



# Innovative methodology for recovering titanium and chromium from a raw ilmenite concentrate by magnetic separation after modifying magnetic properties



Jin-Fang Lv<sup>a,b,d</sup>, Han-Ping Zhang<sup>d</sup>, Xiong Tong<sup>a,b</sup>, Chun-Lin Fan<sup>e</sup>, Wen-Tao Yang<sup>c</sup>, Yong-Xing Zheng<sup>a,\*</sup>

<sup>a</sup> State Key Laboratory of Complex Nonferrous Metal Resources Clean Utilization, Kunming University of Science and Technology, Kunming 650093, China

<sup>b</sup> Faculty of Land Resource Engineering, Kunming University of Science and Technology, Kunming 650093, China

<sup>c</sup> Yunnan XinLi Nonferrous Metals Co., Ltd, Kunming 650100, China

<sup>d</sup> KunMing Metallurgy Research Institute, Kunming 650093, China

<sup>e</sup> State Key Lab. Multi-Phase Complex System, Institute of Process Engineering, CAS, Beijing 100190, China

## HIGHLIGHTS

- A new process was proposed to recover Ti and Cr from a raw ilmenite concentrate.
- FeTiO<sub>3</sub> and Fe<sub>2</sub>O<sub>3</sub> had better magnetic selectivity against FeCr<sub>2</sub>O<sub>4</sub> after roasting.
- A commercial Ti concentrate assaying 47.94% TiO<sub>2</sub> was gained with recovery of 78.52%.
- A Cr concentrate assaying 28.65% Cr<sub>2</sub>O<sub>3</sub> was obtained with total recovery of 84.18%.

## ARTICLE INFO

### Article history:

Received 12 July 2016

Received in revised form

13 November 2016

Accepted 29 November 2016

Available online 30 November 2016

### Keywords:

Raw ilmenite concentrate

Chromite

Oxidizing roasting

Reducing roasting

Modification of magnetic property

Magnetic separation

## ABSTRACT

Raw ilmenite concentrate containing Cr can be either as a resource or as one kind of the most hazardous solid waste. In order to recover titanium and chromium from the raw concentrate which was separated from the Promenade deposit, Gaza province, Mozambique, an innovative technology using modification of magnetic property followed by magnetic separation was proposed. Magnetic property, phase and surface morphology of the sample before and after oxidizing roasting were firstly characterized by magnetism, chemistry, XRD and MLA analyses to interpret the mechanism of oxidizing roasting of the ilmenite. Then, these factors such as oxidizing roasting temperature, residence time and magnetic induction affecting on magnetic separation performance were examined and the optimum process parameters were determined. A commercial concentrate containing 47.94% TiO<sub>2</sub> and 0.23% Cr<sub>2</sub>O<sub>3</sub> was obtained and the recovery of TiO<sub>2</sub> and Cr<sub>2</sub>O<sub>3</sub> was 78.52% and 5.42%, respectively. The tailing obtained was preliminarily concentrated by a high-intensity magnetic separator and a rough chromite concentrate was gained. In order to further purify the rough one, reducing roasting was carried out to transform the minerals containing hematite into the minerals containing magnetite, followed by a low-intensity magnetic separation. The effects of these parameters such as temperature, carbon powder dosage, holding time and magnetic induction on magnetic separation performance were investigated and the optimal conditions were determined. A concentrate containing 28.65% Cr<sub>2</sub>O<sub>3</sub> was obtained and the total recovery of Cr<sub>2</sub>O<sub>3</sub> was 84.18%.

© 2016 Published by Elsevier B.V.

## 1. Introduction

The Promenade deposit, located in Chibuto town, Gaza province, Mozambique, is the largest heavy sand deposit containing separate Ti and Zr bearing minerals in the world, but so far it has not commenced its production [1]. Ilmenite is the major heavy mineral component in the deposit. However, it is usually considered to be

\* Corresponding author.

E-mail address: [yongxingzheng2015@yahoo.com](mailto:yongxingzheng2015@yahoo.com) (Y.-X. Zheng).

of the lowest commercial value [2]. In order to realize the full economic value of the deposit, it is essential to process the ilmenite to a marketable product. For this type of deposit, gravity concentration using cone and spiral concentrators is usually applied to reject significant amounts of gangue in the first step while produce a raw heavy sand concentrate [3]. Then, magnetic or electric separation is carried out to produce a commercial ilmenite product [4], which can be used as feedstock for a smelting-chlorination or sulphate route pigment plant.

But for the raw ilmenite concentrate separated from the Promenade deposit, chromium represented a particular problem for processing. Previous mineralogical investigations have shown that chromium mainly occurs as free chromite particles and in principle, they can be separated along with other separate minerals such as zircon, rutile and monazite from the ilmenite grains by physical concentration procedures [5]. However, in practice, the separation is difficult because the physical properties of chromite grains, such as specific gravity, conductivity and magnetic susceptibility, are similar to the ilmenite grains and sometimes, the situation is more complex due to variable physical properties [6,7], resulting in considerable amounts of chromium reporting the ilmenite concentrate. This makes the downstream extraction of titanium more complicated and additionally, serious environment problems will be generated. Moreover, the presence of minute amounts of chromium compounds with a Cr<sub>2</sub>O<sub>3</sub> content more than 0.0015% will considerably affect the light reflectance properties of titanium dioxide [8,9]. In other words, it is very possible that the raw ilmenite concentrate containing Cr will finally become one kind of the most hazardous solid waste. Therefore, the key factor impacting on the commercial exploitation of this heavy sand deposit is how to achieve a clean separation of the ilmenite from the chromite in the initial beneficiation stage.

Modifying the magnetic property of the ilmenite followed by magnetic separation has received much attention as a potential method for its recovery. Cui, Liu and Etsell [10] investigated oxidizing roasting of oil sands tailings in Athabasca. It was found that temperature had a considerable effect on the magnetic property of the ilmenite. Microwave radiation was also introduced to pre-treat the ilmenite ore. Compared with conventional heat treatment, it was considered as a more efficient and lower cost method [11,12]. However, for ilmenite ore containing chromite, it is also important to understand the magnetic property of the chromite under similar treatment. In the literature available [13,14], it was recognized that the magnetic susceptibility of the chromite was not significantly enhanced after oxidizing roasting, indicating that the ilmenite had better magnetic selectivity against the chromite.

However, little work has been reported on the high-efficiency utilization of a material simultaneously containing ilmenite and chromite by modifying magnetic property followed by magnetic separation. Oxidizing roasting of the raw ilmenite concentrate was firstly carried out, resulting in a distinct discrepancy of magnetic susceptibility between the ilmenite and the chromite. After low-intensity magnetic separation, a commercial ilmenite concentrate and a tailing containing Cr were obtained. Then, the tailing was preliminarily concentrated by a high-intensity magnetic separator and a rough chromite concentrate was gained. In order to further purify the rough one, reducing roasting was performed to transform the minerals containing hematite into the minerals containing magnetite, followed by low-intensity magnetic separation and finally, a chromite concentrate was obtained. In this study, the magnetism changes, phase transformation and morphology variation during oxidizing roasting process were detected by magnetism, chemistry, XRD and MLA analyses to interpret the mechanism of oxidizing roasting of the ilmenite. The oxidizing and reducing roasting conditions such as roasting temperature, carbon powder dosage, roasting time and magnetic induction were further optimized. The goal of

**Table 1**  
Chemical composition of the raw ilmenite concentrate (%).

Constituent	TiO <sub>2</sub>	Cr <sub>2</sub> O <sub>3</sub>	Fe	Zr <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	CaO	MgO	Al <sub>2</sub> O <sub>3</sub>	P
Content	42.56	2.95	36.90	0.15	0.96	0.041	0.48	1.61	0.02

**Table 2**  
Distribution of Ti and Cr oxides at different size ranges (%).

Size range (mm)	Yield	Grade		Distribution	
		TiO <sub>2</sub>	Cr <sub>2</sub> O <sub>3</sub>	TiO <sub>2</sub>	Cr <sub>2</sub> O <sub>3</sub>
+0.2	9.88	34.41	7.21	8.04	23.1
−0.2+0.074	84.45	43.62	2.72	87.15	74.46
−0.074+0.037	4.71	41.6	1.40	4.64	2.14
−0.037	0.96	7.41	0.99	0.17	0.30
Total	100.00	42.27	3.09	100.00	100.00

this paper was to find a feasible way to realize the full economic value of the ilmenite deposit.

## 2. Experimental

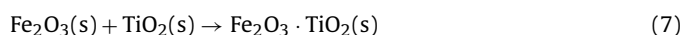
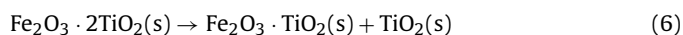
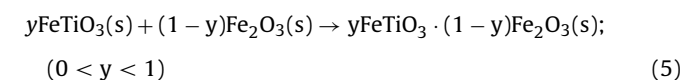
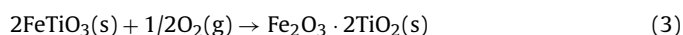
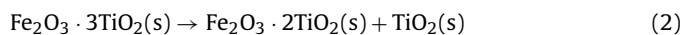
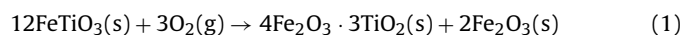
### 2.1. Materials

Representative sample provided was a raw ilmenite concentrate separated from the Promenade beach placer using cone and spiral concentrators, whose chemical composition is shown in Table 1, which reports a high Cr content sample. Scanning electron microscope (SEM) images of the original and colored sample are presented in Fig. 1 where the particle size, shape and the minerals were exhibited at different colors (Fig. 1(b)) for easier recognition. Statistical results shown that the major constituents of the sample, in decreasing order of wt%, were the following: ilmenite (78.58), V-Ti-bearing magnetite (12.7), chromite (3.8), rutile (2.39), almandine (1.35) and that the liberation degree of the ilmenite and the chromite reached 90% and 96%, respectively, indicating that their effective separation were promising. The distribution of Ti and Cr oxides at different size ranges are exhibited in Table 2 and it can be known that more than 95% of them were distributed in the particle size above 0.074 mm, which was beneficial for the physical concentration.

### 2.2. Theoretical fundamental

#### 2.2.1. Oxidation roasting

Reactions during oxidation roasting of the ilmenite [15,16] are listed as follows:



The ilmenite is firstly oxidized to an intermediate phase of Fe<sub>2</sub>O<sub>3</sub> · 3TiO<sub>2</sub> or Fe<sub>2</sub>O<sub>3</sub> · 2TiO<sub>2</sub>, and then decomposed into hematite and rutile (Eqs. (1)–(4)) in the temperature range of 500–800 °C. Meanwhile, the generated hematite is reacted with the ilmenite

Download English Version:

<https://daneshyari.com/en/article/4979738>

Download Persian Version:

<https://daneshyari.com/article/4979738>

[Daneshyari.com](https://daneshyari.com)