Increasing Profitability by Implementation of Sensor Based Sorting

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ABSTRACT

In the last few years optical sorting has become more and more popular in mineral processing. As an alternative either extensive process steps are necessary or still widely spread handpicking is in use.

The increasing costs for the latter results in manual sorting of more coarse material and nowadays sizes less than 40 mm of quartz and magnesite are normally dumped. Therefore enormous quantities of 0/40 mm material are on stock, where exploitation costs were already borne by the mining companies, waiting to be used. A change of existing process treatment might be justified by lower operational costs and might achieve better product qualities. Possibilities to discharge tailings before burdening the current process are attractive as well as gaining the chance to produce different product qualities with proper price differentiation.

With the help of new kind of sensors material can be treated where no optical difference is given and so the development from optical to sensor based sorting was realized and offers new opportunities.

1 INTRODUCTION OF BINDER+CO AG

Binder+Co AG is a public limited company situated in Grazer Strasse 19-25, Gleisdorf, Austria. The company was established in the year 1894 and is nowadays well-known as a specialist for crushing, screening, drying and sorting technologies.

More than 25 years ago, optical sorting plants came onto the market for the first time. The very first machine was working in the field of sorting minerals and is still in operation. Up to now, worldwide more than 2.500 sorting machines were installed. Brand names MINEXX for sorting primary raw material and CLARITY for treatment of secondary raw material like glass, plastics, etc. are well known.

Due to the core competences, mentioned above, and its experienced process engineers, Binder+Co AG has the knowhow and expertise of total processes and is able to assist customers in optimizing their plant design to their needs. Beside the optimized machinery proper implementation and combination of the process steps are the key to a profitable plant.

Figure 1. Picture of Binder+Co AG

2 FUNCTIONALITY OF MINEXX

By the usage of sensor based sorting secondary attributes of materials like their colour or their different absorption behaviour are used to separate unequal kinds of material. Such equipment consists of following key components:

2.1 Feeding device

The material to be separated is distributed on a vibratory feeder. Its task is to create a monolayer and proper distribution even at a low load. The vibration behaviour - amplitude and frequency – has to be adjusted according the material properties.

2.2 Detection system

From the vibratory feeder the material enters the machine via a chute, where the material is accelerated and due to the increase of speed also singularized.

In case of an optical sorting device, a front light system consisting of 2 Power LED strips, which enlightens the stones and avoids shadow effects. An optional background light assists the detection, e.g. for more dark material.

High resolution cameras detect the surface of the material. Software settings, based on the requirements of the customer, determine whether a particle is ejected or not.

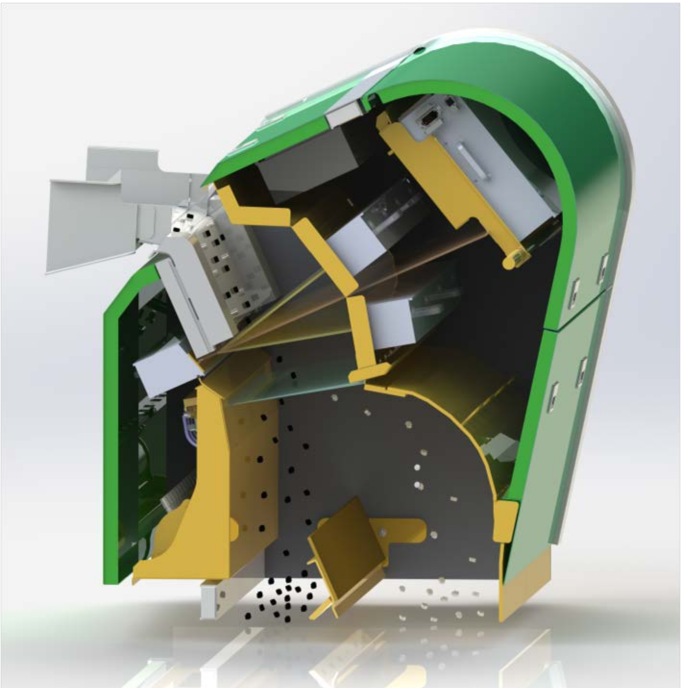


Figure 2. Model of MINEXX

2.3 Ejection system

The ejection is done by pressurized air. Nozzles are actuated exactly in the area where to be ejected objects are passing by. The resolution of nozzles, in particular the distance between 2 nozzles which can be actuated independently, is based on mean grain size of the feed material. Pressure for ejection is determined by the heaviest particle within the feed.

3 RUN OF MINE DESCRIPTION

To check out if a run of mine can be processed by sensor based sorting or with assistance of any other process steps, the material has to be investigated in more detail. Following aspects shall be taken into account.

3.1 Particle size distribution

The particle size distribution has a big influence on the feed rate of sorting machines. In general, the coarser the material the higher is the feed rate.

Sorting machines do allow a certain grain size ratio. The reasons for this are the shadow effects and also the depth of focus for coarser material. In addition it has to be kept in mind that the sufficient impulse for the heaviest material will be too intensive for too fine particles. A minimum grain size is given to prevent material from crushing at the ejection hood. This limitation also is governed by an additional effect: The ejection of neighbouring material, if the impulse is too intensive.

Therefore it has become a general rule to allow a grain size ratio of about 1:3. As an example a feed material of 6 to 20 mm or 10 to 30 mm is seen as an optimum ratio.

It is worth pointing out that also within a fraction e.g. 10/30 the given particle size distribution influences the feed rate. If the main load is dominant at the coarser side ≤ 30 mm the allowable load can be higher compared to a material having more fines of ≥ 10 mm.

3.2 Optical fractions

Whereas particle size distribution and intergrowth are well known phrases, the term "optical fraction" is something special for sensor based sorting devices.

Optical fractions are stones which do have similar appearance. Optical sorters are then capable of sorting according to these optical fractions. E.g. for a first sorting step color classes “GOOD” should be separated from “POOR” and for the next step class “White GOOD” should be ejected from the other residual “GOOD” material.

Figure 3 Example for optical fractions

3.3 Intergrowth

As a matter of fact there will be a lot of grains which will not purely be assignable to one colour class, but which have intergrowth of several colour classes.

For a reliable detection of intergrowth high resolution cameras are necessary. Principles of the ejection are based on algorithms to calculate the distinctive surface contents for one object according to the optical fractions. Hereby the customer defines the allowable surface contents of different colour class contents of the material.

The degree of liberated, means pure, non-mixed, grains is generally higher for finer particles. This of course is contrary to the desire to operate higher capacities which can be realised with more coarse material.

3.4 Essential Design Information

The support of the mine operators is one of the key factors for realising a successful economic design of the plant. No one is more familiar with the deposit than the operators at site and therefore they know the standard and also the extreme conditions best, which might occur and need to be taken into account. Following information is essential:

- continuous feed flow rate,
- typical particle size distribution,
- percentage of the to be ejected material

3.4.1 Feed flow rate and particle size distribution

This information is normally the easiest one to receive. The total amount of material to be separated is evaluated in combination with a representative particle size distribution.

As mentioned above, the grain size ratio for the sorting process is very important for a successful treatment and so the designer will have to check if splitting of the feed is necessary to create different fractions or if it can be handled as one fraction. Sometimes, there already exist different fractions which can be treated separately during and after the sorting process as well.

Handling different fractions can be achieved either on separate sorting machines or on so called divided machines. Hereby the vibratory feeder has a dividing wall as well as the sorter itself. For such a machine the possibility to operate with different air pressures on the two sides exists. Also the separation edge which isolates the two products from each other is divided according the two fractions. A feature of our machinery is that the edges can be adjusted and optimized to the feeding material. The benefit for the customer lies in improved sorting and product quality.

3.4.2 Percentage of to be ejected material

Of course there will be always a fluctuation in the deposit regarding its quality. Just assuming the worst case of bad material, which has to be ejected, might result in oversized equipment. To avoid such a scenario the experience of the operators has to be taken into account. Anyhow, to be prepared for such extreme conditions with higher rates of ejection than usual - which do not happen very often, the compressor plant for the pressurized air supply has to be designed properly. For deposits with strongly varying conditions, frequency converted compressors are the ideal choice.

Compressor plants just can bear a certain amount of switch on and offs per hour and stay permanently in operation when this limit is exceeded, resulting in a low efficiency and higher operation costs. For these plants the classical approach - the bigger the better - is definitely a disadvantage.

Compressor plants with frequency converters avoid this problem and draw only energy according to the actual demand for pressurized air. Though the investment costs are higher, the lower operation costs justify such an investment. Even payback periods of less than half a year can be realised for inhomogeneous deposits.

4 AMBITION FOR SORTING

Above all there is the demand for profitability. Beside this there might be guidelines from the authorities triggering such an investment.

Dumps of hand sorting plants, which normally contain the same percentage of worthy material, are available with a high grade of liberation. All the costs of extraction are already borne. Screening and rinsing is necessary due to degradation at storing at the dump. Directly sorting the material instead of dumping it would reduce process and transportation costs. Another positive effect is that the necessary area for dumping is reduced as well as the positive impact on the environment.

Another typical example for reduction of dumps is the separation of bricks from concrete of demolition waste. This is important, because local authorities give less willingly permissions for new dumps and such sites are precious. Sorted out concrete can be reused in the concrete production, whereas bricks are used for revegetation.

4.1 Reduction of load

In the mining industry the worthy product is generally accompanied by tailings. An early elimination of these reduces the load for all the subsequent process steps. Especially crushing or even grinding is very expensive and therefore operation costs can be saved tremendously, when the tailings are ejected at the very beginning of the production process.

Figure 4 Example for sorting plant

Sometimes it is already a benefit when the opportunity exists to just produce a concentrate. Manipulation of stones up to 200 mm is nothing very exceptional.

4.2 From occurrence to deposit

With too high content of tailings and intergrowth it might have been not economic to mine the resources. New concepts for beneficiation upgrade such sites.

When the liberation of stones for handpicking with at least 40 mm minimum size was requested, sorting devices can fulfill the task down to 1 mm and therefore can be fed with much better liberated material.

Figure 5 Example for sorting of quartz

4.3 Possibility for supplying new products

Run of mine has material with different qualities, from high premium to low grade. With no well-designed processing one has an overall low quality product and so only low prices can be achieved on the market. By sorting the material to different qualities different customers can be served and differentiated prices can be achieved.

E.g. in the quartz industry pure white material is of interest for paving stone industry and achieves prices much higher than for products supplied for glass production. Both have in common that material with high iron content has to be removed completely for not spoiling the quality. Also often feldspar accompanies quartz and has to be removed. Although the appearance of feldspar is close to that of quartz it can be detected and separated.

In the limestone industry the degree of whiteness is essential for delivering to paper industry for coating applications. Poor material, as side product, can still be used for usage in pulp and neutralization.

Sometimes even small amounts of undesired substances are critical and its removal enhances the product value. For instance, mingled parts of rocks in rock salt or impure grains in sea water salt are justifying a sorting plant installation.

Optical sorting devices can work as a quality control and improvement system for various processes.

5 OPERATION COSTS

Following costs do arise in operating a sensor based sorting unit:

- Financing costs
- Personnel costs for daily tour through the plant
- Service costs for sorting unit
- Service costs for compressor unit
- Spare and wear parts for sorting unit
- Spare and wear parts for compressor unit
- Electricity for sorting unit
- Electricity for compressor unit

Depending on the actual case also following costs can arise in addition:

- drying the input material
- costs for washing water
- waste water treatment

5.1 Requested Data

For evaluation of operation costs several data are required from the operators.

Beside the required material throughput for the plant, the expected amount of the product is necessary to know. These data are easily available. Essential for a proper calculation are the effective working hours per year as well as the duration for depreciation of the plant. In regard of this the total investment costs for the plant must be considered and supplied by the owner, which includes civil works, costs for approval procedures, conveyors, etc.

The costs for electricity, water and waste water treatment, if feasible, are obviously necessary to receive from the owners. Other data can be supplied by the manufacturers of the sorting units.

5.1.1 Example for classical sorting unit

For a sorting plant with 40 to/h of a normally dumped 15/40 material and an ejection rate of 25%, costs for electricity of Euro 0,1 per kWh and for water as well as for waste water treatment of Euro 0,5 per m³ are assumed. 4000 operation hours per year are the basis and for the total investment costs of Euro 400.000,- a linear depreciation rate over a period of 3 years is set.

The results show that the depreciation costs are the biggest portion by far. The main operation costs are the electricity demand for the compressor plant followed by water supply and treatment costs. Service, spare and wear part costs for the sorter are more or less equal to those of the compressor plant. The total costs for services and spare and wear parts including costs for daily inspection are in the range of the costs for the demand on electricity. Excluding the depreciation costs, the overall operation costs for the sorting at this example are less than Euro 1,- per ton of product.

It has to be stated clearly that these figures are strongly connected to actual prices and will vary accordingly.

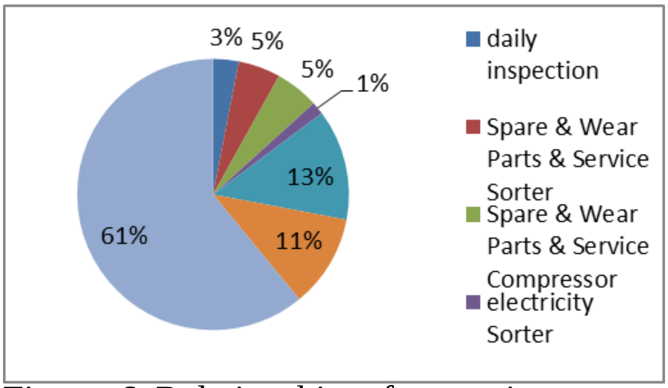


Figure 6 Relationship of operation costs for the given figures

5.2 Lessons to be learned

Obviously sorting units do require just a low amount of manpower. Keeping such a plant in operation as long as possible per year is clearly a benefit, especially because of the high availability of the sorters. Usage of water should be adjusted carefully to the needs to avoid unnecessary costs. The most important fact is to design the compressor unit properly and in most cases the surplus of investment costs is worth to install a frequency controlled plant.

6 SORTING IS ONLY ONE PART OF THE SOLUTION

Even the sorting itself is the core process of the plant, other equipment is essential too, to achieve the intended goal in the most economic way. Installation of pretreatment steps to condition the material for the sorting is common.

Due to the fact that colour nuances can be detected much better in wet condition, water spraying equipment for the feed material is more or less a standard for optical sorting. This can be upgraded to rinsing equipment if it is even the intention to clean the feed material. For heavily soiled material specific washing equipment might be necessary. Thus leads again to the necessity to remove surface water for the sorting process. For this purpose dewatering screens in combination with blowing equipment are popular.

One of the most important additional process steps is screening. As a pretreatment it could either be for creating an ideal fraction for the sorting or to remove fines. Especially at low cut points with wet material the BIVITEC has gained a worldwide reputation for difficult to screen material. Sometimes cut points are already defined for a final product and can accordingly be adjusted in the screening process.

For very fine material even drying can be an option to improve the sorting quality. The stickiness of the fine material due to moisture is eliminated thereby.

Figure 7 BIVITEC 3-deck screen for 4 products, where 3 fractions are fed to sensor based sorting units and the fines are removed

7 ALTERNATIVE SENSOR TECHNOLOGY

Most of the sorting applications are performed with the wavelength band of visible light which is between 380 nm and 780 nm. But how can one distinguish between materials, which look exactly the same? The solution is to use wavelengths outside the visual ones.

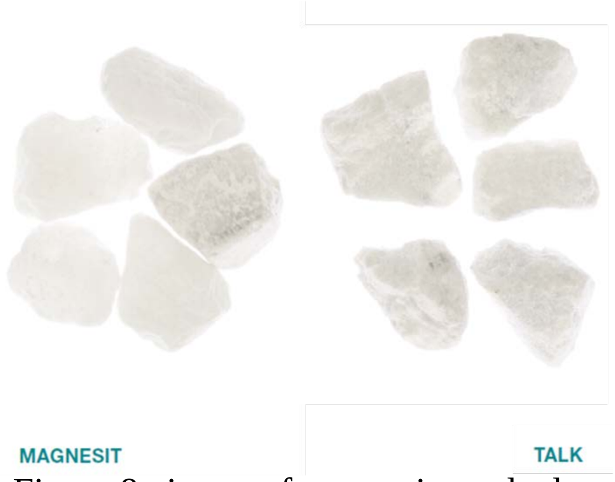
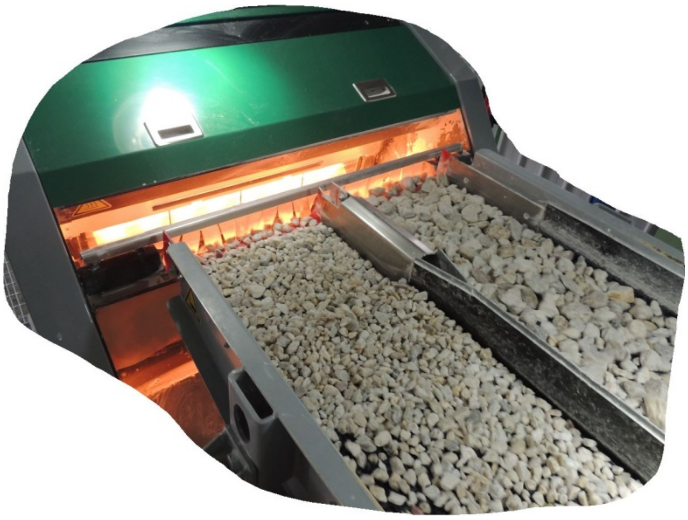


Figure 8 picture of magnesite and talcum

Near infrared is an example therefore. Binder+Co AG installed e.g. a plant for such an application for sorting talcum from



magnesite. In former days the separation was done by manual scratching each stone. Nowadays a machine detects the specific absorption behaviour of the stones and can classify it properly. Grains with intergrowth can be handled the same, according to their surface contents of material classes.

Figure 9 MINEXX NIR sorter

Near infrared is not the only possibility to achieve sorting where visual detection systems fail. In the recent years intensive investigations were done in ultraviolet wavelength as well. More than 200 minerals are known to show an induced fluorescence behavior which can be used for sorting.

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