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A Study on Separation Efficiency of Multiphase Desander

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Abstract: Drilling process in the oil and gas industry will commonly result in large amounts of solids (typically sand and small stones) to make its way into the pipeline. In overcoming this predicament and to prolong the life of the processing machineries, a desander is used. However, a large desander usually results in higher cut point where the smaller particles are not efficiently removed, reducing its separation efficiency. The study was aimed to develop a 12" desander or better known as a hydrocyclone that is able to have a high separation efficiency. The hydrocyclone is designed to handle high throughputs of a 12" desander but is able to achieve lower cutpoints and efficiency equivalent to a smaller hydrocyclone if not better. The geometry of the hydrocyclone was designed based on the optimal configuration for 12" hydrocyclone while manipulating the vortex finder to total length ratio ranging from 0.1 to 0.5. The 3D geometry was developed in ANSYS Space Claim then was proceeded to ANSYS Fluent for carrying out Computational Fluid Dynamics (CFD) Simulation. The hydrocyclone was subjected to a fixed feed pressure of 20 Psi to obtain the optimal design. Upon obtaining the optimal design, the hydrocyclone was subjected to varying feed pressure from 15 to 35 Psi with fixed intervals of 5 Psi. Conclusively, the hydrocyclone with *0.1* vortex finder ratio was found to result in the highest separation efficiency and the hydrocyclone operating at *25* Psi was found to further increase in the separation efficiency. However, this research has a gap in terms of the performance of the other designs at various feed pressures and has a lack of data in terms of cutpoint.

Keywords: hydrocyclone, desander, drilling, vortex finder length, pressure

Introduction

Drilling process in the oil and gas industry will commonly result in large amounts of solids (typically sand and small stones) to make its way in to the pipeline (Rawlins, 2002; Amer et al., 2020). The drill fluid plays a vital role in the drilling process where it serves as a lubricant as well as carrying the solids to the surface. In overcoming this predicament and to prolong the life of the processing machineries, a desander is used. However, a large desander usually result in higher cut point where the smaller particles are not efficiently removed. Hence, resulting in a lower separation efficiency (Bridges & Robinson, 2020).

The increasing flow rate is beneficial in the sense that it is able to handle higher flow rates which means it can separate a higher volume of fluid in a given amount of time. According to ERITIA (2016), the processing capacity is vital to ensure the optimal fraction of drill fluid processed is achieved. However, the increase in processing capacity with the cone size will result in larger cut point or cut size. The cut point is typically denoted in terms of d50 cut point where 50% of the particles of the specific diameter or size is able to make its way into the overflow (Cilliers, n.d.). It was found that as the cone size increases, the cut size increases which means a higher processing cone will not be able to separate relatively smaller particles resulting in lower separation efficiency. This can be clearly observed in the Figure 1. Having a larger cut size or not meeting the requirements prior to processing could result in erosion and damages to machineries, especially if the fluid is headed to downstream machineries. Besides that, having a higher cut size desander will result in poor separation efficiency of the desilter.

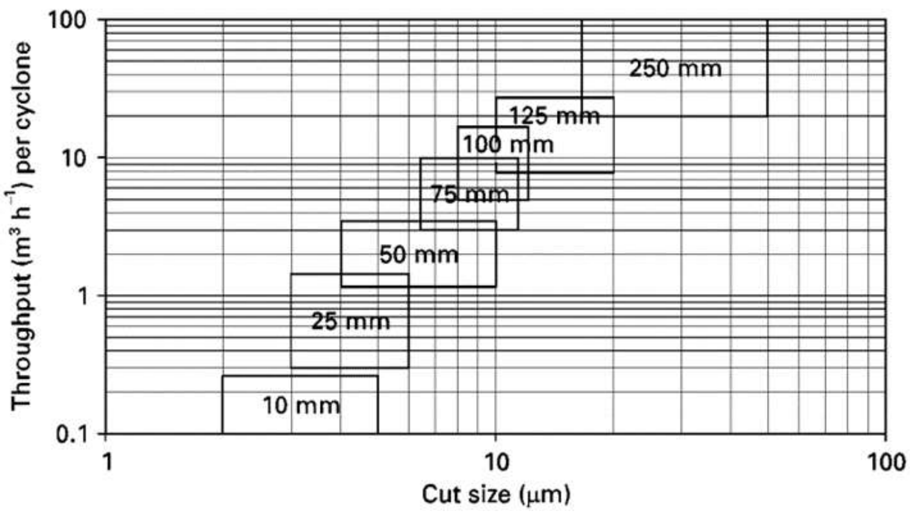

Figure 1 Cut size and through put of different cyclone diameters (Cilliers, n.d.).

The aim of the study was to develop a 12” desander or better known as a hydrocyclone that is able to have a higher separation efficiency. The hydrocyclone is designed to handle high throughputs of a 12” desander but is able to achieve higher separation efficiency equivalent to a smaller hydrocyclone if not better. The geometry of the hydrocyclone was designed based on the optimal configuration for 12” hydrocyclone as learnt in Silva et al., (2012) while manipulating the vortex finder to total length ratio ranging from 0.1 to 0.5 as it was learnt from the study performed by Martínez et al., 2008 and Patra et al., 2018.

Upon obtaining the optimal geometry, the desander was then further studied by subjecting to various feed pressures as per the studies performed by Mukherjee et al., 2003 and Neesse et al., 2015. The feed pressures were varied between 15 to 35 Psi with a 5 Psi interval. Hence as an outcome of the study, it was expected that the desander to be developed is to have a high processing capacity at the same time to have a high separation efficiency.

Methodology

Literature on various modification done in terms of design and operating conditions on hydrocyclone and their results were studied. The hydrocyclone was designed with the optimal configuration to provide a higher efficiency as in the figure below.

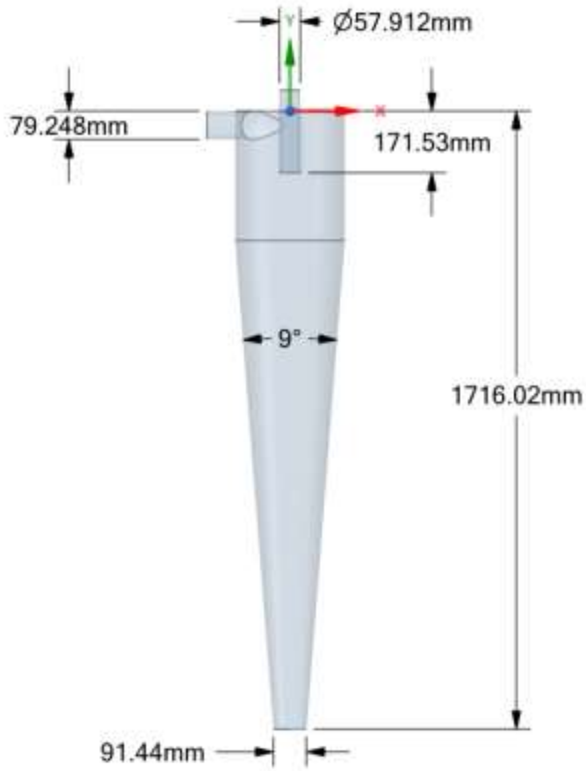

Figure 2 Optimal hydrocyclone geometry

The 3D geometry was developed in ANSYS Space Claim then was proceeded to ANSYS Fluent for carrying out Computational Fluid Dynamics (CFD) Simulation. The hydrocyclone was subjected to a fixed feed pressure of 20 Psi to obtain the optimal design as the vortex finder length ratio was varied. Upon obtaining the optimal design, the hydrocyclone was subjected to varying feed pressure from 15 to 35 Psi with fixed intervals of 5 Psi where the hydrocyclone will be tested within the pressure rating range noted in Bridges and Robinson, (2020), as well as 5 Psi lower and higher than the range for further understanding the effects out of the range.

In this section of ANSYS Fluent Setup is where all the settings with regards to the simulation will be defined. This includes all fluids and solids properties involved and boundary conditions will be defined. Based on, Bridges and Robinson, (2020) it was noted that a balanced 12" desander has feed pressures ranging from 20 to 30 psi. In this study the effects of pressure on the separation efficiency will be studied. However, to further study the effects of operating at various feed pressures value out of the range will be included in the study. Hydrocyclones rely on the turbulent flow to aid the separation of solid particles. Hence, a turbulent model is to be used in the fluent setup and it was learned from Enea.it, (2009) that the Realizable k-epsilon model is able to provide great outputs and processing as this simulation will be involving rotational flow and separation. For the base case of this on performing simulation for various vortex finder length designs the base feed pressure is set 20Psi and is varied for the optimal design. In addition, for the introduction of solid particles as a mixture with the water feed Discrete Phase Model will be used (Tian et al., 2020). Hence, the boundary conditions involved in this study is as follows;

Table 1 ANSYS Fluent Boundary Condition Settings

Phases	Boundaries	Boundary Condition
Continuous	Feed Duct Inlet	Pressure Inlet: 15Psi (103.421kPa), 20 Psi (137.895kPa), 25 Psi (172.369kPa), 30 Psi (206.843kPa), 35Psi (241.317kPa) *For the base case 20 Psi will be used
	Underflow and Overflow Outlet	Pressure Outlet: 1atm
	Wall	No slip
Discrete	Feed Duct Inlet	Reflect
	Underflow and Overflow Outlet	Fully Escapable
	Wall	Surface Reflection

Results and Discussion

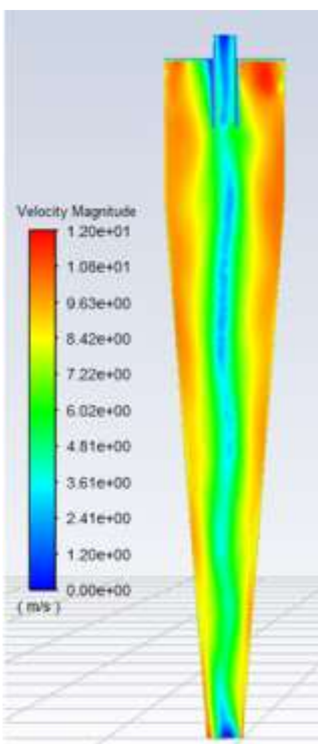

Figure 3 Velocity distribution in desander

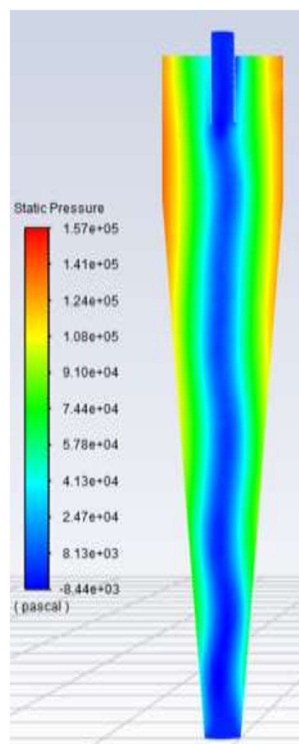

Figure 4 Pressure distribution in desander

Upon observing the pressure and velocity distribution as per Figure 2 and Figure 3, it can be seen that cyclonic flow was developed in the desander with greater pressure and velocity towards the wall due to the centrifugal forces. The effects of vortex finder length ratio can be observed in the table below.

Table 2 Separation efficiency based on varying vortex finder length ratio

Vortex Finder Length Ratio	Solid Particles Mass Flow in Feed, kg/s	Solid Particles Mass Flow in Underflow, kg/s	Efficiency, %
0.1	**0.3310**	**0.3243**	**97.97**
0.2	0.3297	0.3056	92.69
0.3	0.3348	0.3160	94.38
0.4	0.3403	0.3265	95.94
0.5	0.3292	0.3091	93.89

The hydrocyclone with 0.1 vortex finder ratio was found to result in the highest separation efficiency hence, it was selected to be subjected to varying feed pressures. The effects of the varying feed pressure on the separation efficiency can be observed in the following table.

Table 3 Separation efficiency based on varying feed pressure

Feed Pressure, psi, (kPa)	Solid Particles Mass Flow in Feed, kg/s	Solid Particles Mass Flow in Underflow, kg/s	Efficiency, %
15(1096.27)	0.2892	0.2857	98.79
20(137.895)	0.3310	0.3243	97.97
25(172.369)	**0.3669**	**0.3647**	**99.40**
30(206.843)	0.3991	0.3863	96.79
35(241.317)	0.4287	0.4226	98.57

It was found that the hydrocyclone operating at 25 Psi had further increased the separation efficiency by 1.43%. As for the separation efficiency, when the vortex finder length ratio was varied, it was found the peak efficiency of 97.97% was achieved at 0.1 vortex finder ratio which is similar to the findings of Martínez et al., (2008). It was found that this length was optimal as it was able to prevent short circuit flow from occurring where the particle from the feed directly makes their way into the overflow as well as not interfering with the cyclonic flow in the desander.

Besides that, when the feed pressure was set to be 25 Psi it was found that there was minimal particle recovery from the upward swirl as the particles have gained sufficient centrifugal forces at the same time not having a high upward flow where the particles were carried into and eventually making their way into the overflow. The study with respect to feed pressure has resulted in an increase in separation efficiency by 1.43% and total efficiency of 99.4%. It was also found that this combination of modification with respect to the geometry and operation pressure to have a processing capacity of 36.69 kg/s.

Conclusion

In conclusion, the goal of developing a desander 12" desander with a high separation efficiency while maintain a high processing capacity was achieved. In addition, it was also learnt how various aspects such as the vortex finder length and feed pressure affect the performance of a desander. The peak performance was achieved when the vortex finder ratio was at 0.1 at a feed pressure of 25 psi at a separation efficiency of 99.4% which had an increase of 1.43% increase in pressure when compared with the base pressure of 20 psi. Besides that, the processing capacity of the desander was also found to be at 36.69 kg/s which is higher than the relatively smaller desanders. However, this research has a gap in terms of the performance of the other designs at various feed pressures as well as results with respect to cut point. For the purpose of continuous improvement and sustainability, other design parameters such as material selection could be further investigated.

Acknowledgements

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