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ADVANCED SLUDGE DEGRITTING - A COST EFFECTIVE SOLUTION TO ABRASIVES REMOVAL

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ABSTRACT

Wastewater treatment plants are significantly impacted by grit. The majority of installed grit removal systems fail to keep settleable grit out of the plant. Grit is a nuisance material, depositing in treatment processes and causing abrasive wear to mechanical equipment. In addition to the abrasive effects, grit accumulates in processes throughout a plant, especially digesters. Since it happens gradually and continuously, it often goes unnoticed until a process is completely overwhelmed and needs to be shut down to manually remove the grit that accumulates in aeration basins and digesters. This shut down and manual removal is expensive, time consuming and requires taking processes off line.

Grit that is not removed at the plant headworks typically settles in the primary clarifier, exposing all sludge handling processes to accelerated wear or failure. Sludge degritting is an option to address ineffective grit removal in the headworks. Sludge degritting reduces grit induced wear on the sludge dewatering system as well as reducing grit accumulation in the digestion process. Conventional sludge degritting systems utilize hydrocyclones coupled with screw classifier units. These conventional systems often fail to effectively remove grit because they are designed to remove coarse grit (over 150 micron) and they cannot effectively handle the increased grit load experienced during peak wet weather and first flush conditions.

As much as 50-80% of grit entering wastewater treatment plants can be finer than 150 micron. The volume of grit received increases significantly during peak wet weather conditions. Some plants receive up to 40 times the normal grit load during peak wet weather conditions (Wilson 2007). A successful sludge degritting system design must take these factors into account. Sludge degritting systems offer a cost effective solution when designed with an accurate understanding of the size and volume of material to be processed. This presentation will provide designers and plants with the insights required to successfully design cost effective and efficient sludge degritting systems that will minimize abrasion and deposition problems.



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INTRODUCTION

Conventional wastewater treatment plant design is primarily focused on meeting the final effluent quality required by the plant discharge permit. Achieving the required effluent quality in the most cost effective manner is a primary objective. While grit removal is a common component to wastewater treatment plant headworks design, grit removal efficiency is seldom considered as there are no industry standards with which to compare. Lack of design criteria can lead to a purely cost driven technology selection process which often results in ineffective grit removal processes being implemented. As a result many plants fail to remove more than 50% of the incoming grit (Sherony 2010) which allows the remaining grit to accumulate in downstream processes.

Wastewater treatment plants are significantly impacted by grit. Grit is a nuisance material, depositing in treatment processes and causing abrasive wear to mechanical equipment. The prevalence of mechanical sludge dewatering processes raises the costs associated with ineffective headworks grit removal. The result is increased maintenance costs as well as equipment downtime which often drives the need for dewatering equipment redundancy. In some documented instances the annual costs of abrasion related repairs have exceeded \$750,000 USD (Garelli 1992)

In addition to abrasive effects, grit accumulates in process tanks throughout a plant, especially digesters. Since it happens gradually and continuously, it often goes unnoticed until a process is completely overwhelmed and needs to be shut down to manually remove the deposited grit. Shutting down digesters to manually remove grit is time consuming, expensive and requires taking processes off line. Lengthy start-up time can leave plants short on capacity forcing them to operate outside ideal parameters.

Inefficient grit removal is more common with larger plants that do not have adequate space to install more advanced grit removal processes or older plants with antiquated grit removal technologies. While the ideal situation is to utilize high efficiency grit removal processes at the headworks, one cost effective alternative is sludge degritting.

GRIT BEHAVIOR

One reason that many conventional grit removal systems fail to capture a majority of the incoming grit load is because the design guidelines used in their development assume that wastewater grit behaves like clean spherical silica sand. In reality, grit is affected by several factors which impact its behavior. Characteristics such as size, specific gravity and geometry can have a significant impact on settling velocity which ultimately affects the performance of grit removal systems. The attachment of in-situ materials such as fats, oils, greases, and organics can also affect settling velocity (Sherony 2010).



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Specific gravity significantly impacts settling velocity in headworks grit removal and sludge dewatering applications. Table 1. below lists the specific gravities of various materials that are likely to enter a wastewater treatment plant. As can be seen, none of the materials listed has a “conventional” specific gravity of 2.65.

Table 1: Specific Gravity of Likely Constituents of Grit
(Reade Advanced Materials, 2010)

| Specific Gravity of Various Materials | | | |
|---------------------------------------|------|-----------|------|
| Quartz Sand | 1.2 | Earth | 1.4 |
| Limestone | 1.55 | Granite | 1.65 |
| Clay | 1.8 | Red Brick | 1.9 |
| Sand, wet | 1.92 | Gravel | 2 |
| Asphalt | 2.2 | Concrete | 2.4 |

One means to address the variability of grit characteristics is to perform a grit characterization study. An effective grit characterization study should include data on the physical size of the native grit as well as measured settling velocity of the graded grit. The measured settling velocity of the graded grit can be correlated back to a silica sand particle size with the equivalent settling velocity. This data gives the designer a profile of the native grit settling velocity and an understanding of the expected capture efficiency for designs at various cut point sizes. If a complete grit study is not available, design should be based on the smallest practicable particle size which would typically be in the 75-106 micron size range. (Sherony 2010).

Another aspect of grit behavior which must be accounted for is the effects that the collection system can have. Plants with wide peak to average flow ranges can expect grit to settle throughout the collection system during low flow periods. Settled grit will be re-suspended and delivered to the plant in concentrated form. Grit loads of 20 – 40 times average are possible during the first flush portion of these wet weather flows. (Wilson 2007). It is critical that any grit handling process is capable of managing this solids volume or grit bypass should be expected. It is the combination of both high flow and high solids volume occurring simultaneously that causes many headworks grit removal systems to bypass grit which is then carried downstream to the primary clarifiers. This variability in grit concentration also impacts sludge dewatering processes as it carries through to those systems as well.

SLUDGE DEGRITTING OPTIONS

Conventional Sludge Dewatering

Sludge dewatering has been practiced for years, typically with hydrocyclones and screw



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classifiers. This technology was essentially borrowed from the mining industry where it can be very effective in concentrating and dewatering inorganic minerals from water which contains little or no organics. This type of system is designed for a material with a known specific gravity and is fed at a constant solids concentration and flow rate.

There are several operational and maintenance challenges associated with hydrocyclones and screw classifiers when applied to municipal sludge dewatering applications (WEF and ASCE, 2009). One of the key challenges is the variability in specific gravity found in municipal grit. As previously discussed, it is not uncommon for the specific gravity of municipal grit to vary significantly. Some plants have reported measured native grit specific gravities in the range of 1.05 – 1.6 (Borys 2002). This variability can result in substantial impact on the capture efficiency of a sludge dewatering system that relies heavily on specific gravity and settling velocity differentials to separate grit from organics.

Hydrocyclones are a free vortex based technology that uses centrifugal force to separate high specific gravity solids from water with a lower specific gravity. The technology has little means to distinguish organics from grit and as a result, organics are concentrated along with the grit. The concentrated grit/organics slurry is delivered to the screw classifier at a high solids, low volume flow rate. This slurry is delivered to the classifier by use of an apex valve at the bottom of the cyclone. The apex valve is a fixed orifice which restricts the volume that can be discharged. This restriction is a significant problem when the grit volume can increase 20 – 40 times average during the first flush of wet weather events. The increased solids concentration can lead to “roping” which results in both reduced capture efficiency and loss of finer particles (Heiskanen 1993). Because the increased grit volume cannot pass through the apex valve, excess grit is carried out with the Hydrocyclone effluent and typically makes its way back into the process or the unit plugs completely.

The primary means for separation of organics is in the screw classifier where a differential in settling velocity determines washing effectiveness. The solids concentration of the slurry entering the screw classifier complicates this process which typically results in high organic content of the output grit. Surface loading rates on the screw classifier clarifier pool and the specific gravity of grit will dictate what grit particle size can be retained. The variability in grit specific gravity results in an overlap where many of the organics have the same settling velocity as the grit. This results in low capture efficiencies for fine grit as the surface loading rates used on classifiers are normally set high to encourage washing. The typical result is grit carryover which results in it returning back to the process while larger organics with a high settling velocity are retained.

Many screw classifier systems are designed primarily with solids handling capacity in mind where screw diameter and speed are critical. The impact of the screw’s rotational speed is another factor that is often overlooked. For example, a 30 cm (12”) diameter screw rotating at only 4 rpm has a tip speed roughly equivalent to the settling velocity of a 400 micron



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silica sand particle. As the screw rotates it suspends the finer material (grit and organics) which allows them to be carried out with the overflow, returning it back to the plant. Ultimately, screw classifiers can be designed to retain fine grit particles but this will significantly increase the organic content of the output material as hydrocyclones are only capable of concentrating solids, not washing organics.

Advanced Sludge Degritting

Advancements in free vortex separators now allow systems to classify and remove organics prior to the dewatering process. By separating the classification process from dewatering, each process can be optimized. An optimized system of this type is capable of consistently capturing grit as fine as 75 micron while producing a low organic (<15% VS by weight) output solid.

The Eutek SlurryCup™ grit classifier utilizes centrifugal force, boundary layer separation and rinse water to effectively capture grit while separating organics from the grit laden slurry. This process eliminates the concern associated with screw classifiers which classify primarily based on differential in settling velocity. Grit is classified from organics based primarily on size. Grit particles are able to pass through the boundary layer while larger organics are stripped out due to exposure to the vortex motion within the unit. A secondary rinse as grit exits the unit removes remaining unattached fine organics.

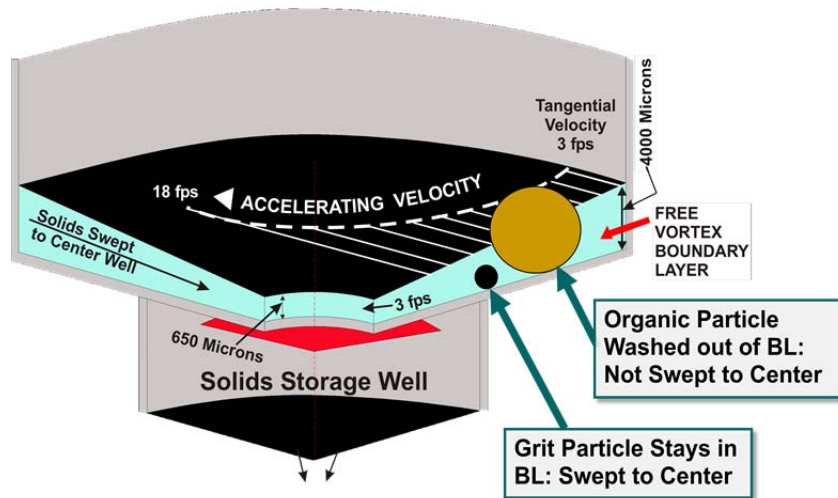
Flow enters the stainless steel vessel tangentially at a controlled rate and velocity. The flow regime established in the device forms an open free vortex which results in high centrifugal forces and a thin predictable boundary layer. Grit is forced to the outside perimeter or held in suspension until it falls by gravity into the boundary layer (Figure 1) which sweeps the grit, but not organics, into the collection chamber at the bottom of the unit. The concentrated slurry exits the vessel through a hydraulic valve where a secondary wash with rinse water occurs prior to discharge. These two levels of washing produce clean (<15% VS by weight) grit ready for dewatering. Degritted effluent containing the organics exits from the overflow through the discharge box and returns to the plant.

This technology provides a larger diameter body providing significantly more volume for grit to attenuate during spikes in grit concentration found in the first flush of wet weather events. Sizes range from 0.6 – 1.4 m diameter (2.0 – 4.7 ft) capable of degritting a slurry volume of 9.5 – 70 L/sec (150 – 1,100 gpm). Clean grit is discharged through a 76 mm diameter (3 in) pipe and vortex valve which is capable of passing significantly more volume compared to a hydrocyclone thus virtually eliminating the plugging issues typically associated with an apex valve. The clarifier pool on the grit dewatering system is appropriately sized to accommodate the hydraulic load from the SlurryCup classifier.



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Figure 1: SlurryCup Boundary Layer Separation



Classified grit with low organics is dewatered in the Eutek Grit Snail[®] which is designed to capture 75 micron grit particles. The clarifier pool is sized based on a surface loading rate of 2.2 L/sec/m² (3.2 gpm/ft²). Grit captured in the clarifier tank is conveyed and dewatered by a cleted rubber belt which moves slowly at a rate of 0.3 – 0.6 m/min. (1 – 2 ft/min.). The slow speed of the conveyor belt allows fine grit particles to be gently transported without stirring the tank. Additionally, the slow speed results in a drier discharge solid due to the residence time spent above the water level traveling to the discharge chute.

The key to advanced sludge dewatering is the separation of the classifying and dewatering processes. By performing these processes in separate components a highly efficient design can be implemented. The combination Eutek SlurryCup[®] /Eutek Grit Snail[®] can be highly effective in dewatering primary sludge while capturing 75 micron grit and producing an output solid of <15% VS by weight. Side-by-side testing shows that the Eutek SlurryCup[™] grit classifier technology removes over 20 times the grit volume removed by hydrocyclone/screw classifier systems. The organic content of the grit output from hydrocyclone/screw classifiers typically exceeds 35% VS which significantly increases odor issues and the volume of materials to send to landfill.

CONCLUSIONS

Wastewater treatment plants are significantly impacted by grit. Grit is a nuisance material, depositing in treatment processes and causing abrasive wear to mechanical equipment. The costs associated with abrasive wear significantly increase when advanced sludge processing



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technologies are utilized. While effective headworks grit removal is the ideal situation, sludge dewatering can be an effective approach to abrasives removal. Advanced sludge dewatering technology improves efficiency while producing a lower organic content output solid.

The key to increasing the performance of sludge dewatering systems is separating the classification and dewatering processes. Washing, by nature is a turbulent process while dewatering on the other hand is a quiescent process. Through separating the processes, each can be optimized to perform in a highly efficient manner. An advanced sludge dewatering system can capture over 90% of grit as fine as 75 micron while producing output solids with less than 15% volatile solids by weight. Advanced sludge dewatering is the only means to truly achieve the objective of protecting downstream processes from the effects of abrasives.

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