OPERATIONAL PAPER

GREEN SCREEN – HIGH-EFFICIENCY SUGAR SCREENING THROUGH DIRECT EXCITATION

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Introduction

Even though sugar-refining processes have been well-known for a very long time, the process design itself is still challenging. As Mark Twain stated in his book *Life on the Mississippi* in 1883, “Do not deceive yourself. To make sugar is really one of the most difficult things in the world. And to make it right, is next to impossible” [4]. In this paper the problems and solutions for the screening of different types of sugar will be examined, while the focus will be kept on its energy efficiency.

If one takes a look at screening processes in sugar production lines, the first screening process is the washing screen, which is often used to remove the earth and clay that sticks to the beet or cane. In the second screening process, it makes sense to de-water the bagasse or beet slices after the extraction process. These two screening processes are relatively easy to handle and are therefore not the subject of this paper.

However, the following screening processes in the refining of the product are more challenging, due to the different types of sugar that have to be produced. As there are no worldwide standards concerning the particle size distribution of sugar products, the machines for screening sugar have to be flexible enough to adapt to every situation. Furthermore, the demand for sugar is constantly growing [3], which often results in sugar plants being revamped in order to raise their capacity, while aiming to keep the energy consumption low. Thus, the machines that will be replaced must have a higher capacity, while keeping the same footprint. In addition, the quality of the product must constantly be kept at a high level.

Rhewum machines have been used in the sugar industry for decades [1] and are constantly improved to meet these requirements. They have gained an outstanding reputation for being reliable and economical, especially for the challenging screening of fine and sticky sugars.

Procedures

A case study was conducted to give an overview of the modern screening technologies in the sugar industry and their respective energy efficiency. This case study shows a screening process for crystallized sugar with a particle size distribution of between 0 and 5 mm. The goal is to classify sugar with screen cuts of 2.0 mm, 1.0 mm and 0.212 mm, at a feed capacity of 300 t/h. The challenging task is to achieve a high product purity of ≥90% that is required by the customer and that has to be guaranteed for the product fractions 0.212 to 1.0 mm and 1.0 to 2.0 mm at this constantly high feed-rate.

The particle size distribution of the feed material is shown in Figure 1. The bulk density of the feed material is 0.88 kg/l, the angle of repose is 35° and the moisture content is less than 0.2% (m/m) H_2O.

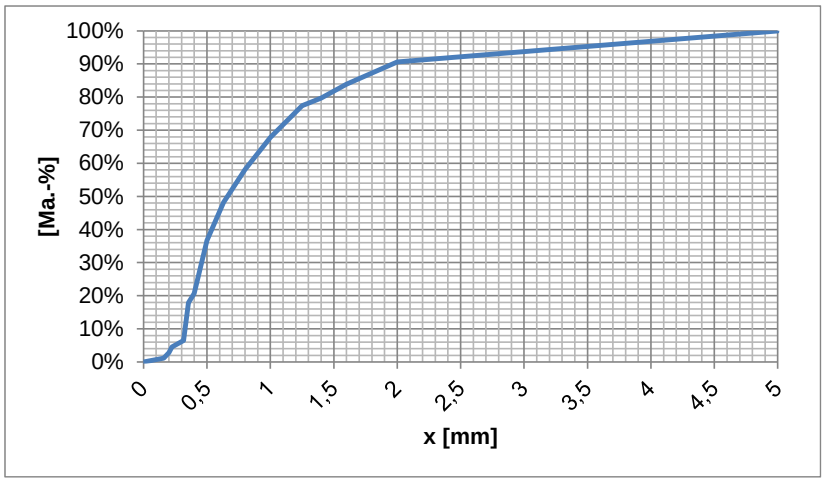

Figure 1. Particle size distribution of the feed material

In order to solve this task, trials were undertaken at the Rhewum laboratory. The aim of the trials was to check whether the desired product parameters can be guaranteed and to find the most economical screen type and its required dimensions.

The first step was to choose the best suitable and efficient screen type. Basically, the following four different screen types are currently being used in the sugar industry:

Inclined screens with a linear movement

These screen types are usually called ‘sizers’. Their advantage is that the material flow on the screen cloth is fast, due to the inclination. Usually the inclination varies between 20° and 50° [2]. The transportation speed can vary between 0.5 and 1.3 m/s; thus, the capacity is relatively high. Nevertheless, this type of screen does not have a cleaning device that can be used for fine screen meshes, so the tendency for them to clog is high. Furthermore, the screening efficiency is relatively low, due to the relatively short screen decks and the resulting residence time of the feed material on each deck.

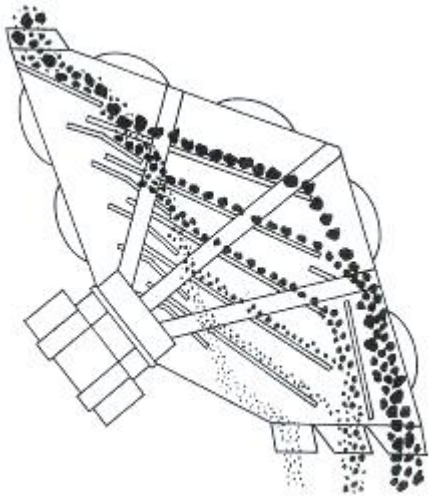

Figure 2. ‘Sizer’ type linear motion screen
(source: http://www.steine-und-erden.net)

Flat screens with a gyratory movement

These screens normally have an inclination of between 5° and 15°. The transport of the material results partially from the inclination and partially from the gyratory movement. The transportation speed of the material on the screen cloth is much slower, compared to the inclined screens. Therefore, the product layer on a flat screen with the same dimensions as an inclined screen will be higher, at the same feed rate. Usually bouncing balls are used as anti-clogging devices for this screen type. Due to the gyratory movement of the screen, however, there is no force that throws the bouncing balls directly against the screen cloth. Therefore, the movement of the bouncing balls has to be deflected by the inclined side walls. The following figure indicates the problem:

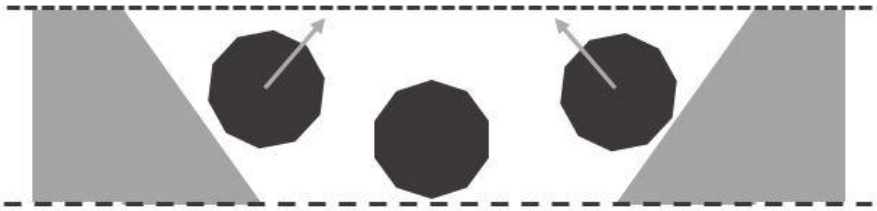

Figure 3. Bouncing ball movements on gyratory screens

Due to the geometry of the inclined side walls and the bouncing balls, the latter only have a limited impact zone on the screen, which is concentrated in the middle of each chamber. As a result, this screen type has a relatively low specific load and tends to clog relatively fast.

Flat screens with a linear movement

Flat screens with a linear movement usually have an inclination of between 0° and 15°. Typical representatives of this type of screen are the Rhewum Type MDS (Figure 4) and Rhewum Type RIUS (Figure 5) screens.

Figure 4. Rhewum type MDS

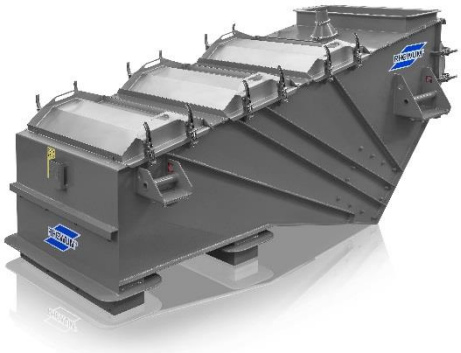

Figure 5. Rhewum type RIUS

Depending on the degree of inclination, the transportation only, or mainly, takes place by throwing the particles over a little distance with every screen oscillation [2]. The transportation speed for this screen type is relatively low. It normally varies between 0.08 and 0.3 m/s. The specific capacity of such a screen is therefore low, compared to the inclined screens. One advantage, compared to the flat screens with a gyratory movement, is that the bouncing balls are thrown directly against the screen mesh, thus efficiently preventing

clogging. For coarse sugar separation (e.g. screen cuts >1.0 mm), or very high product quality requirements, these screen types will probably deliver the best results.

Inclined screens with direct excitation

Inclined screens with direct screen cloth excitation are normally used when a high feed rate and a high-quality product are desired at the same time. Typical representatives of this screening technology are the Rhewum Type WA (Figure 6) and Type WAU (Figure 7) types.

Figure 6. Rhewum Type WA

Figure 7. Rhewum Type WAU

The material on the screen is thrown up at right angles from the screen mesh, by a high frequent vibration of only screen mesh. For the Type WA screen, the vibration is generated by robust electromagnetic vibrating heads that are mounted outside of the machine, and for the Type WAU screen, it is generated by small out-of-balance motors. Vibrations are transferred to the screen mesh by swiveling axes. At the screen mesh itself, accelerations of up to 15 g and more can be achieved (1 g ≈ 9,81 m/s^2). Due to the inclination, the transportation speed of the material on the screen is very high, thus enabling a low product layer at a high feed rate. Compared to the inclined screens with a linear movement, this type of machine is advantageous because of the direct excitement of the screen cloth. This helps to efficiently disperse the material and to prevent the mesh from clogging, due to the high forces impinging on the product. In addition, an automatic cleaning cycle can be set periodically to increase the forces to a maximum, which results in highly-efficient anti-clogging [2].

The Rhewum Type WA and Type WAU screening machines are dust-tight. The machine housing has an only static function. Therefore, no vibration and dynamic load are transferred to the building and the steel structure. In addition, this system allows fixed connections without compensators to the on- and off-going aggregates. Because of these advantages, the Rhewum Type WA and Type WAU screens have become standard industrial screens in the industry.

When comparing these screen types, it becomes clear that the WA type screen will probably show the best results for the given screen task.

The results of the laboratory trial on the Type WA screening machine are displayed in Figure 8. A so-called de-loading deck between the 0.212 mm and 1.0 mm screen cuts helps to relieve the high load on the lowest deck, thus improving its screening efficiency. The relevant process parameter was to achieve a product purity of more than 90% in the product fractions 0.212 – 1.0 mm and 1.0 – 2.0 mm, which could even be surpassed with product purities of 92.4% and 92.5%, respectively.

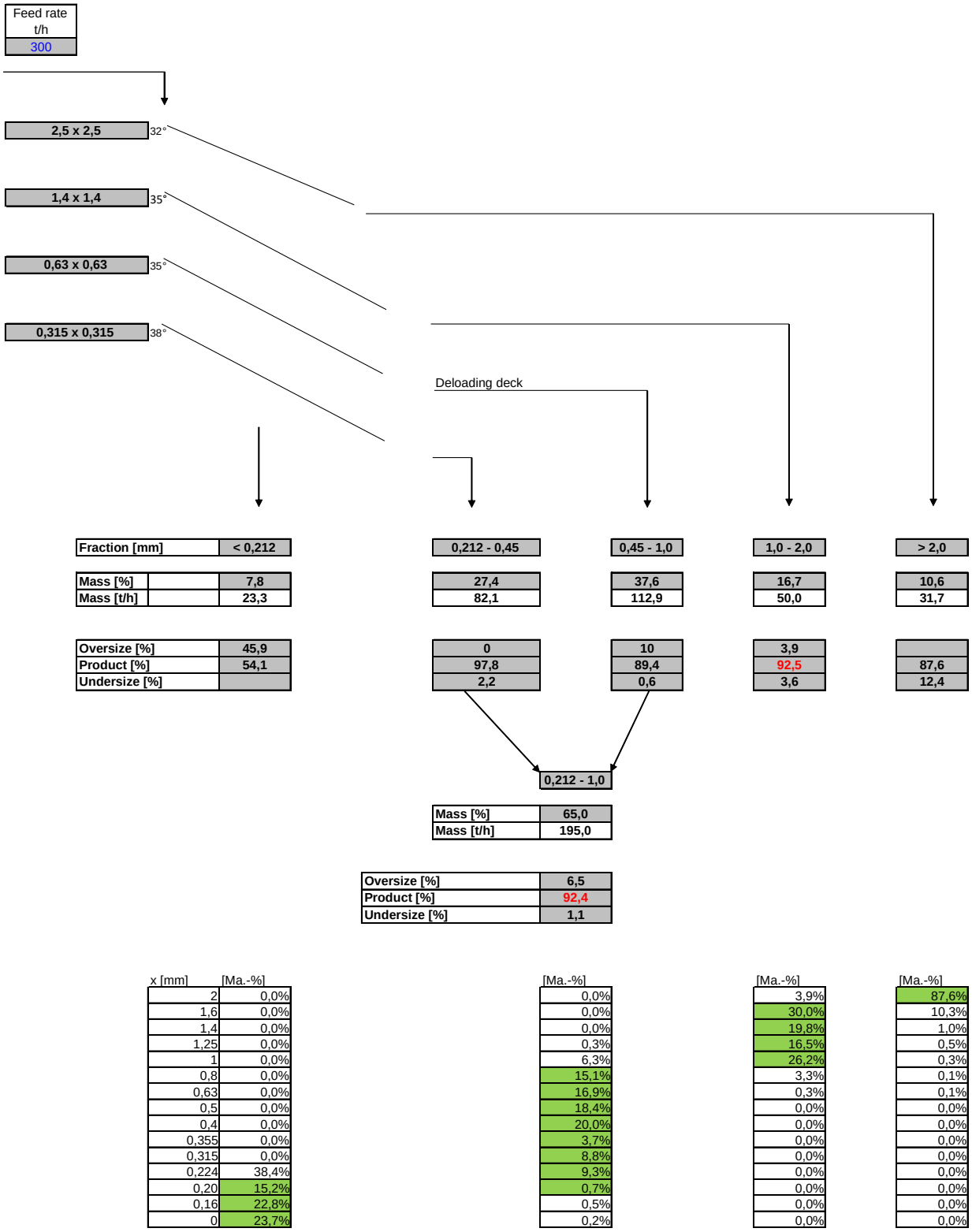

Figure 8. Results of the laboratory trial

Results

Based on the trial results, it was possible to design the required machine size. For a feed of crystallized sugar at 300 t/h, two Rhewum Type WA machines, with a width of 3.9 m and a length of 4.5 m, were installed.

To handle the same capacity, at least eight linear motion 'sizers', with a capacity of 37.5 t/h each, would be necessary. However, long-term experience has shown that, due to the lack of cleaning mechanisms, the efficiency of these screens drops dramatically during operation, because of clogging.

Another technical advantage of the chosen inclined screens with direct excitation is the static housing, which dynamic loads transmitted into the building are approximately 20 times lower, as less mass is moved. This will be explored more deeply below, where the moving mass and the energy consumption between those two types of screening machine will be examined:

The moving mass of linear motion and direct-excited screens

A typical 'sizer'-type screening machine that is used in the sugar industry weighs approximately 3.5 t. As the entire machine is vibrating, approximately 28 t of mass (excluding the screen feeders) are shaking in the screen house for a 300 t/h of sugar feed. This not only creates significant static, but it also creates dynamic forces in all directions that have to be considered when designing the structure of the building.

The two directly-excited Rhewum Type WA screening machines that are required for a feed capacity of 300 t/h, weigh approximately 26.5 t combined (including the under-hoppers, and excluding the feeders for a direct comparison). The moving mass, however, consists only of the knocker shafts, which weigh about 5.6 t in total.

Power consumption and energy costs

As the directly-excited screening machines have less mass to move, the total energy consumption is about 25.6 kW, whereas the 'sizer'-type linear screening machine requires eight times 9 kW, which results in a total of 72 kW. This means that the directly-excited screening machine consumes 2.8 times less energy than the linear motion screen.

Considering the average electricity costs of about 0.09 €/kWh, this gives a saving potential of 29 500 €/annum (approx. 510 000 ZAR or 35 000 USD). In countries with higher electricity costs, the saving potential naturally increases linearly.

Conclusions

It becomes clear, from the above findings, that directly-excited screening machines are highly efficient, not only in terms of their screening efficiency, but also in their energy efficiency. Therefore, the directly-excited screening machine is considered a 'green screen'. Furthermore, an efficient screening machine reduces the energy consumption of the sugar plant even more, as less material needs to be recirculated. Thus, high quality sugar can be produced, while saving energy at the same time.

References

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