Development of Technology for the Production of Natural Red Iron Oxide Pigments

Yana Vadimovna KUSKOVA[1)], Vadim Borisovitch KUSKOV[2)]

[1)] Assistant Lecturer; Saint-Petersburg Mining University, Faculty of Mineral Raw Materials Processing, Department of Mineral Processing, 21 Line V.O., 2, 199106 Saint-Petersburg, Russia; email:yana.kuskova@gmail.com
[2)] Associate Professor; Saint-Petersburg Mining University, Faculty of Mineral Raw Materials Processing. Department of Mineral Processing, 21 Line V.O., 2, 199106 Saint-Petersburg, Russia

Abstract

The most common inorganic pigment is red iron oxide. World production of iron oxide pigments is about 600 thousand tons per year and greatly exceeds the production of other color pigments, with the highest demand is for red iron oxide pigments, slightly below demand for the yellow iron oxide pigments. Production of red iron pigment from iron ores is promising and will meet the demand for high quality and inexpensive pigment. The raw material for the production of a pigment is a paint grade ore. The main task of obtaining the pigment is removed from raw materials coarse mafic minerals. Designed wasteless flowsheet for separation of iron ore in two qualities – paint grade quality (pigment) and metallurgical grade. The technology includes accumulation paint grade ore, crushing, screening, then fine grinding in a ball mill, magnetic separation and multi-stage classification in hydrocyclones. After this, the cyclone overflow is thickened, filtered on a press filter, dried and sent to storage bin for subsequent shipment to the customer. The resulting pigment is suitable for use in the paint industry.

Key words: iron oxide pigments, fine grinding, magnetic separation, classification

Introduction

Pigments are widely applied to colouring of building materials, plastic, fibres, paper, rubber, and another, at manufacturing of polygraphic and other paints. They not only give colouring, but in certain cases improve properties of the colourful films protecting a material from corrosion. Pigments can be inorganic or organic substances. The most widespread inorganic pigment is oxide iron. World production of iron oxide pigments is about 600 thousand tons per year and greatly exceeds the production of other color pigments and most a great demand use red oxide iron pigments [1].

At present almost all iron oxide pigment production plants are located in the near abroad. Ukrainian enterprises greatly reduced their production due to ecological hazards of the out of date technologies. The Yaroslavl' plant principally meets only its own maintenance needs. Russia has almost no iron oxide pigments while all the elaborated and approved varieties of composition of paint materials include these very iron oxide pigments.

Nowadays the paint and varnish industry predominantly uses substitute goods instead of iron oxide pigments. The substitute goods are mostly metallurgical production waste, the latter being bright brown or red brown in colour due to the presence of iron oxide pigments. The use of substitute goods instead of pigments has resulted in the paint materials quality decline, service life and storage time decrease. Such paint materials rapidly lose their protective properties and even hasten corrosion of the products or installations treated by them. Thus, ecologically safe technology development for pigment ore production appears to be actual.

Research work on pigment ore production

The research work on pigment ore production for the paint and varnish industry has been carried out at the department of mineral dressing of Saint Petersburg State Mining Institute. The work is aimed at technology planning of colour bearing (pigment) ore recovery for the paint and varnish industry. The assumed capacity is 10,000–30,000 tonnes of pigment a year.

Samples of martite hydrohematite ore of Yakovlevskiy deposit (Kursk magnetic anomaly) have been analyzed. According to the mineralogical composition, high grade ores of Yakovlevskiy deposit are divided into two main types: zheleznorudnogo-martinova and martita-zheleznorudnaya (Fe content of 64–69%); martita-hydrohematite and gidrogelevye ore (iron content of 62–64%).

The ore was characterized by variable grading. The maximum prills were no more than 200 mm in size. Martite and martitized magnetite prevailed in the sample. Around 5% of the debris included hydrogetite, lepidocrocite, and aggregates of hydrogetite and hematite. Sulphides were a very rare case.

Initially, an attempt to produce the pigment by a "dry" method was made, it use of dry crushing, reduction, dry magnetic separation, roasting. The "dry" scheme seemed logical because the prepared pigment required roasting. However, the experiments have shown that when the time needed for applying this method increased fines yield (less 0,050 mm) reached as much as 60–65% and did not go up any longer because the powder tended to roll down into ultimate

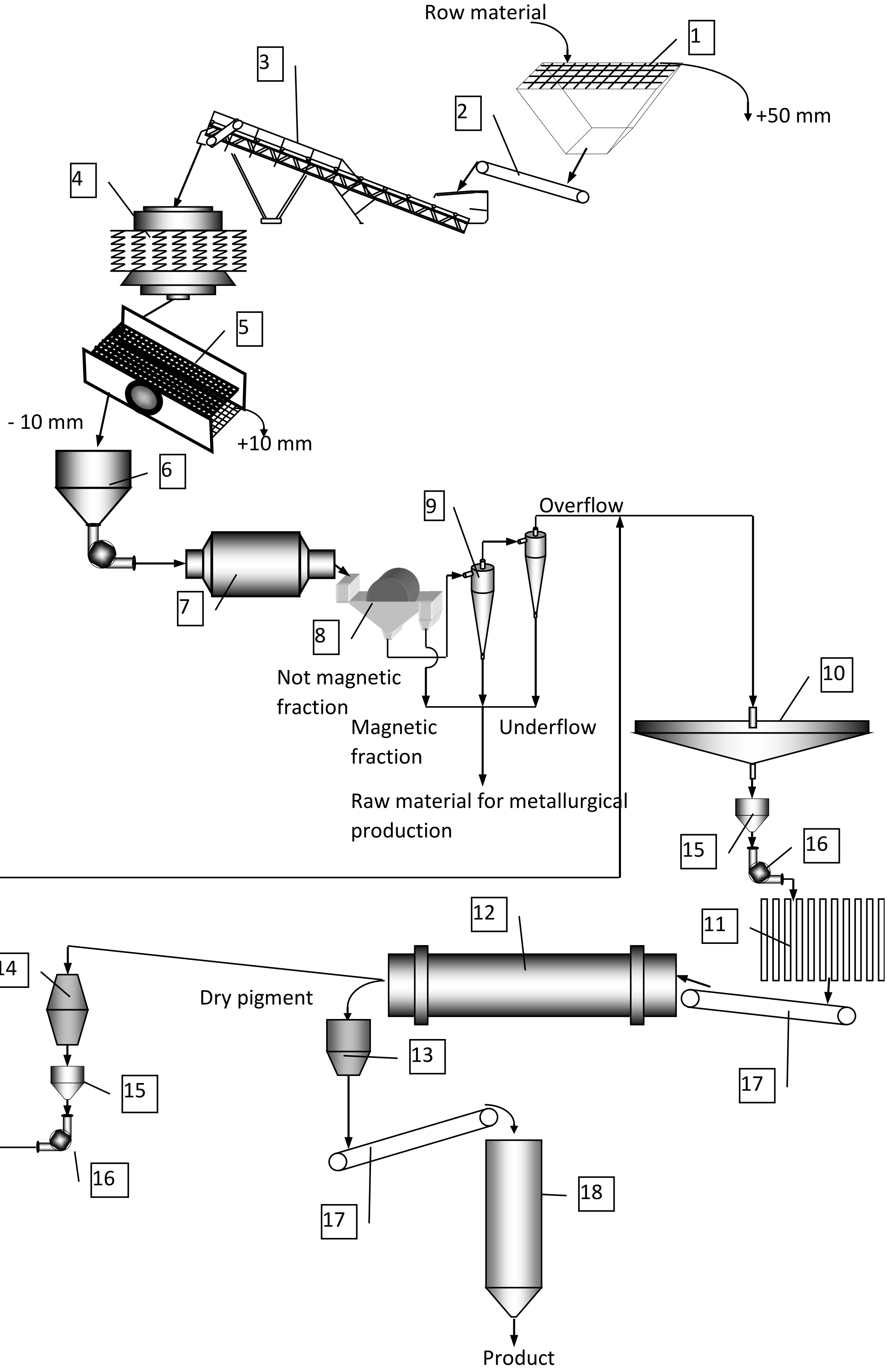

Fig. 1. Flowsheet of production of a pigment from iron oxide

Rys. 1 Schemat produkcji naturalnych czerwonych pigmentów tlenku żelaza z rud żelaza

Fig. 1 Flowsheet of production of a pigment from iron oxide particles of different size. Apart from this, the original ore often has a high water content which hinders dry crushing. Further investigations were conducted by a "wet" method.

It develops that dry ore (with water content less than 7–8%) is readily crushed in conventional crushers (jaw, cone, cylinder crushers, etc.). Significant difficulties relevant to crushing since the material gets sticky results from moisture increase. Wet crushing in the cylinder crusher, particularly in that of the cone inertial type completely solves the problems.

Magnetic separation in a weak magnetic field is aimed at removal of magnetic minerals (martite, where clots are abundant, etc.) as potentially deleterious impurities. Depending on the contents and impregnation of different minerals, a one, two, and more stage magnetic separation has been tested. Let us note that the magnetic fraction can be used as a raw material for iron production.

The classification of the ore grinded in the ball mill in the hydrocyclone, mechanical and hydraulic classifier has shown a possibility of the material fineness based clean cut separation. Since the underflow consists primarily of dark-coloured (deleterious) minerals, the classification also serves as a dressing process.

The table concentration experiments have shown that magnetic iron has an irregular distribution within the products, i.e. the sinking fraction chiefly contains mafic minerals. Concentration by jigging and concentration in screw shaped sluice boxes and spiral separators bring results similar to those of table concentration (strong magnetic iron mainly gets into the sinking fraction). Thickening of classification and separation products has shown that the sample material is condensed satisfactorily, especially with the use of flocculating agents.

Design of flowsheet for production of pigment

So, the following wasteless flowsheet of production pigment (figure 1) can be recommended: raw ore enters the bunker (1) after sieving of class +50 mm with a grate or a bar screen. Class +50 mm is used as a raw material for metallurgical production. Then, by means of the feeding mechanism (2) and belt conveyor (3) the ore is discharged into the cone inertial crusher (4) operating in "wet" conditions. The crushed ore enters the vibration screen (5) for removal of class +10 mm, which is used as a raw material for metallurgical production. Class – 10 mm accumulates in the bunker (6). From the bunker the material is pumped into the ball mill (7), the grinded material goes to magnetic separator (8). Magnetic fraction is used as a raw material for metallurgical production, not magnetic fraction pumped into the hydrocyclones (9). The hydrocyclones makes it possible to obtain several classes of material fineness, the production of several pigment grades being feasible. Classes of different fineness can be grouped in any order, too. The hydrocyclones overflows enter the thickener (10), granular residue of which is filtered by the press filter (11); the thickener overflows are used as recycled water. The press filter cake gets dry in the cylinder drier (12). The dry product is reground in the grinding mill, if necessary (13). The dust gas, leaving the cylinder drier, is scrubbed by the wet dust collector (14), with the water returning to the thickener.

In case of further ore composition degradation, the classification can be applied after grinding with removal of the granular residue from the scheme, magnetic separation, secondary grinding, etc. Such a scheme is rather flexible and can readily respond to the changing ore composition [2, 3].

Summary

Besides, gravitational and magnetic separation was preliminarily tested (ore particles were separated simultaneously under the influence of gravitational and magnetic fields; and, considering the fact that magnetite separated from pigment minerals is denser, harder grained and more magnetic, the separation being rather effective) [4, 5]. Thus developed a technology for producing red iron oxide pigment from ore. The pigment suitable for use in the paint industry. On the consumer properties of pigment not yield the same synthetic pigments, but the production cost is much lower.

Literatura – References

1. Korsunsky L.F, Kalinskaya T.V. Inorganic pigments // SPb.: Chemistry, 1992, 331 p.
2. Kuskov V.B., Kuskova Y.V. Complex use of iron ores in the metallurgical industry. St. Petersburg, 2013, №202. Pp. 111–113.
3. Vasilyev A.M., Lenyov L.A., Kuskov V.B. On the possibility of separation of magnetite impurity from hematite ore by different dressing methods. Ore dressing. 2007, №1. Pp. 6–8.
4. Grishkin N.N., Kuskov V.B., Kuskova Y.V., Mozer S.P. Magnetic and gravitational separator. Patent of invention of the Russian Federation № 2359759. Published 27.06.2009. Bull. № 18.
5. Kuskov V.B., Kuskova Y.V., Utkov V.A. Method for processing of ferrous materials/ Patent of invention of the Russian Federation № 2466196. Published 27.10.2012. Bull. № 30.

Opracowanie technologii produkcji naturalnych czerwonych pigmentów tlenku żelaza

Najbardziej powszechnym nieorganicznym pigmentem jest czerwony pigment tlenku żelaza. Światowa produkcja pigmentów tlenku żelaza wynosi około 600 tysięcy ton rocznie i znacznie przewyższa produkcję innych pigmentów kolorowych, przy czym największy popyt dotyczy pigmentów z czerwonego tlenku żelaza, nieco poniżej zapotrzebowanie na pigmenty żelaza żółtego. Produkcja czerwonego pigmentu tlenku żelaza z rud żelaza jest obiecująca i pozwoli zaspokoić popyt na pigment o wysokiej jakości oraz stosunkowo niskiej cenie. Surowcem do produkcji pigmentu są złoża natiralnych pigmentów żelazowych. Głównym zadaniem uzyskania pigmentu jest usunięcie z surowców surowych minerałów maficznych. Został opracowany bezodpadowy schemat rozdziału rudy żelaza na dwa sortymenty: piegmentowy oraz metalurgiczny. Technologia obejmuje składowanie rudy, jej kruszenie, przesiewanie, następnie drobne mielenie w młynie kulowym, separację magnetyczną i wielostopniową klasyfikację w hydrocyklonach. Po procesie klasyfikacji przelew hydrocyklonu jest zagęszczany, poddawany procesowi filtracji w prasie filtracyjnej, suszony i transportowany do zbiornika z którego idzie załadunek dla odbiorców. Otrzymany pigment spewnia wymogi do stosowania w przemyśle lakierniczym.

Słowa kluczowe: pigmenty tlenku żelaza, drobne szlifowanie, rozdzielanie magnetyczne, klasyfikacja