AADE-02-DFWM-HO-23

New High Capacity Oilfield Centrifuge

Rick Koch, Edwin Kubena Jr. and Ken Seyffert; *Brandt, a division of Varco L. P.*

This paper was prepared for presentation at the AADE 2002 Technology Conference "Drilling & Completion Fluids and Waste Management", held at the Radisson Astrodome, Houston, Texas, April 2 - 3, 2002 in Houston, Texas. This conference was hosted by the Houston Chapter of the American Association of Drilling Engineers. The information presented in this paper does not reflect any position, claim or endorsement made or implied by the American Association of Drilling Engineers, their officers or members. Questions concerning the content of this paper should be directed to the individuals listed as author/s of this work.

Abstract

Brandt has introduced a revolutionary new design, decanting centrifuge.

Decanting centrifuges rely primarily on centrifugal force for solids separation. Decanters that keep solids at full G-force longer enhance the settling rate and, therefore, improve the liquid/solid separation.

Settling rate in a centrifuge is a function of retention time, G-force, pool depth and differential density (1). The Brandt 2172 (21-inches by 72-inches or 533 mm by 1829 mm) decanting centrifuge contains unique new features that reduce the decanter's dependency on fluid retention time and pool depth. The new centrifuge accelerates the fluid more rapidly to the full G-force so that the retention time is at the full G's and delivers the fluid directly to the conical section where the pool is shallow and some solids are settled out quickly. The newly designed scroll (conveyor) has several unique features, see Figure 1 and 2. The scroll contains a fluid accelerator (patent pending) and pool surface diverters (PSD's) (patent pending) to provide additional separating force to the slurry. The scroll has a new skeleton style, axial flow body. These design features allow the centrifuge to process very high volumetric rates for its size and fully accelerate all feed, to maintain excellent separation efficiency.

In field tests, the 2172 centrifuge has processed in excess of 500 gpm (1893 lpm) of drilling fluid. Data presented shows a reduction in mud weight from 8.7 ppg to 8.5 ppg (1042 kg/m^3 to 1019 kg/m^3) at a process rate of 470 gpm (1779 lpm). The unit can generate over 3,000 G's when operating at 3200 rpm.

Introduction

The oil industry has relied on re-applying centrifuge technology from other industries. Centrifuges that were originally designed for separating animal by-products, chemicals and other materials have been modified for use in the oil industry to clean drilling fluids.
Current centrifuges suffer from a weakness in maintaining removal efficiency as the process volumes increase. We believe this is due to those machines' inability to completely accelerate the fluid as the feed rate increases as well as a highly turbulent feed area produced by a jetting effect, see Figure 3.

The new Brandt design includes specific design parameters that accelerate slurries to separation velocities quickly and introduces them to the bowl with few turbulent areas. These design changes help improve solids removal performance and increase process capacity.

Most centrifuges today remove fine solids present in an unweighted mud system but at much lower process rates (25-250 gpm or 95 – 946 lpm); meaning they must allow a large portion of the circulating volume to bypass without treatment (2). For example, a centrifuge having an internal bowl diameter of 16-inches (406 mm) and a bowl length of 55-inches (1397 mm) would have a maximum hydraulic capacity of about 250 gpm (946 lpm) depending on the design of the unit and mud weight and viscosity. This hydraulic capacity tells us nothing about solids removal efficiency. This same machine may be very efficient at removing solids up to 100 – 125 gpm (379 – 473 lpm). At higher flow rates, the separation efficiency is reduced dramatically for most centrifuges.

These older design models can remove some low gravity solids from a fluid but could process only a small portion of the total circulation rate. A typical 12.25-inch (311 mm) hole would have a pumping rate of approximately 750 gpm (2839 lpm); therefore, an old style centrifuge could handle up to one third of the fluid flow but with poor separation efficiency. The remainder of the fluid, containing undesirable solids, would be re-circulated without being processed.

The 2172 is a true high volume, high G-force drilling fluid centrifuge developed for better treatment of today's more sophisticated fluids. The greatest benefit of this new design is its ability to continue to accelerate the drilling fluid as feed volumes increase. This has been accomplished with the introduction of new methods to accelerate the fluid as it enters the decanter (patent pending).

Another significant improvement is the introduction of pool surface diverters (patent pending). These pool surface diverters interrupt the slurry flow on the surface of the pool and force the slurry down with gravity into the pool. Now the solids settling distance is reduced, which improves fines removal and only the liquid phase moves up against G-force to return to the surface of the pool and continue towards the effluent overflow ports. This action removes more solids.

Many in the industry have the opinion that the solids separation in a decanter will decline as the rate increases due to reduced liquid retention time, i.e. solids are subjected to the G-force for less time as the velocity of the fluid increases. In general, that is true, but lack of efficient feed acceleration as throughput increases has a much greater effect on separation than loss of retention time.

To reduce the dependency on fluid retention, the 2172's unique design introduces the accelerated feed to the conical area of the bowl. This allows the fluid stream to enter the bowl above or in the shallow end of the pool and most of the solids are deposited at or near the bottom of the shallow pool where they need not settle through the main pool body.

Because the feed accelerator of the 2172 spreads the feed over a large area, the turbulent jetting effect caused by feed ports, found on conventional decanters, is avoided. These conventional ports focus the feed into (usually four) jets that direct the slurry into the pool at the start of the beach. Normally, the first port gets the greatest amount of feed. The jetting force/velocity of this feed increases as the processing rates rise. This feed area can be visualized as a turbulent zone with turbulence rising as the feed increases. (See associated view.)

In conventional machines, the fine solids separated between the feed zone and the liquid effluent end of the machine must move through this highly turbulent area, the feed area, before exiting the centrifuge. The separation of those fine solids is then compromised in the feed zone. The result is less efficient solids removal and a higher cut point.

Feed Accelerator

The new Brandt design allows the feed accelerator to convert high velocity axial feed slurry to radial motion while spreading the slurry over the wide, long surface of four accelerator blades. The tangential speed of the slurry is increased slightly faster than speed of the pool surface, caused by the bowl rotation allowing the slurry to fall into the bowl with virtually no turbulence. The slurry is introduced over a wide area, which further reduces turbulence. With slurry acceleration complete and with turbulence minimized, the fine solids that have been separated are available for conveyance and discharge.

Pool Surface Diverters (PSD)

The PSD's job is to prevent the liquid phase flowing axially through the machine from carrying fine solids to the discharge in a thin film at the top of the pool. It is generally agreed that there is very little fluid in motion within the pool, except at the surface. This layer of slurry moving axially begins as a thick layer and gets thinner as it moves toward effluent discharge, as solids are lost to settling. Because the PSD's push the surface flow deeper into the pool, the solid particles have less distance to settle before they displace the liquid at the bottom of the pool and join the solids being moved by the scroll to the solids discharge of the machine. Three PSD's are used to direct the solids into the static pool where G-force continues the settling process. The liquid phase continues back to the pool surface toward effluent discharge.

Feeding on the beach

The 2172 design utilizes a unique method of introducing the feed slurry entirely in the beach section, which reduces the distance solid particles need to travel to reach the bowl wall and begin transport to the solids discharge ports. This action reduces the dependency of fines removal on fluid retention time.

A thin sheet of slurry slides off the four faces of the feed accelerator and is deposited axially along the length of the beach. Depending on the pool depth being used, some of the thin sheet of accelerated slurry enters the leading edge of the pool, some enters at the transition of the pool to the beach, and the balance enters on the dry beach. As this thin layer of slurry comes in contact with the bowl wall or pool surface, it is already fully accelerated to the full G-force. Solids particles have only to move through the liquid that they entered with to be separated. Allowing much of the separation to occur on the beach can reduce the amount of solids that normally would be held and transported from the cylinder section of the bowl, lowering torque, reducing the amount of solids held in the bowl and reducing the workload of the gearbox.

Data

The 2172 centrifuge is in limited supply for testing purposes since all available units have been allocated to the Canadian market. Canadian field data and data collected at the Brandt facility located at 13700-Luthe B in Houston will be discussed.

Most wells drilled in northern Alberta do not require high mud densities and utilize a minimum of solids control equipment, mainly shakers and centrifuges. On one well using a water-base mud, the 2172 reduced the mud density from 8.7 to 8.4 ppg (1042 – 1007 kg/m^3) at a feed rate increasing from 50 to 151 gpm (189 – 572 lpm). As the feed rate increased from 151 to 470 gpm (572 – 1779 lpm) the mud weight was reduced from 8.7 to 8.5 ppg. (1042 – 1019 kg/m^3), see Figure 4. These data were collected over a 75-minute time period. The amperage on the main drive increased from 68 amps at 50 gpm (189 lpm) to 130 amps at 470 gpm (1779 lpm). (See Figure 5.)

At the Brandt test facility in Houston, a fresh water mud was prepared as shown in Table 1. About 20 ppb (57 kg/m^3) sized calcium carbonate was added to the mud to simulate drill solids. After mixing the solids into the mud, the centrifuge was used to remove as much solids as possible. The test tank was set up in such a way that the centrifuge discharges effluent and underflow, returned to the test tank through a hopper. Samples of feed, underflow and overflow were collected during each test. Data were collected while varying the centrifuge speed, pool depth and flow rate. The maximum amperage was the upper limit of our tests.

At 2400 rpm the flow rate was increased from 150 to 400 gpm (568 – 1514 lpm) with the amperage going from 96 to 185 amps. The centrifuge reduced the mud density by 0.2 ppg (24 kg/m^3) over the full range of flow rates see Figure 6.

The 2172 also processed the mud at 500 gpm (1893 lpm), at 2000 rpm, and made the same cut as discussed earlier, reducing the mud weight from 9.0 ppg (1078 kg/m^3) to 8.8 ppg (1054 kg/m^3). (See Table 2.)

Conclusions

The new 2172 centrifuge design overcomes many of the design constraints found in conventional decanters, which capacity-limit the machines. The higher capacity for bowl size is achieved by the following:

- Fully accelerating the fluid before it enters the pool to utilize the entire pool length for settling.
- Spreading the feed over a large area to reduce the turbulence in the feed zone.
- Feeding on the beach to remove a large portion of the solids immediately while leaving the remainder of the machine to remove the remaining solids resulting in better separation at reduced horsepower.
- Using axial flow to additionally reduce turbulence and improve cut point.
- Using PSD's to enhance the separation of ultra-fine solids in the axial surface flow.

Acknowledgements

Thanks to our Brandt Canadian co-workers, Randy Beebe, Todd Iverson and Don Symes for collecting field data on un-weighted drilling fluids. Charles Grichar added his review and permission to present this paper. We also want to thank Dr. Frank Tiller and Dr. Wenping Li, both of University of Houston, for their comments.

Nomenclature

Define symbols used in the text here unless they are explained in the body of the text:

g = gravity

G's = $r\Omega^2/g$

gpm = gallons per minute

lpm = liters per minute

ROP = drilling rate of penetration

rpm = revolutions per minute

PSD = pool surface diverters

ppb = pounds per barrel

amps = amperage

References

1. Leung, Wallace Woon-Fong, "Industrial Centrifugation Technology," Copyright 1998.
2. Phillips, Victor: "Smart Centrifuge for Solid Answers to Solids Control," SPE Paper No. 39378, presented at the 1998 IADC/SPE Drilling Conference held in Dallas, Texas, March 3-6.

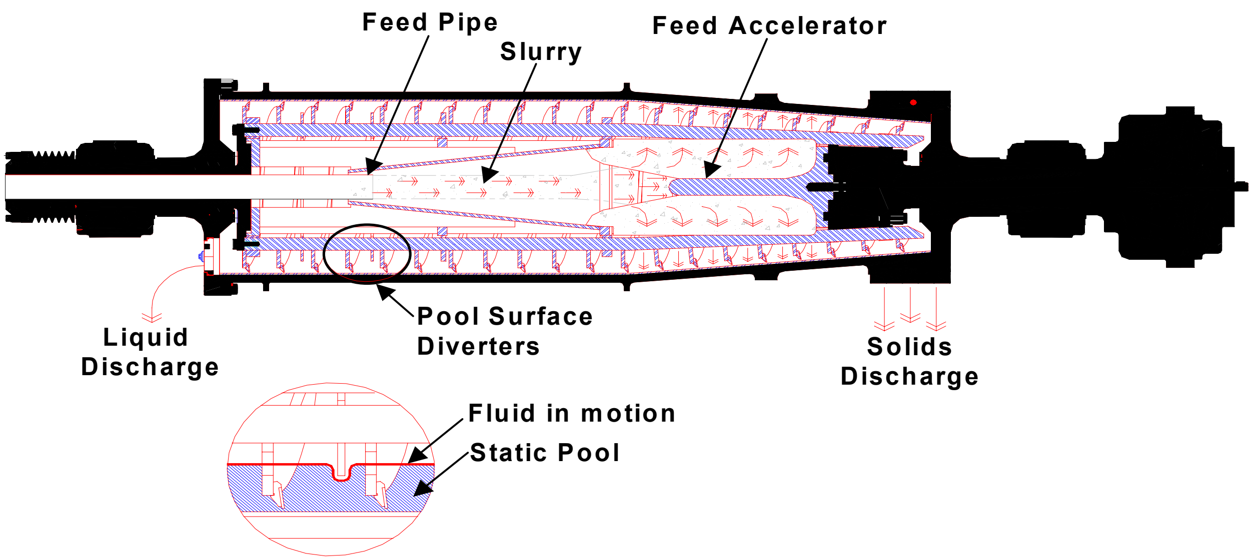

Figure 1 - 2172 Rotating Assembly

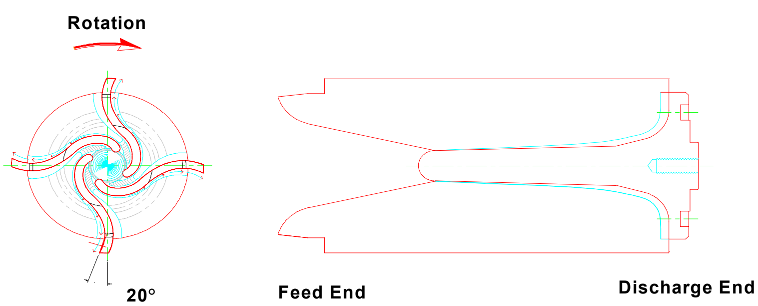

Figure 2 – 2172 Feed Accelerator

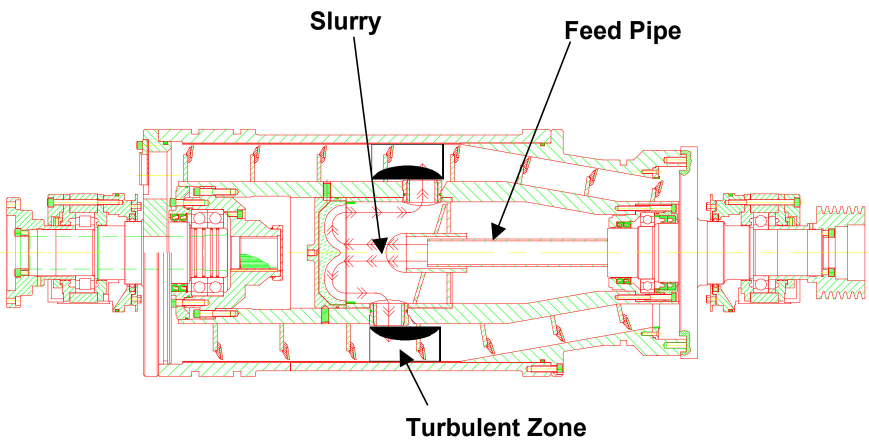

Figure 3 - 3400 Rotating Assembly

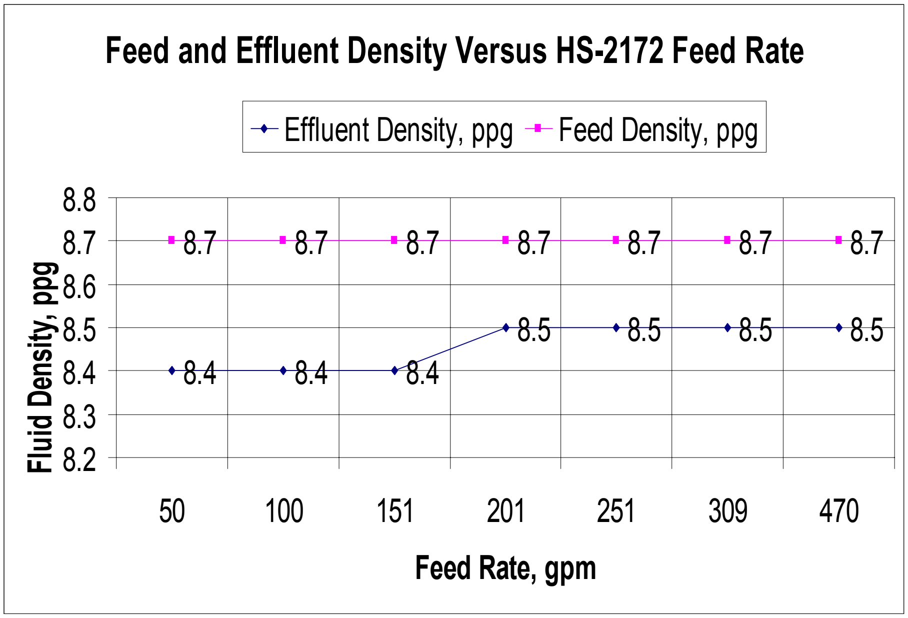

Figure 4 – Canadian Field Data – Density

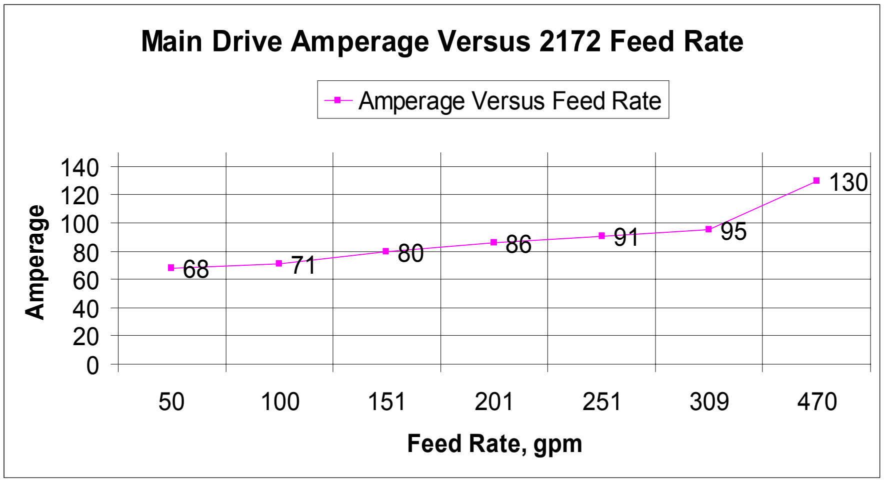

Figure 5- Canadian Field Data - Amperage

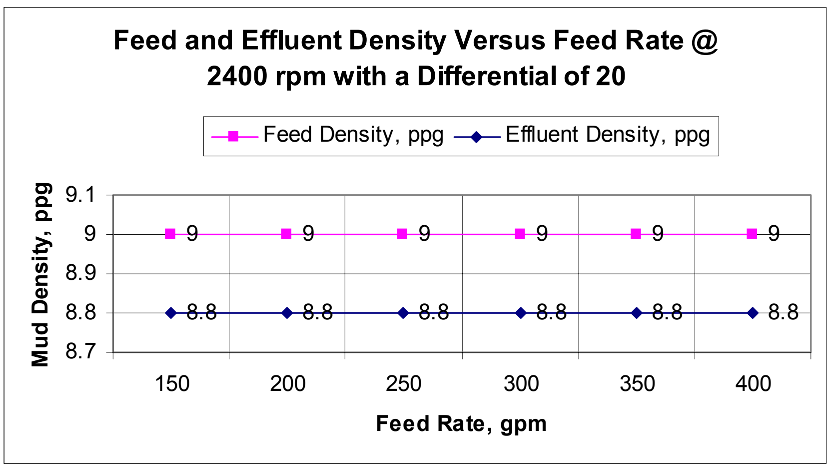

Figure 6 – Houston Data - Feed and Effluent Density Versus Feed Rate

40 Barrels of Fresh Water + 5 Barrels of Old Mud	
Additives	
Bentonite	1100
Calcium carbonate 5	300
Calcium carbonate 25	500
Calcium carbonate 50	50

Table 1 - Mud Formulation for Centrifuge Tests

500 Gallon per Mintute Flow Rate					
Main Drive rpm	Feed, gpm	MD amps	BD amps	Feed density, ppg	Effluent density, ppg
2000	500	181	25.8	9	8.8

Table 2 - High Process Rate Test