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Evaluation of a New High-Performance 8-in. Hydrocyclone

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Abstract

A new high-performance (HP) 8" hydrocyclone has been designed. This hydrocyclone has novel features that maximize capacity, and minimize turbulence, the main factor that inhibits a finer particle separation and contributes to excessive wear. The geometrical features on this new design include a smoother transition zone between the cylindrical section and the conical section, and a larger cone length. This new configuration ensures a minimum cut point without sacrificing capacity.

Preliminary field results with a HP 10" hydrocyclone indicate this new design makes a cut point very near to the conventional 4" cone cut point (35 – 70 microns) using water based drilling fluids, and with a capacity ratio of 10:1. Simulation results with the HP 8" hydrocyclone show a significant cut point reduction by minimizing turbulence and increasing residence time. In comparison with the 4" cones (desilters), the HP 8" hydrocyclones are very competitive. The computed cut point is in the 37 – 67 microns range with a capacity ratio of 7:1. Field and simulation results are presented graphically.

Utilization of HP 8" hydrocyclones will result in significant savings due to lower drilling fluids costs, increased rate of penetrations and lower maintenance costs.

Introduction

Hydrocyclones have been used for decades in various industrial applications ranging from classification of solids in the mining industry, to removing fine solids in municipal water systems, pulp and paper, food processing, and other industries.

In the Oil & Gas industry, hydrocyclones, or better known as cones, have been used for many years in drilling operations to remove the smaller solids. Early implementation of this technology was used to remove sand from the drilling fluid. These desanders ranged from 6" to 12" and were able to remove particles larger than 60 microns (230 Mesh). This technology has continued to be refined over the years and remains an integral part in today's solids control systems. Even after the use of desanders became commonplace it showed that additional solids control measures were required due to side wall sticking problems. These sticking problems were traced to thick filter cakes caused from too many fine solids remaining in the drilling mud. As a result a 4" cone was introduced in the early 1960's. These smaller hydrocyclones were able to remove much smaller particles, down to 20 to 30 microns, and became known as "desilters". This evolution yielded better than expected results, by increasing bit life, reducing pump repair costs, increased penetration rates and lower drilling mud costs[(1)].

The operation of a hydrocyclone is largely controlled by the feed pressure. The operating state is reflected by the pressure drop from feed to overflow. The feed pressure is in turn linked to the feed flow. The combination of feed flow and geometry of the hydrocyclone ultimately determines the centrifugal effect. Consequently, centrifugal effect, flow rate, pressure drop and hydrocyclone geometry are all interdependent. Although versatile, this interdependence exposes the relative inflexibility of a specific hydrocyclone[(2)]. The inflexibility of a hydrocyclone implies that its geometry always has to be optimized for a specific separation task.

Hydrocyclones

Hydrocyclones are devices that separate particles of different sizes by forces of fluid dynamics. The separation action is produced by the rotation of the fluid, which develops high centrifugal forces. These forces tend to direct the larger (heavier) particles to the wall where they flow down to the underflow exit. At the same time, the smaller (lighter) particles are left nearer the center of the hydrocyclone with the bulk of the fluid, because drag effect (relative to inertial forces) of the fluid on the smaller particles causes slower movement of particles with respect to fluid. The major part of the fluid, carrying the finer particles, reverse direction at the bottom of the tapered end of the cone (apex) and flows upward to the cone overflow.

Hydrocyclones are normally rated by the diameter of the cylindrical section. Figure 1 shows the components of a typical hydrocyclone.

Median (D50) Cut Point and Processing Capacity

For every size and design of hydrocyclone operating at a given pressure with feed fluid of a given viscosity, density and particle size distribution, there is a certain size (mass or volume) of particles that show no preference for either the overflow or underflow stream. In other words, there is a fraction of each size in feed to the equipment which is sent to the underflow stream, and the complement, to the overflow stream. A plot of these fractions is called Performance curve or partition curve.

The size at which 50% exits through the Vortex Finder and 50% to the Apex is called the median (D_{50}) cut point.

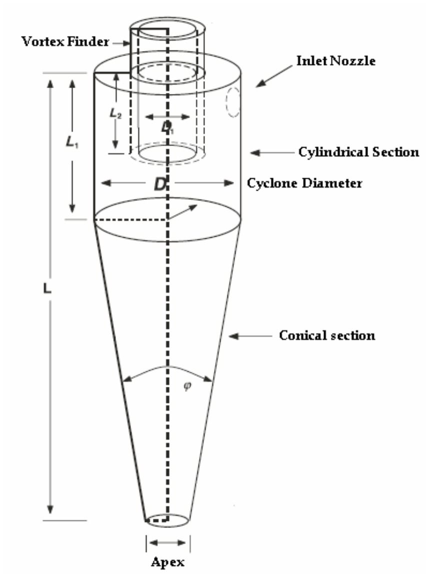


Figure 1. Components of a typical hydrocyclone.

Typically a 12” cone has a D_{50} cut point for low-gravity solids in water of approximately 60 to 80 microns; a 6” cone, around 30 to 35 microns, and a 4” cone around 15 to 20 microns (Table 1). However, as stated earlier, the cut point will vary with the size and amount of solids in the feed, as well as fluid viscosity[3].

Cone Diameter (in)	D_{50} in Water	D_{50} in Drilling Fluid
2	8 – 10	15+
4	15 – 20	35 – 70
6	30 – 35	70 – 100
12	60 – 70	200+

Table 1. Hydrocyclone size vs. D_{50} cut point.

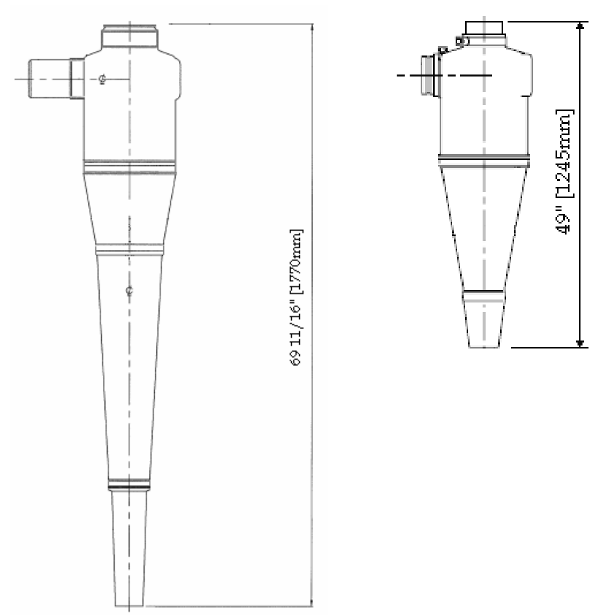
Hydrocyclone diameter is the main factor in determining processing capacity. Table 2 lists the capacity of standard hydrocyclones.

Designation	Cone Diameter	Capacity (GPM)
Desilter	2”	10 – 30
Desilter	4”	50 – 65
Desilter	5”	75 – 85
Desander	6”	100 – 120
Desander	8”	200 – 240
Desander	10”	400 – 500

Table 2. Flow rates through typical hydrocyclones.

HP 10” Hydrocyclone

Turbulence reduces the efficiency of the separation due to it increases the fraction of coarse material misplaced to the overflow stream. In order to minimize turbulence into the cone, a new geometrical design was proposed. It considers two conical sections at different angles. The first conical section provides a smooth transition from the cylindrical section while increasing the tangential velocity. The second conical section is longer than the first section to provide residence time. Figure 2 shows a comparison between the HP 10” and the standard 10” hydrocyclone.



2(A) 2(B)

Figure 2. (A) HP 10” hydrocyclone vs. (B) standard 10” hydrocyclone.

Field Results with HP 10” Hydrocyclone

Two (2) HP 10” hydrocyclones were mounted above one four-panel shaker and tested in a drilling mud system. Hydrocyclones were operated at 35-40 psig with a centrifugal pump feeding from the degasser discharge compartment. Samples were taken from the feed, overflow and underflow products, and they were analyzed for particle size distribution and weight. Samples were taken at different hole depths (from 919 to 1,558 ft) to take into account the differences in formation and mud weight.

Table 3 shows the D_{50} cut points for the HP 10” hydrocyclone tested under the following drilling conditions:

Bit Diameter:	26”
Hole Depth:	280 – 475 m (919 – 1,558 ft)
Formation:	Sand & Clay
Solids Sp. Gr.:	2.60
Mud Pump flow rate:	900 GPM
Mud Type:	Water Based Mud
Mud Weight:	1.18 – 1.20 g/cm^3 (9.8 – 10 ppg)
Mud Temperature:	60 °C (140 °F)
Shakers	Four (4) with 110 and 80 mesh screens

Sample	D_{50} in Drilling Fluid		% Deviation
	HP 10”	Standard 4”	
1	79	70	12.9
2	80	70	14.3
3	107	70	52.9
4	94	70	34.3
5	102	70	45.7
6	89	70	27.1
Average	92	70	31.2

Table 3. HP 10” hydrocyclone D50 cut points.

Table 3 is a comparison of the D50 cut points obtained with the HP 10” hydrocyclone and the D50 upper limit of the standard 4” hydrocyclone in drilling fluid. The D50 cut points ranged from 79 to 107 microns. The lowest deviation is 12.9%.

In comparison with the standard 12” hydrocyclones, the HP 10” hydrocyclones shows a significant reduction of the D50 cut point (greater than 100%).

It is important to point out that the D50 cut points of the HP 10” hydrocyclone lie in the same interval of D50 cut points of the standard 6” hydrocyclone.

These results indicate that the performance of the HP 10” hydrocyclone was improved by changing the geometrical design and increasing the residence time of the material.

HP 8” Hydrocyclone

Based upon the experimental results obtained with the HP 10” hydrocyclone, a HP 8” hydrocyclone was designed. It is highly possible that the performance of the HP 8” hydrocyclone surpasses the HP 10” hydrocyclone, and therefore gets closer to the performance of the standard 4” hydrocyclone.

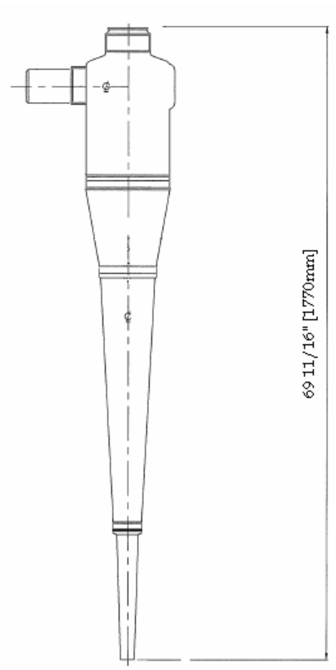


Figure 3. HP 8” hydrocyclone.

The new design was scaled down from the HP 10” hydrocyclone but the total length was kept in order to increase the residence time. Figure 3 shows a schematic of the HP 8” hydrocyclone.

Simulation Results with HP 8” Hydrocyclone

Before manufacture and test the new HP 8” hydrocyclone, it was proposed to know the effect of the new geometrical design by computer simulation. The Plitt model[4] was used to evaluate the performance of the HP 8” hydrocyclone. This model is widely used because it offers a complete process prediction as a function of common design and operating variables.

Figure 4 shows the predicted performance curves of the HP 8” hydrocyclone for different design parameters. The following operating parameters were used in the simulations:

Solids Sp. Gr.:	2.60
Mud weight:	10 ppg (1.20 g/cm^3)
Feed pressure:	35 – 40 psig
Flow rate:	300 – 350 GPM
Solids size:	-250 microns

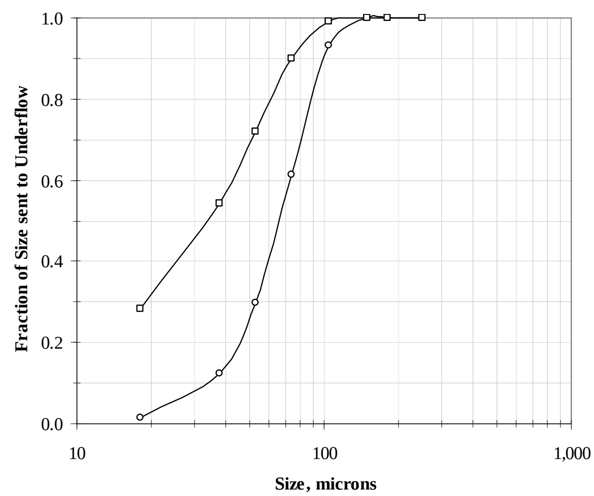


Figure 4. HP 8” hydrocyclone performance curves.

The simulation results show a D50 cut point from 37 to 67 microns, which lie in the same range of the standard 4” hydrocyclone.

Conclusions

The HP 10” hydrocyclone offers a better alternative of cleaning drilling fluids. These hydrocyclones provide a D50 cut point around 92 microns vs. 200 microns of the standard 12” hydrocyclones.

Simulation results show that the HP 8” hydrocyclones are capable to make a D50 cut point between 37 and 67 microns processing up to 350 GPM.

The removal of fine solids, with more efficient hydrocyclone technology, will have a positive impact on the drilling fluids costs and increased rates of penetration.

The use of HP 8” hydrocyclones will reduce the quantity of units in operation. This enhancement minimizes operating and maintenance costs.

The HP 8” hydrocyclone will be tested in the summer of 2008.

Acknowledgements

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Nomenclature

D50 = Size of particle that has a 50% chance of being discarded
GPM = Gallons per minute
ppg = Pounds per gallon
psig = Pounds per square inch gauge
Sp. Gr. = Specific gravity

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