Efficient Dewatering Solutions on Vibrating Screens

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1 Introduction

Any wet applications in bulk material processes ultimately raise the question of dewatering. Usually the purpose of dewatering is to put the solid material into an either sellable or at least transport-ready state. A variety of machinery options exist for that purpose. Each of these come with there very own range of usage and there pros and cons.
This paper will evaluate a range of processing equipment for its dewatering capabilities and operating parameters. Special focus will be set on environmental aspects as energy and water consumption and the effects the performance of dewatering equipment has on the entire process.
Vibrating screens have been proven to be an economical means for a multitude of dewatering applications ranging from aggregates over coal to food. Operating conditions that affect the dewatering performance will be discussed. These parameters are not limited to the mechanical behavior of the screen but include material properties and overall process conditions.

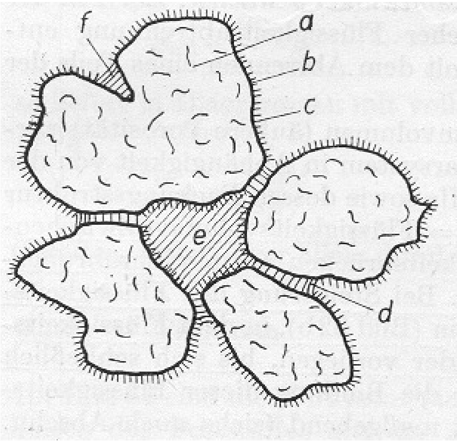
2 Background

Dewatering is the process to separate a mixture of solids and liquids. During this process none of the components will be altered. If the target of the process is the solids we speak about dewatering. In that case we look for a solids product with a liquid content as low as possible.
There are other applications that look at the liquid as the final product with as little as possible solids in it which won’t be discussed here.

Table 1: Process Classification by Remaining Water Content [1]

Process	**Remaining Water Content [%]**
Thickening	***> 40***
Pre-Dewatering	***< 40***
Dewatering	***> 10***
Drying	***>0***

The term “Dewatering“ can be further limited to materials smaller 2 ½”. Solid mixtures of that and larger sizes do not have a substantial capacity to carry water.
In order to dewater a bulk material we have to look at the means of how water or liquid is bound to solids (figure).



a) Inner liquid
b) Adsorbed liquid
c) Adhesive liquid
d) Small capilare liquid
e) Free liquid
f) Large capilars liquid

Figure 1; Water in Bulk Materials [2]

Looking at the process of dewatering one can see three basic states of the material:

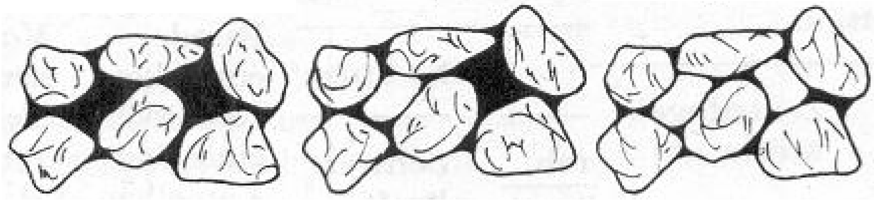


Figure 2; Dewatering Stages in Bulk Materials [2]

The first stage shows a material fully saturated with water. The entire porosity volume is filled with water. In this stage the mixture of solids and liquid behaves mostly like a liquid.
During dewatering the second stage will occur. In this stage we will find fully water-filled porosities as well tight solid-solid contacts allowing only adhesive and small capillary water.
The final stage of dewatering is reached when the solids are in the most compacted stage allowing only adhesive and small capillary water.

3 Main Dewatering Principles

3.1 Sedimentation

Sedimentation uses either gravity or some means of centrifugal force to separate solids from liquid. The focus is usually not only set on the solids material but also on the cleanliness of the liquids. As previously shown the water content of the solids achievable by sedimentation is rather high as naturally the mixture is still fully saturated. Industrial use of sedimentation is found in thickeners.

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3.2 Filtration

For this paper filtration is of greater importance. During filtration a means of filter media is used that allows water or other liquids to leave the mixture. The solids will form some sort of a filter cake on top of the filter media. When this cake is established it acts as a filter media in itself and can retain particles that are smaller then the porosity or openings of the filter media. If that is the case we speak of cake-filtration.

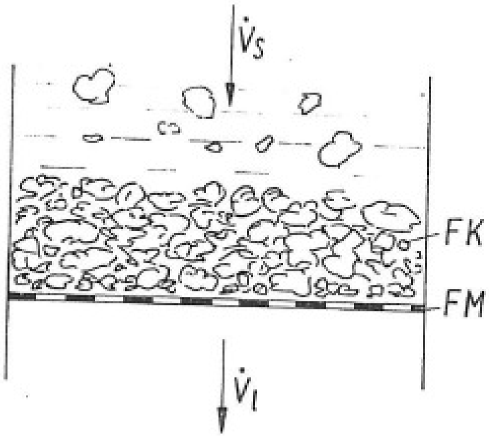

Figure 3: Cake Filtration [2]

The process of cake filtration can be described in 3 phases:

- Creation of the cake. Water drains through filter media.
- Compaction of the cake. Water in porosities in the cake is replaced by air.
- Final stage. Remaining water content is in balance and cannot be reduced further.

4 Material Properties for Dewatering

It is of utmost importance to evaluate all material properties relevant to dewatering before selecting machinery.

4.1 Feed Material Properties

4.1.1 Gradation

The single most important material property is its gradation. The gradation defines how much water can be bound in the product. It also defines how small the pores or openings of the filter media have to be.

4.1.2 Density

The greater the difference between the density of solids and liquid the easier is the separation.

4.1.3 Particle Shape

The shape of a particle not only defines the surface area and therefore its capacity of binding adhesive water but also the resistance against liquid flow in a material.

4.1.4 Other

Other properties like firmness, abrasiveness, toxicity, product value have to be taken into account as well. During the process particles could get destroyed and increase the fines content hence increasing the overall surface area and hindering the dewatering. Corrosiveness and abrasiveness will play a large role in the selection of the machinery. The value of the product will determine how much sense it makes to dewater to a certain percentage.

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4.2 Finished Product - Remaining Water Content

The one product property that comes to mind when speaking about dewatering is the remaining water content. This property mainly defines the entire process. It also affects the following processes as the water content will determine whether the material can be transported on a belt conveyer.

4.3 Process and Machinery Conditions

Before selecting dewatering machinery one should consider the following conditions:

- Allowable gradation
- Allowable solids percentage
- Throughput
- Remaining water content
- Efficiency
- Economy: investment and operation cost

5 Dewatering by Sedimentation

The following gives a brief overview of machinery and principles using sedimentation for dewatering.

5.1 Gravity as Separating Force

Table 2: Dewatering by Sedimentation

Machinery	Size range	Feed Solids Percentage [Vol. %]	Remaining Water Content [Wt. %]	Dewatering Time
Clarifyer	*0.1 - 0.5 mm*	*< 15*	*20 - 50*	*0.5 - 24 hrs.*
Thickener	*0.1 - 0.3 mm*	*< 10*	*20 - 50*	*0.5 - 24 hrs.*
Stockpile	*> 0.1*	*< 50*	*5 - 10*	*0.5 - 24 hrs.*
Sand screw	*0.15 - 63 mm*	*< 50*	*22 - 25*	*30 - 60 sec.*

It quickly becomes obvious that none of above principles deliver a “dry” product. Exception to that is stockpile–dewatering which on the other hand takes a rather long time.
When time is of the essence it is worthwhile to enhance gravitational forces by centrifugation.

5.2 Centrifugation as Separating Force

Table 3: Dewatering by Centrifugal Forces

Machinery	Size range	Feed Solids Percentage [Vol. %]	Throughput [m^3/h]	Remaining Water Content [Wt. %]	Dewatering Time [sec.]
Hydro Cyclone	*.005 - 0.5 mm*	*2 - 30*	*0.2 - 650*	*20 - 30*	*< 30*
Centrifuge	*0.0001 - 0.1 mm*	*0.005 - 3*	*< 4*	*3 - 6*	*< 30*
Seperator	*0.0001 - 0.1 mm*	*0.002 - 6*	*< 200*	*3 - 6*	*< 30*
Decanter	*0.001 - 5 mm*	*4 - 40*	*< 200*	*3 - 6*	*< 30*

From the data above it becomes clear that only Hydro Cyclone and Decanter are capable to dewater a relatively wide size range with decent throughputs.

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6 Dewatering by Filtration

The following table compares the major machinery groups using filtration by gravity.

Table 4: Filtration by Gravity

Machinery	Size range	Feed Solids Percentage [Vol. %]	Throughput [m³/h]	Remaining Water Content [Wt. %]	Dewatering Time [sec.]
Silo	*0.063 - 2 mm*	*50 - 90*	*-*	*4 - 8*	*8 - 10 hrs*
Vibrating Screen	*0.063 - 63 mm*	*50 - 80*	*35 - 500*	*10 - 20*	*10 - 30 sec*
Fine Sand Recovery Wheel	*0.063 - 63 mm*	*20 - 50*	*3 - 400*	*20 - 25*	*10 - 30 sec*

The vibrating screen presents the widest application range for in-line processing and comes in at relatively low remaining water percentages.
A variety of other machinery options are available that use a combination of filtration and centrifugal forces. Very common are units applying over- or under-pressure to improve the dewatering efficiency and time. In this area we find all the filter presses.

7 System Comparison

7.1 Feed Size Range

The size range that can be fed to the individual dewatering systems is shown below. It can be seen that only screens (stationary or vibrating) and of course the stockpile cover wide range of sizes. Other units mostly focus on the fine end of the scale.

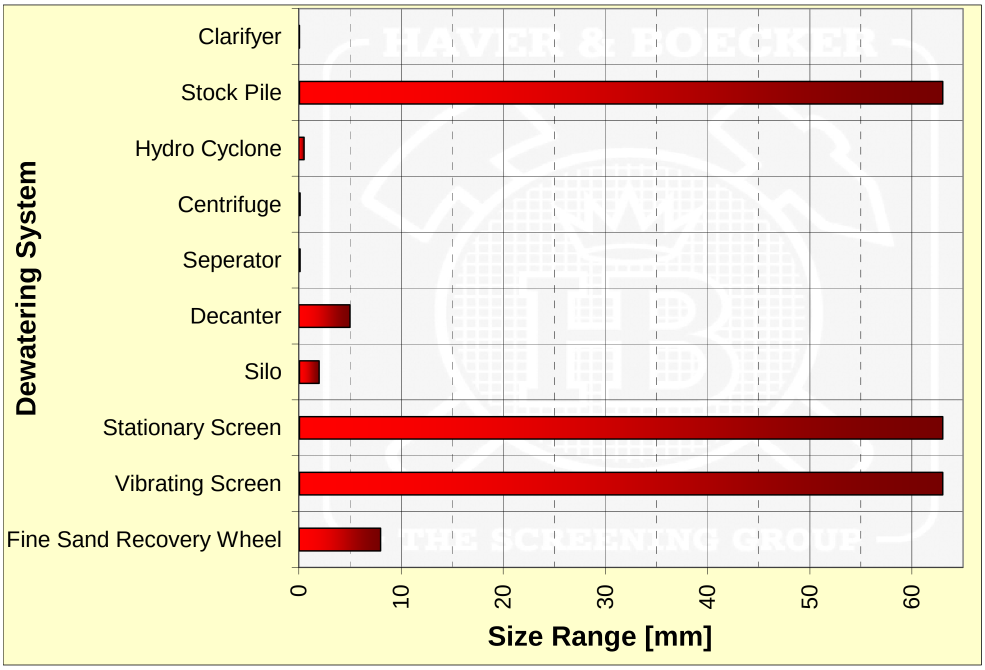

Figure 4: Dewatering Systems by Size Range

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7.2 Throughput

Looking at the achievable throughput hydro–cyclones and fine-sand-recovery-wheels come out first for small size while vibrating screens clearly dominate in the mid-size range.

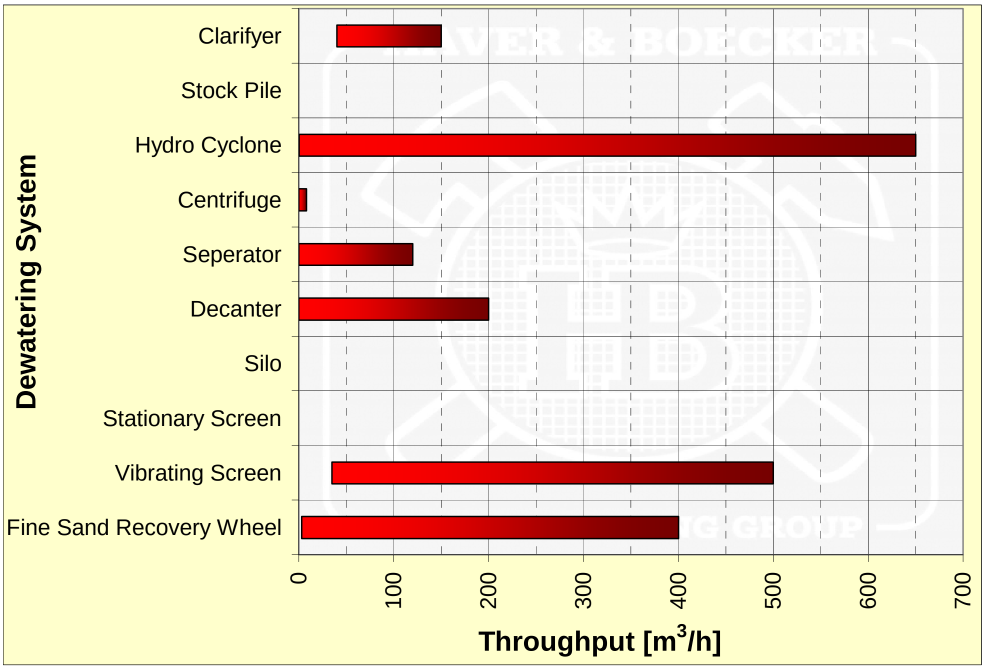

Figure 5: Throughput by Dewatering System

7.3 Feed Solids Content

An important aspect is the condition of the feed or it's solid to water ratio. A number of dewatering systems like clarifier, separator and centrifuge clearly focus on the liquid side of the scale while again screens cover a wide range.

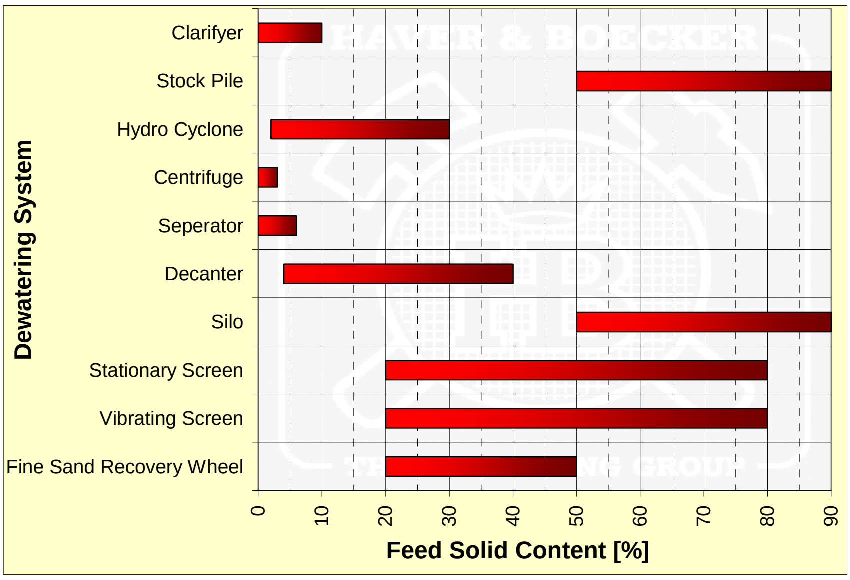

Figure 6: Feed Solids Content by Dewatering System

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7.4 Remaining Water Content

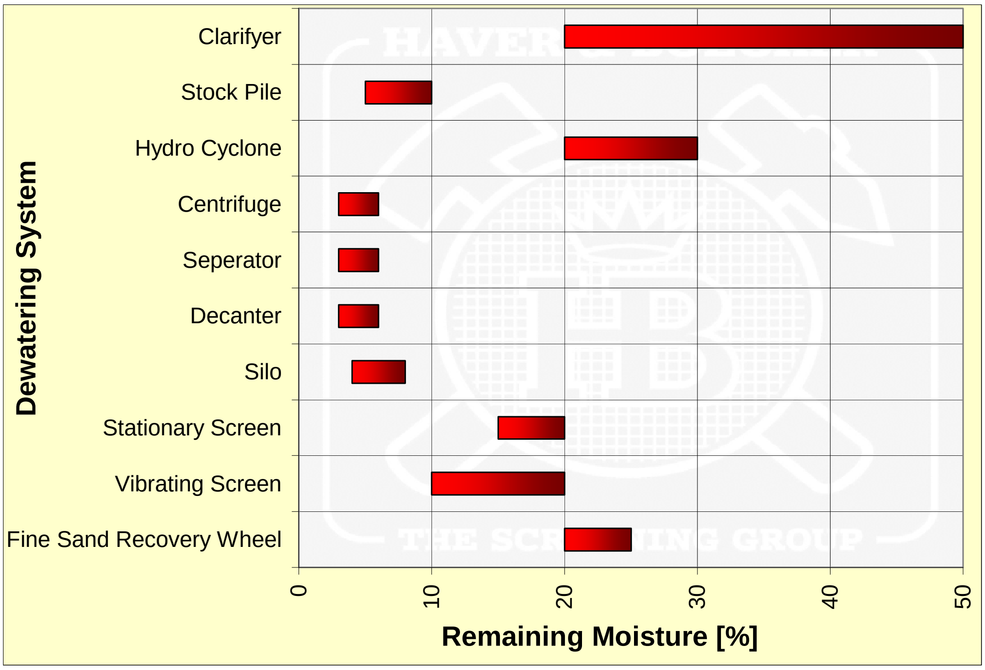

Figure 7: Remaining Moisture Content by Dewatering System

The remaining water content is usually the scale to be used to evaluate dewatering options. Some of the systems deliver exceptional values that all come with a downside like long dewatering times or very high machinery costs. Others are more focused on the liquid end of things like the clarifier. Screens (vibrating or stationary) are in mid range.

7.5 Conclusion

It can be said that from all options presented the vibrating screens are the most versatile. Especially in the application range of dewatering of bulk materials in mining, sand and gravel or recycling they are second to none.

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8 Dewatering on Vibrating Screens

8.1 INCLINED SCREENS

The material is usually introduced as slurry. On an inclined dewatering screen the accelerations along with a portion of the gravitational force will cause the material to travel towards the discharge end while the water is being screened out by means of proper screening media (figure).

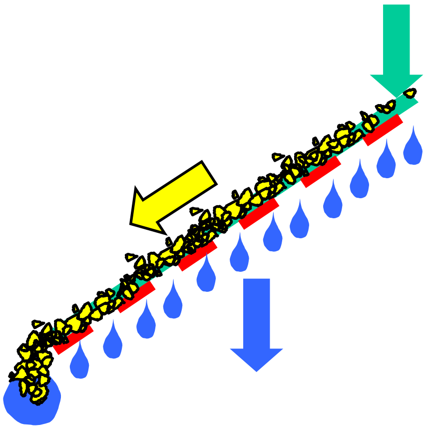

Figure 8: Dewatering on Inclined Screens

The resulting force for material travel is indicated as the yellow arrow. The force causing the water to separate from the solids is gravity enhanced by the vertical vector of the g-forces produced by the screen.
The problem in this design is that the gravitational forces are only partially used towards dewatering but also towards material transport. The later will ultimately drag water into the product.
In order to improve dewatering one would have to decrease the inclination of the screen which in return will also decrease the material travel rate drastically. In other words the “dry” product will end up quite wet.
This can raise a couple of problems. A customer could be quite hesitant to pay for a high amount of water in the product. A product with high water content will flow back on a conveyer belt and will cause severe damage to the rollers of the belt by washing fine solid product into the bearings. Finally the amount of water in the product is a loss if the customer doesn’t pay for it just as well as it is a loss if the plant runs a closed water circuit.

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8.2 Horizontal Screens

The horizontal screens used for dewatering are actually not exactly set at 0º. It has proven to be very beneficial to set them up at a negative incline of about 3º.

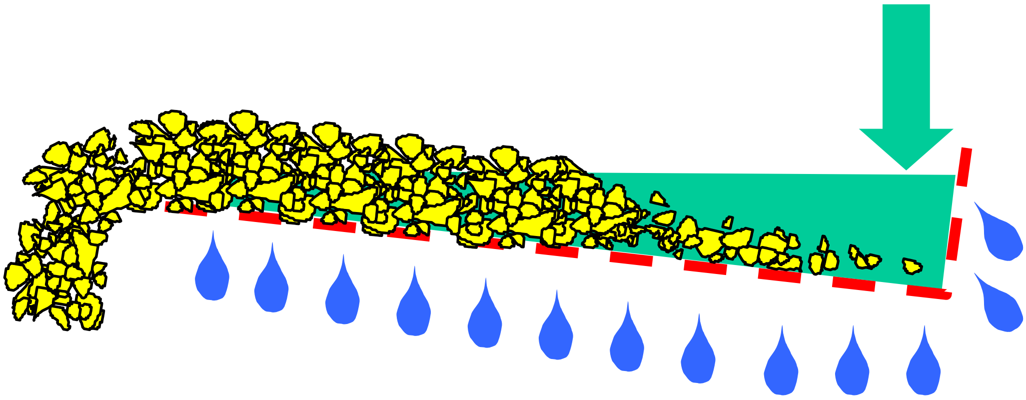

Figure 9: Dewatering on Horizontal Screens

As for the applications discussed above the material is usually introduced as slurry. Other then on inclined machines the only force resulting in material travel is the g-force produced by the screen. This g-force is aligned a 45º and transports the material uphill. The gravitational forces enhanced by the vertical portion of the acceleration of the machine are fully utilized towards dewatering.

In operation those forces will build a material layer on the screen that is pushed out of the wet zone towards the discharge end. A back dewatering field is used to reduce the amount of water right after feeding the screen. The thick layer of material acts as a filter cake and not only presses water out but traps fine particles that would be lost in a thin layer screening process.

Furthermore a dam at the discharge end is normally used to further enhance product quality.

The main advantages of that technology can be summarized as follows:

Large angle between material transport and gravity -> Good separation

Filter-cake bridges openings and “traps” fine particles -> Minimal material loss

Water won’t run uphill + Filter-cake presses water out -> Excellent dewatering

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8.3 FIELD DATA

The following describes field data of an 8x24 Tycan XL-Class.

Figure 10: TYCAN XL-Class 8x24

The machine is being fed at a rate of 300 tph solids and 750 USGPM of water. The transport speed of material over the screen is 0.19m/s.
The resulting product water content ranges from 10to15%, which delivers a belt conveyable product (figure). It can be seen how the material breaks of at the end of the discharge as a very well dewatered product whereas the last visible water is about 2 ft away from that point.

Figure 11: Dewatered Material

9 Figures

10 Tables

11 Literature

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