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Research Article

5-10 Mm Kuvars Cevherini Optik Ayırıcı ile Zenginleştirerek Verimlilik ve Üretim Kalitesinin Artırılması: Uygulama Örneği

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Öz

Üretim tesislerinde, manuel diye tabir ettiğimiz el ile ayıklama yönteminin yerini giderek yaygınlaşan sensor temelli ayırma sistemleri almaya başlamıştır. Özellikle, proseslerde üretim performansını artırmak için üretim takibinin yanı sıra insan gücüne gereksinim olmadan, optik makineler ile bu işlemleri yapmak artık tercih sebebi olmaktadır.

Çalışma kapsamında optik makineleri üzerinden beslenen, istenen (beyaz) ve istenmeyen (koyu) ürün şeklinde ürün spesifikasyonu yapılmıştır. Ürün olarak ise, manuel seçimde zorluk çekilen 5-10 mm ebatlarındaki kuvars malzemeler tercih edilmiştir. Müşteri ürün kalite spektrumuna uymak için iki ayrı besleme ürün seçilmiş olup, farklı besleme hızlarındaki bu ürünlere ait veriler incelenmiştir.

Yapılan çalışma kapsamında optik makinesine giren besleme numunesinin çıkış verileri incelendiğinde, farklı besleme hızlarında (10-20 ton/sa) istenen beyaz renk üründe makine seçim verimliliği 99,3-98,4% olarak bulunmuştur. Yine farklı besleme hızlarında (10-20 ton/sa) istenmeyen ürün olan koyu renkli (Pasa) üründeki verimlilik ise 91,2-83,2% olarak elde edilmiştir. Farklı besleme miktarlarındaki pasa üründeki kaçak diye tarif edilen beyaz ürün oranları ise 8,8-16,8% olarak bulunmuştur. Bu durum besleme miktarındaki artıştan kaynaklı olup, koyu üründeki beyaz ürün (nihai ürün) olarak tarif ettiğimiz kaçak oranını arttırmıştır. Kalite kabul kriterine göre ürün içerisinde 1-2% oranında koyu malzeme olması ürünün işletme içindeki Mikronize ve Değirmen Üniteleri için besleme harman reçetesinde kullanılabileceğini göstermiştir.

Anahtar Kelimeler: Optik Sınıflandırma, Optik Makine Verimi, Cevher Zenginleştirme.

Increasing of Efficiency and Production Quality by Enriching 5-10 Mm Quartz Ore with Optical Separator: A Case Study

Abstract

Sensor-based separation systems, which are becoming increasingly common in production facilities, have started to replace the manual sorting method. In particular, it is now preferred to carry out these operations with optical machines without the need for manpower as well as production follow-up, in order to increase the production performance in the processes.

Product specification was made in the form of desired (white) and undesired (dark) products fed through optical machines within the scope of the study. As the product, quartz materials of 5-10 mm dimensions, which are difficult to choose manually, were preferred. Two separate feeding products were selected and the data of these products at different feeding rates were examined in order to comply with the customer product quality spectrum.

When the output data of the feed sample entering the optical machine within the scope of the study was examined, the machine selection efficiency was found to be 99.3-98.4% for the desired white colour product at different feed rates (10-20 tons/h). On the other hand, the productivity in the dark coloured (waste) product, which is an undesirable product at different feed rates (10-20 tons/h), was obtained as 91.2-83.2%.

Keywords: Optical Sorting, Efficiency of Optic Sorting Mechanical, Ore Enrichment.

1. Introduction

The manual sorting method, which we call manual, is an old ore preparation application, and it still maintains its functionality today. However, this sorting method has started to be replaced by sensor-based separation systems, which are becoming increasingly common.

Automatic applications based on the surface and mineralogical properties of the material will allow the evaluation of primary and secondary sources with higher efficiency and purity thanks to these separation systems [1].

The history of sensor-based discrimination in the mining industry goes back to a hundred years. The first commercial applications in agriculture in the 1950s were followed by the raw material applications in the 1970s, and the first automatic separation equipment was brought to the sector for waste recovery in the early 1980s [1]. Since this date, as well as in mining [2-4], it has made great progress and continues to be used in the food [5] and recovery [6] industry.

In optical separation technology, the single or multiple use of sensors that can identify in a wide electromagnetic wavelength spectrum from alternating current (10^{4} m) to gamma radiation (10^{-12} m), makes it possible to define many different materials [7].

Optical separation technology has been a good alternative to traditional methods in the separation of minerals (intricate, etc.) that are very difficult to identify physically in the mining industry. There are many applications where enrichment studies are carried out with the use of optical separation technology. In one of these studies, Tessier et al. [8] showed that nickel ore can be enriched with an optical separator. Lane et al. [9] defined metals such as copper, lead and zinc spectroscopically and formed a data source for optical separation. Batchelor et al. [10], on the other hand, studied the pilot scale microwave classification of copper ores in their study in 2016. In their study, they found that low average moisture content, co-mineralization of copper and iron sulfides (or bulk sulfide classification) reduced drift and provided better stability performance. Gülcan and Gülsoy [11] investigated the effects of feed rate and particle size on separation performance with the use of magnesite, quartz, lignite, hematite, copper and gold ore samples. Apart from these studies, there are also different studies on the identification and enrichment of limestone [12] and chromite [13] ores with visible light source using optical sorter devices.

Although the visible light region and ore identification and enrichment studies are intensively included in the literature, there are few studies on the effect of feed amounts on the definition of the visible light source according to the physical properties of minerals. The aim of this study is to adjust the machine settings according to the color characteristics of the quartz in order to obtain the desired selection efficiency during the selection of the quartz produced in the composite stone industry with the optical machine, and thus to perform the efficient selection process.

1.1. Field of Study and Feature

The place where the study was carried out is Aydın and Muğla quartz fields, and a facility operating was chosen as an example in these regions. The company to which the selected facility is affiliated is a company that has been mining and processing quartz since 1991. Quartz rocks are blasted and crushed in open pit mines in the firm example. The company operates its own mineral processing plants for crushing, washing and sorting of raw materials.

1.2. Minerals by Color, Composition and Size Sorted

Precise sorting is needed for quartz minerals in the study area. Therefore, sieving was done by feed material size before sorting: -20+50 mm size stones are processed with a higher priority; -5+10 mm size stones are sent to the sorting line in a separate batch. After crushing and washing (via trommel sieve), the process consists of four basic steps as the sorting process. In the first step, the minerals are sieved according to their size and only -20+50 mm stones pass to the next step. In the second stage, the optical color machine extracts the wastes and colored pebbles from the quartz pieces with a capacity of 10-12 tons/hour. In the third stage, the remaining minerals were divided into two parts, one being the white quartz mineral and the other dark quartz mineral. Finally, these two sections were manually sorted by product type, with residual gravel and waste removed. The composition and sizing processes of the processes are performed as shown in Figure 1.

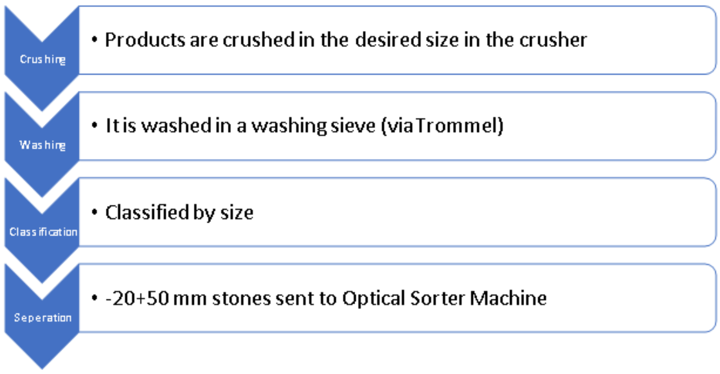

Figure 1. Composition and Sizing Process Sequence.

1.2. Optical Color (Colour) Machine Working Principle

The Optical Color (Visible light sensor) machine works for color detection and mineral extraction. Multiple material properties such as size, shape, gloss and color distribution are processed simultaneously. The lighting unit on the machine consists of technological liquid cooled LED technology. It can provide stable and repeatable sorting results. The material entering the machine is fed evenly through a vibro feeder (vibration feeder) into a channel where it is detected by the COLOR camera. This information is recorded and evaluated by electronic system. At the end of the trough is an injection module with several separate valves. If the sensor system detects the particles to be separated, individual valves are opened at the exact position and the material is expelled by means of compressed air. The extracted material is divided into two fractions in the separation chamber. These are desirable and undesirable products. The image of the Optical Color Machine is shown in Figure 2 and the working principle of the Optical Color machine is shown in Figure 3.

Figure 2. Optical Color Machine

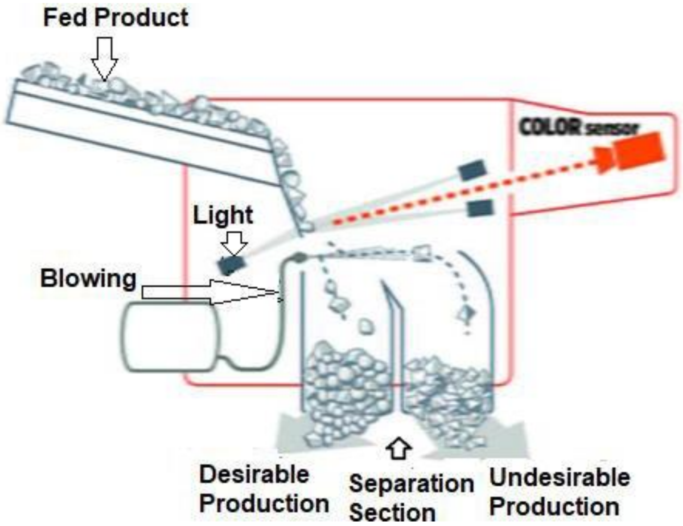

Figure 3. The Working Principle of the Optical Color Machine

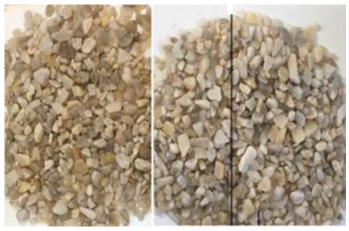

Figure 4. Fed Product – White Material (5-10 mm)

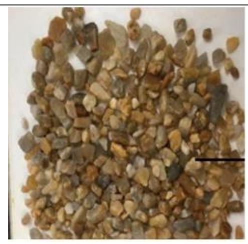

Figure 5. Fed Product – Waste (Dark Material, 5-10 mm)

As a result of the classification, the products are shown as dark and white product images in Figure 6 and Figure 7.

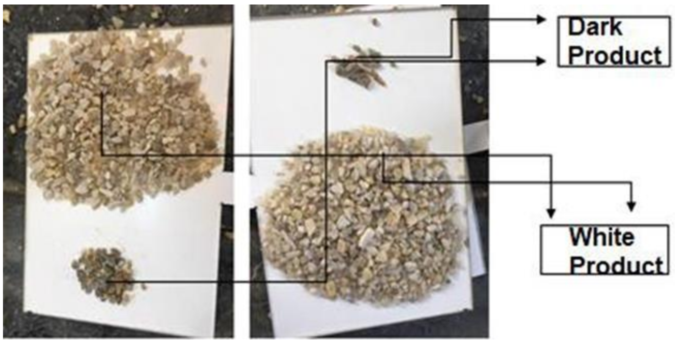

Figure 6. Visual Classification of Output White Product (White-Dark).

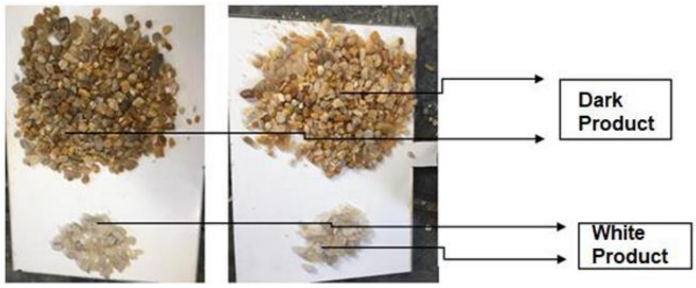

Figure 7. Visual Classification of the Removed Waste Product (Dark - White).

2. Application

An optical sorter machine with a visible light sensitive (Color) and linear reading sensor/camera was used within the scope of the study. Product specification will be made in the form of desired (white) and undesired (dark) products fed through optical machines in the study. Firstly, a 5-10 mm white product will be fed to the optical machine, and this product will come out of the optic in white and dark colours with a size of 5-10 mm. Then, the rust (dark) product will be fed to the optical machine, and at the exit of this product, dark and white products in 5-10 mm dimensions will come out. In the control and observation of the products themselves, gram, and percentage ratios of the products on the basis of colour will be examined. Tomra Quartz Color Sorting Optical Machine, shown in Figure 2, was used to distinguish quartz minerals on a colour basis in the study. As seen in Figure 4, white feed quartz minerals of 5-10 mm were fed to the Optical machine, first of all. Then, the Pasa product shown in Figure 5 was fed.

Two separate sensitivity settings were made for each feeding tonnage to the optical machine. Because it is to detect the fugitive product (Final white product) in the dark product by feeding the waste material other than the final product back into the system. In addition, the purpose of feeding two separate products to the system is due to the fact that a maximum of 1-1.5% of the product is allowed to leak (undesirable dark) product in order to meet the product acceptance criteria according to the customer's perspective. At other rates, the product quality will not be sufficient, and it will cause a negative situation in terms of quality in customer preference.

The second feed product, which we describe as rust in the feed product, is the product we describe as dark in the first feed product. Since these products contain white quartz materials, we feed them back to the system to recover them. In this feedback, the sensitive setting of the machine needs to be made again. Because the characteristic of the feeding product has changed (Due to the intense color feature, we change the blowing). In the first feed, the dark color product is blown in the machine sensitive settings, while in the second feed, the final product, which we call leakage (final product in the unwanted product), is blown.

3. Findings

It is essential to determine the optimum conditions in production feeding. This is also related to the machine to be fed. In this context, it is of great importance to operate optical machines efficiently in the field of study. Machine efficiency is directly proportional to the correct feeding of the production.

The feeding tonnage settings made on the machine must be selected correctly, in order to achieve the desired efficiency during the selection of the final product in the Optic machine. Thus, by making this choice correctly, the color characteristic of the final product is also chosen correctly. In the study, weight meters were used to obtain efficiency values. The data obtained as a result of weighing the products coming out of the optical machine with a calibrated precision scale (Figure 8) are shown in Table 1.

Figure 8. Accuracy Calculation of the Products Coming Out of the Optical Machine by Weighing.

As can be seen from Table 1, while the feed amount in the Optical Unit is 10 tons/h, the white ratio in the rust (dark colored feed material) material is 12%. When the feed tonnage was increased to 15 tons per hour, it was observed that the white ratio in the rust material was 14%. When the feed tonnage is adjusted as 18 tons/h, it is seen that the white ratio in the waste material is 16%. Likewise, when the feed tonnage is adjusted to 20 tons/h, the white ratio in the rust material is 18%.

As can be seen from the values, the increase in the amount of feed increased the white ratio in the rust material up to 18%. In addition, the low amount of dark matter in the product is important according to the product Quality Acceptance criteria. According to the quality acceptance criteria, the presence of 1-2% dark material in the product showed that the product can be used in the feed blend recipe for Micronized and Milling Units in the enterprise.

Table 1. Final Amount and Percentage Calculation of Optical Machine Based Feed Products.

DATE	NAME OF UNIT	Size of Feed Product (mm)	Feed Tonnage (tons/h)	Programme Name	Adjustment of Sensivite	Band Sample of Waste Stone (Dark) Coloured				Band Sample of Final Product (White coloured)			
						Amount of Dark Prod. (gr)	Amount of White Prod. (gr)	Percentage Amount of Dark Prod. (%)	Percentage Amount of White Prod. (%)	Amount of Dark Prod. (gr)	Amount of White Prod. (gr)	Percentage Amount of Dark Prod. (%)	Percentage Amount of White Prod. (%)
15-16.01.2022	TOMRA GRAVEL OPTIC MACHINE	5-10	10	MEDIUM SENSIVITE* 5-10 mm	80-22 90-10	562	54	91,2%	8,8%	6	896	0,7%	99,3%
			15	MEDIUM SENSIVITE5-10 mm	92-28 88-36	835	140	85,6%	14,4%	14	727	1,9%	98,1%
			15	MEDIUM SENSIVITE5-10 mm	92-28 88-36	760	95	88,9%	11,1%	68	994	6,4%	93,6%
			15	MEDIUM SENSIVITE5-10 mm	90-26 88-36	765	103	88,2%	11,8%	35	1102	3,1%	96,9%
			15	MEDIUM SENSIVITE5-10 mm	88-24 88-36	771	96	88,95%	11,05%	49	989	4,7%	95,3%
			18	MEDIUM SENSIVITE5-10 mm	92-28 88-36	780	155	83,4%	16,6%	30	960	3,0%	97,0%
			18	MEDIUM SENSIVITE 5-10 mm	92-28 88-36	812	129	86,3%	13,7%	21	1100	1,9%	98,1%
			18	MEDIUM SENSIVITE5-10 mm	92-28 88-36	855	133	86,5%	13,5%	27	1182	2,2%	97,8%
			18	MEDIUM SENSIVITE5-10 mm	92-28 88-36	906	127	87,7%	12,3%	31	1098	2,7%	97,3%
			20	MEDIUM SENSIVITE 5-10 mm	85-30 80-45	840	195	81,2%	18,8%	19	1023	1,8%	98,2%
			20	MEDIUM SENSIVITE 5-10 mm	85-30 80-45	856	176	82,9%	17,1%	24	1106	2,1%	97,9%
			20	MEDIUM SENSIVITE 5-10 mm	85-30 80-45	858	193	81,6%	18,4%	19	1005	1,9%	98,1%
			20	MEDIUM SENSIVITE 5-10 mm	85-30 80-45	762	154	83,2%	16,8%	17	1053	1,6%	98,4%

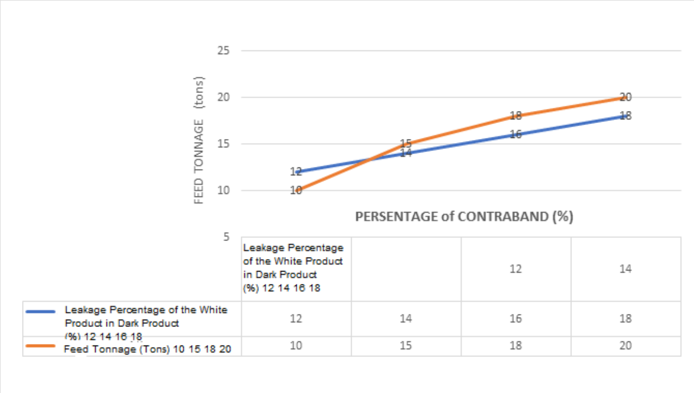

Figure 9. Product Selection and Performance Status of Optical Machine.

The maximum feeding capacity of the machine is 10t/h, and as can be seen from Figure 9, the leakage percentage increases as the feeding tonnage increases. This is an undesirable condition, and a low level of feeding capacity is a desired product quality-oriented result. However, it is ensured that the capacity is determined by considering the optimum quality spectrum, considering the production performance and the increase in costs. In the study, it is seen that the most suitable conditions for providing both the desired maximum capacity and product quality are 10 tons/h feed tonnage, as can be seen in Table 1 values and Figure 9 display. However, when the producer only considers the production performance, when the feed tonnage increases, the number of illegal products in the final product increases. Thus, there will be a decrease in revenues due to material losses that can be sold as the final product. However, there will be no reduction in production costs per ton. In addition, in feeding tonnages to be selected above the machine capacity, there may be an increase in repair costs due to early maintenance due to machine fatigue and increased deformation rate. For these reasons, the decrease in product quality and the increase in costs will not benefit the operator economically and efficiently.

3. Results and Discussions

The machine selection efficiency was found to be 99.3-98.4% for the desired white colour product at different feed rates (10-20 tons/h) when the output data of the feed sample entering the optical machine within the scope of the study was examined. The productivity value in the dark coloured (Waste Product) product, which is an undesirable product at different feed rates (10-20 tons/h), was obtained as 91.2-83.2%. The ratio of white product, which is defined as rust and leakage in the product at different feeding amounts, was found to be 8.8-16.8%. This situation is due to the increase in the amount of feed, and it increased the leakage rate, which we describe as the white product (final product) in the dark product.

For the most part, businesses are production oriented. For this reason, they attach importance to the increase in ton-based production amounts. However, machine-based efficiency calculation is important and directly affects the production performance of the enterprise. Therefore, while determining the selection criteria depending on the material characteristics of the optical machines, it is useful to determine the most optimum feed amount values. In this context, the use of optical separators in the most optimum conditions in the ore enrichment processes of quartz minerals will increase the product quality and minimize the problems of goods supply and waste material (dark coloured). In addition, it will work with maximum capacity, ensure that the final product is produced without re-feeding, and these processes will be carried out without loss of production, considering the desired quality in the operation of the system.

4. Acknowledgment

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