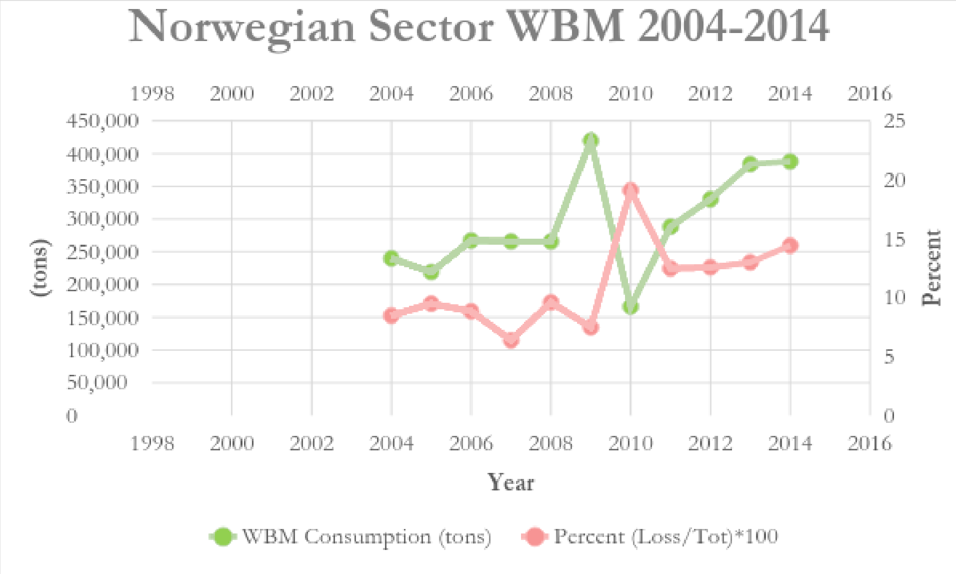

Figure 4 –Water Based Mud Consumption and Loss[3]

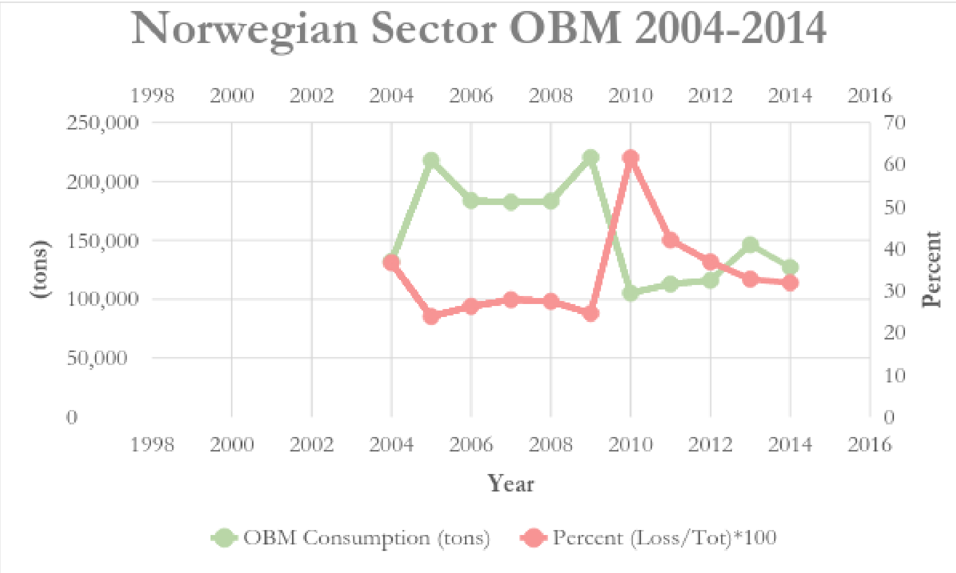

Figure 5–Oil Based Mud Consumption and Loss [4]

In addition to the cost of lost drilling fluids and the cost of Lost Circulation Treatments, the Non-Productive Time (NPT) associated with lost circulation is typically more significant, otherwise the service companies would not be able to sell magic formulas for curing drilling fluid losses which often exceed the per kilo cost of precious metals or whiskey.

[3] Source: https://www.norskoljeoggass.no/Global/Milj%C3%B8rapport%202015/Milj%C3%B8rapport%202015.pdf
[4] Source: https://www.norskoljeoggass.no/Global/Milj%C3%B8rapport%202015/Milj%C3%B8rapport%202015.pdf

DEVELOPMENT

While various scenarios may be applicable, we propose a simple four phase process:

#1 Finalize agreements and Qualification and Selection of one or more Companies with experience or competence in cuttings slurrification and designing, building and testing downhole tools with moving drill string parts and bearings

#2 Design a prototype and use software to simulate tool operation

#3 Machine a prototype, lab test the prototype and make any necessary adjustments

#4 Build a Downhole LCM Generator and use it in a test well

Phase #1 of the he process begins with discussion on how Oilfield Innovations, the Joint Industry Project, and Developing Service Companies can work together in a mutually beneficial arrangement. Next is the construction of a CAD model of the tool and then developing an interactive model, which would run through different software simulations (hydraulic, structural integrity, vibration modeling, flow modeling) in Phase #2.

The timeframe of Phase #3 manufacture and lab testing will depend upon the reworking of designs in Phase #2, while the length of Phase #4 is measuring the performance according to the assumptions in Phase #2.

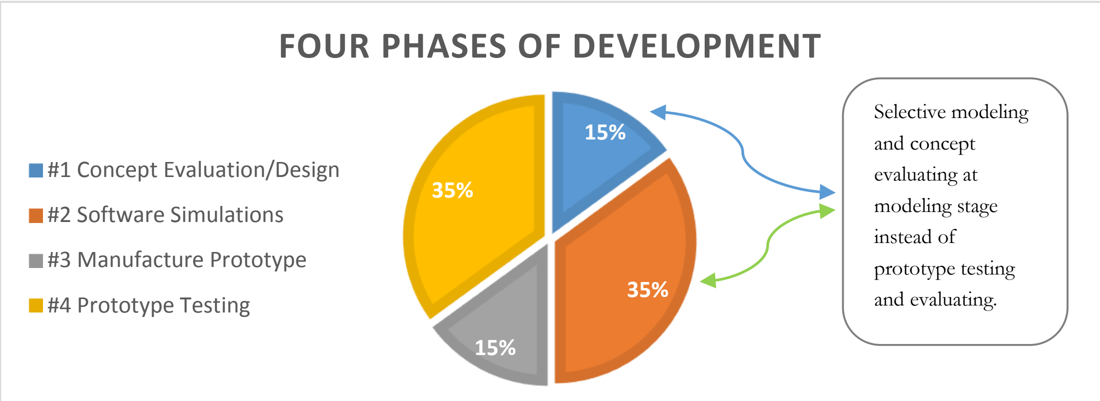

Figure 6 – Four Phases of Development

GANT –PROGRESS PLAN

New product development is a challenging task to schedule. If all resources are made available when needed, we expect that development could be completed in 9-16 months, excluding a test run. We suggest a robust Phase 2 software modelling and simulation to reduce the probability of returning to the drawing board. Faster development would require a larger team running simultaneous modelling and engineering calculations prior to building a prototype and testing.

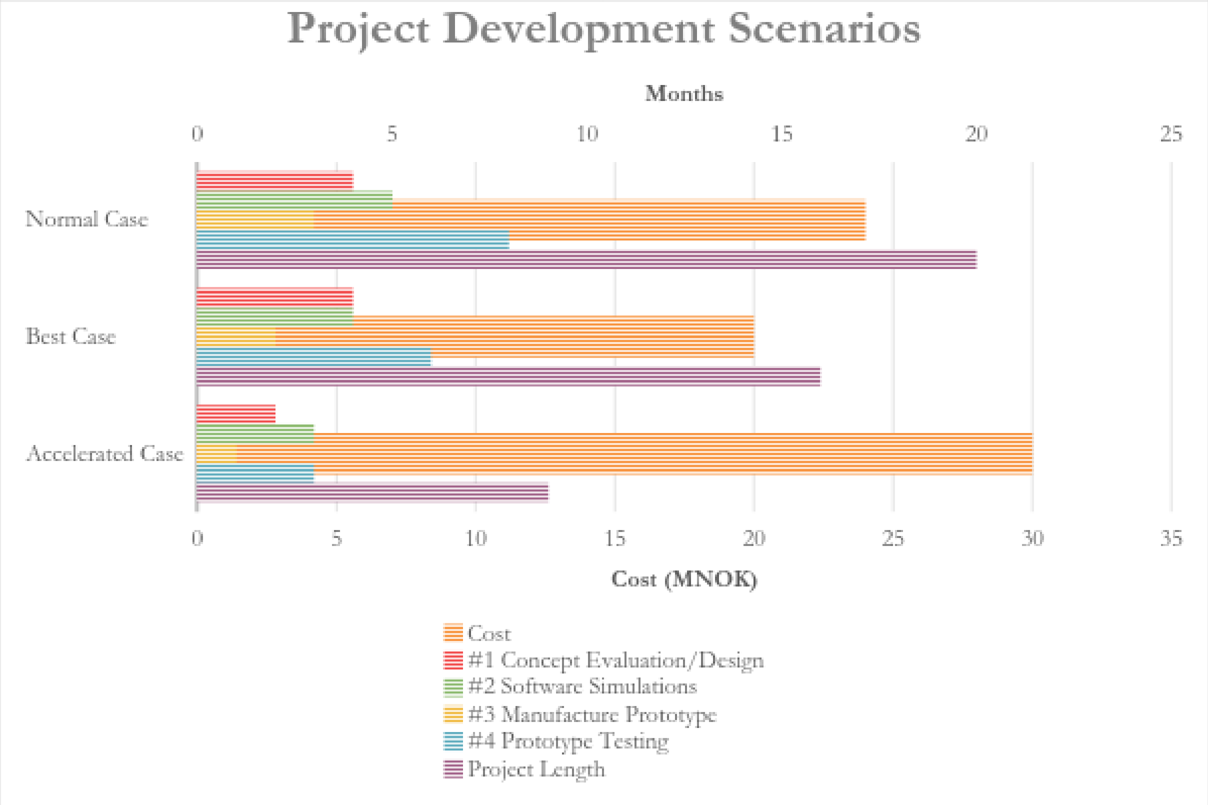

Figure 7 – Gant Progress Scenarios

The deciding factors that directly affect the speed of development, are the size of the development team, allocation of resources, availability of the laboratory testing facility, and whether the developing Service Company is willing to prioritize this project's schedule over other ongoing projects.

DEVELOPMENT PROCESS DESCRIPTION

Our best guess of the minimum development cost is shown in Figure 8 below. These costs are based upon typical oilfield industry time/cost for new development.

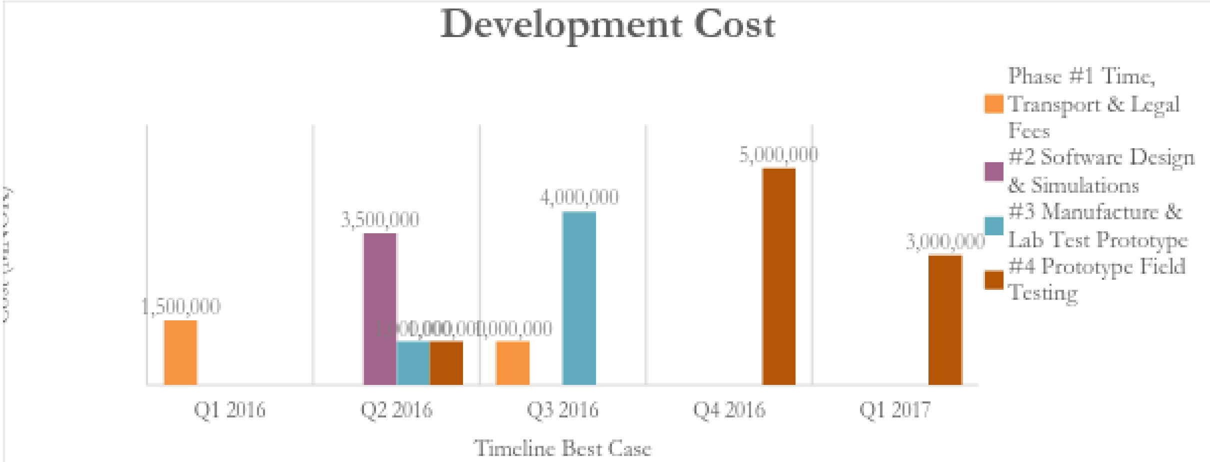

Figure 8 –Minimum Development Cost

	#1 Finalize Initial Agreements and Qualify Companies	#2 Software Design & Simulations	#3 Manufacture Prototype & Lab Test	#4 Prototype Field Testing
Q1 2016	Face-to-face meetings, Legal Reviews and Quality Assurance			
Q2 & Q3 2016		Design and build a software model of the tool. The design drawings and model runs used in vibration, hydraulic, integrity models, fatigue, and tool life expectancy engineering calculations.		
Q4 2016	Accumulate documentations, calculations, and (ISO/QA) inspection specified by agreements.	Software model of LCM crushed cuttings for drilling operations for cuttings to be crushed, particle distribution, and cutting removal. Redesign prototype if necessary.	Build a prototype from drawings/models generated in phase #2 and test in Laboratory.	
Q1 2017				Run the prototype in real case scenario, evaluate.
Q2 2017	Complete Agreement Requirements			Compile Tool Qualification Info & Submit to Verification Agency (e.g. DNV)

Table: 1 –Product Development Phases

ADDITIONAL PROJECT PARTNERS

Oilfield Innovations Limited is willing to work with any Joint Industry Project and qualified service companies, for example Sintef, along with other parties that are interested in developing the LCM Generation Stabilizer.

ADDITIONAL MATERIAL

- SPE-95895-PA Best Practices Managing Lost Circulation
- SPE-151227-MS Size Degradation of Lost Circulation Materials
- IPTC-17565-MS Cuttings Re-injection Challenges