Behavior of the chromite tailings in a centrifugal concentrator (FALCON)

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Abstract

The application of the centrifugal concentration gains importance in the world scenario, considering the low environmental impact and the concentration of fine particles. Literature does not present articles using centrifugal concentration (Falcon) for chromite. The material used in the tests is the tailings from a Northeastern Brazil concentration plant, which was homogenized in the laboratory. In the process assays, the number of G (25–300 G) and the fluidization water pressure (20–100 kPa) were optimized. The initial tests used a wide range of particle size of 1 kg mass, with the "best results" being for 50 and 100 G at a pressure of 60 and 80 kPa, respectively, where a metallurgical recovery of 25% and grade close to 20% of Cr_2O_3 were obtained. The amount of mass showed to be a significant variable in the process, being 250 g the ideal for the material used, which obtained considerable recoveries, even though the grade is still low. These results led to a cut at 250 µm, considering that the liberation of the chromite is of the order of 77 %. The best result was with 150 G and fluidization water pressure of 60 kPa for a metallurgical recovery of 72% and a grade of 28% Cr_2O_3.

keywords: centrifugal concentrator; Falcon; chromite; tailings.

1. Introduction

Chromium minerals are found on Earth under the form of oxides and silicates. However, chromite is the only chromium mineral with an economically viable production, which gives it an outstanding position in the mineral industry. Its theoretical composition is 68% Cr_2O_3 and 32% FeO: however, these grades are never found in nature, due to the existence of contaminations.

Chromite is one of the most important industrial minerals: It is used in the metallurgical (main consumption), refractory, chemical and foundry industries. It was first used as a pigment in the late eighteenth century. In the early nineteenth century, it was discovered that this mineral provided stainless properties to the alloy steels (SAMPAIO, ANDRADE AND PAIVA, 2008).

Centrifugal concentrators are machines that emerged in the 80's and exert a high centrifugal force, which can be used for a retraction of tailings of heavy minerals such as chromite, gold, scheelite, among others, making better use of the mineral concentrate. They have relatively low operating and equipment costs, as stated by Sampaio and Tavares (2005). Falcon applications can be found in literature. Initially, centrifugal concentrator application was restricted to the concentration of gold. Leite and Freitas (2001) carried out experiments with this ore in a region of Pedra Lavrada-PB, reaching concentrations around 82%. Also, Lins *et al.* (1992) verified that Falcon was able to recover fine particles of gold (- 74 µm) in the order of 44% in 30 minutes of operation in sulfide ore (17% pyrite and 2% chalcopyrite). Applications related to coal were studied by Honaker, Wang and Ho (1996): the researchers efficiently reduced the ash and sulfur grade in the coal fines, with the maximum separation achieved in the particle size range between 210 x 37µm.

More recently, studies over the subject of gravity separation tailings have been developed. Fernandes (2011) performed a pre-concentration of scheelite using a Falcon SB-40 for posterior acid leaching. Leite and Souza (2010) studied the behavior of kaolin reject, and the results showed that the concentrator operated by classifying the particles with greater inertia, while the fine kaolin particles behaved as a fluid. This process led to recoveries in the order of 90% of kaolin, showing that its application may be an alternative to increase the recovery of kaolin in the region. Sen (2016) indicated that fluidization water flow rate was the independent variable affecting both grade and recovery of the chromite concentrate in Knelson.

The objective of this study is to verify the application of the centrifugal concentration in metallurgical recovery of the plant and processing waste, so that a reuse of the chromite can be planned.

2. Materials and methods

The chromite tailings were sent to the Rio Grande do Norte Mineral Technology Laboratory (IFRN), Campus Natal, in seven bags, with an average of 22 kg per bag. The material was homogenized using prismatic cells. The aliquots for the centrifugal concentration assays were prepared by a Jones splitter. The centrifugal concentrator used was a Falcon SB-40 model. The methodology of the study is expressed in Figure 1. The material retained in Falcon's rings was called concentrate.

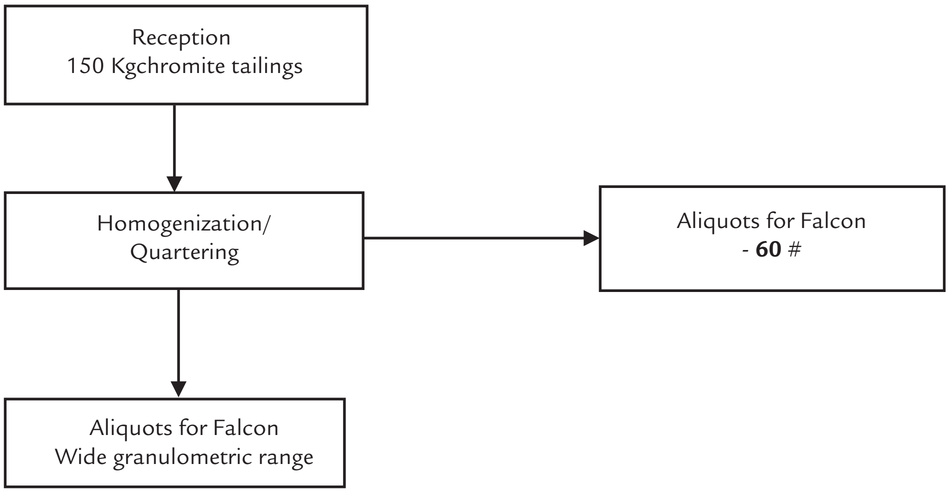

Figure 1
Methodology flowchart
for the lab process steps.

3. Results and discussion

The samples of chromite tailing used in this work present 8.41% of Cr_2O_3. This material is composed mainly chromite (specific gravity: 4.50 – 5.09), serpentine (specific gravity:2.53 – 2.65) and talc (specific gravity:2.7 – 2.8). It has been found that 48% of the tailings particles are less than 300 µm. It was observed that 80% of the chromite is liberated from 150 µm (FREIRE *et al.*, 2017).

3.1 Centrifugal concentration in a wide granulometric range

The metallurgical recovery for Cr_2O_3 from the chromite tailing as a function of the fluidization water pressure for the centrifugal accelerations of 25, 50 and 100 G is shown in Figure 2.

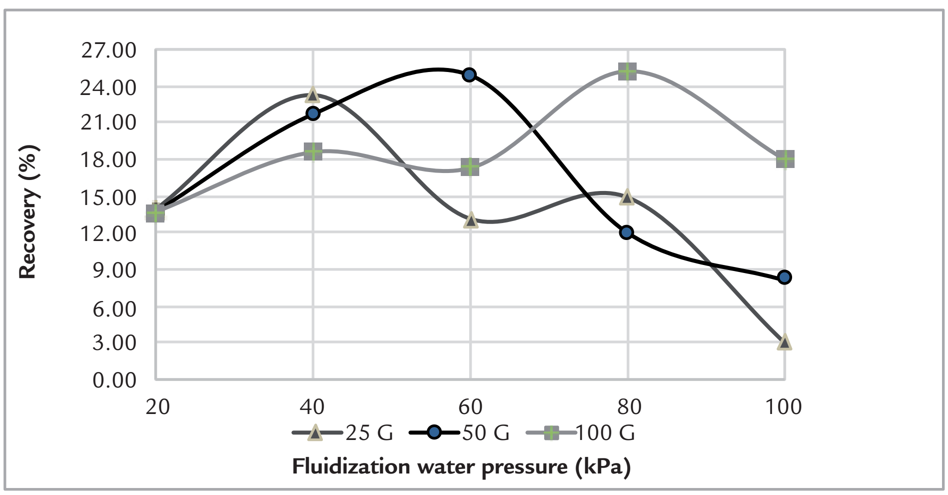

Figure 2
Recovery (Cr_2O_3) as a functi
on of the fluidization water pressure.

The best metallurgical recoveries were 23.27, 24.89 and 25.22% Cr_2O_3, which were reached for centrifugal accelerations 25, 50 and 100 G and fluidization water pressures of 40, 60 and 80 kPa, respectively. The results indicate that higher fluidization pressures require higher centrifugal accelerations. In the centrifugal accelerations 25, 50 and 100 G, the metallurgical recovery decreased from 40, 60 and 80 kPa, respectively, considering that the chromite particles were possibly ejected from the retaining rings.

Figure 3 shows the metallurgical recovery of Cr_2O_3 in the chromite tailings as a function of the fluidization water pressure at two levels of acceleration (150 and 200 G).

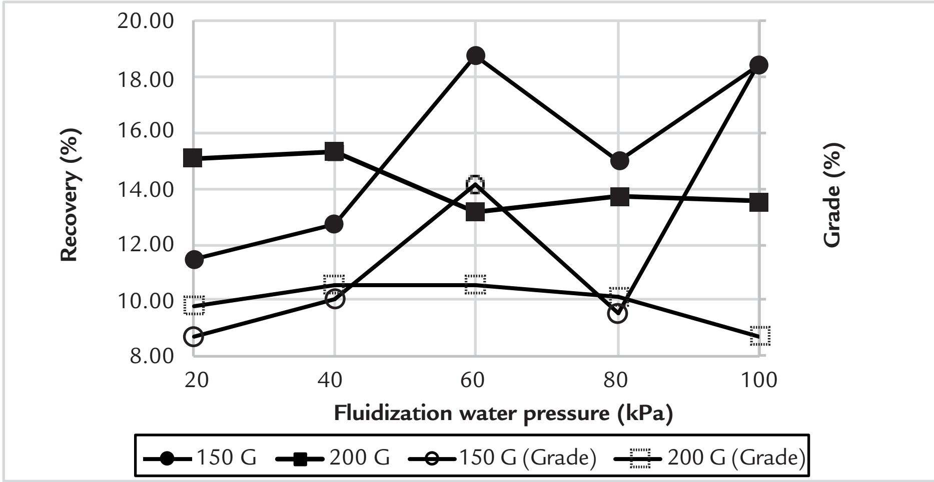

Figure 3
Recovery and grade as a function of the fluidization water pressure (150 and 200 G).

The grade of the chromite concentrate reached 15.40% Cr_2O_3 at a fluidization water pressure of 100 kPa and centrifugal acceleration of 150 G. At 200 G, the grade of the concentrates was below 11% Cr_2O_3 at all levels of fluidization water pressure, resulting in low values of metallurgical recovery. The results indicate that high centrifugal accelerations, such as 200 G, caused the contamination on the chromite's concentrate with large and light mineral particles. Because of the inertia of the particles, the bigger particles fill the retention rings, obstructing the access of the chromite's concentrate. Another aspect also observed is that in the wide range, there are mixed particles that may interfere with the concentrate grade.

In order to evaluate the grade and the metallurgical recovery, with other parameters, the influence of the feed in the process of centrifugal concentration using the Falcon SB-40 was examined.

3.2 Centrifugal concentration under variable feed in a wide granulometric range

Figure 4 shows the Cr_2O_3 metallurgical recovery in the chromite concentrate obtained as a function of the feed mass, for the centrifugal acceleration levels of 50, 75 and 100 G and fluidization water pressures of 60, 70 and 80 kPa, respectively.

The acceleration for these tests was chosen due to the fact that 50 and 100 G presented the best results in the tailings with a wide granulometric range, as seen in Figure 3. The acceleration of 75 G was chosen for being between the other two values (50 and 100 G), which at the beginning of the experiments presented the best results.

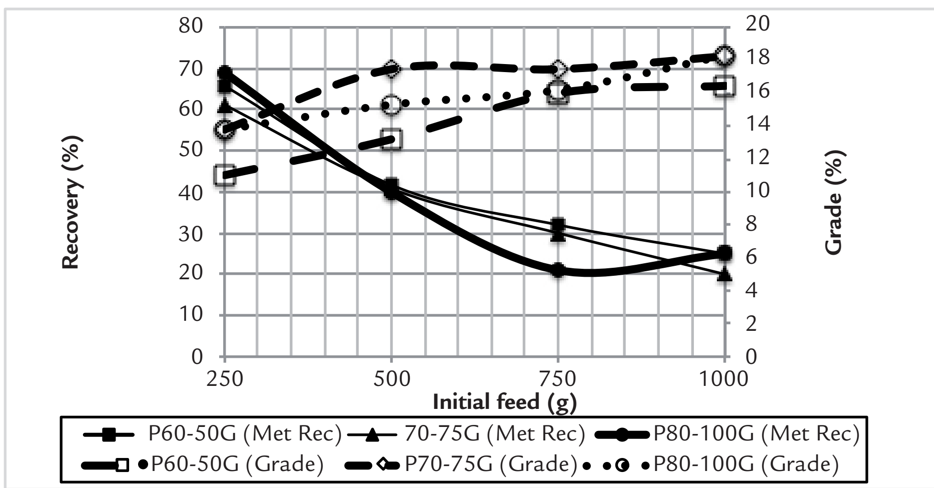

Figure 4
Recovery and grade as a function of the initial feed, in 60, 70 and 80 kPa pressures and 50, 75 e 100 G accelerations.

It can be seen from Figure 4 that recoveries tend to decrease with higher amounts of feed mass. This can be explained by filling the available volume of the rings to concentrate the minerals. The available volume of Falcon SB-40 retention rings is only 40.51 cm^3. Considering that the bulk density of the chromite concentrate is 2.84, the rings are completely filled in 115 g. In other words, after filling the rings, the rest of the material tends to be discarded. Recoveries of 69% (P80 – 100 G), 65.94% (P60 – 50 G) and 61.07% (P75 – 70G) were achieved with 250 g.

3.3 Centrifugal concentration of the chromite tailings in below 60 mesh fraction

In this step, the effect of particle size on the chromite tailings process was investigated. For that, aliquots of the chromite tailings were used in the particle size less than 250 μm (60 mesh), representing 37.34% weight and an average grade of 10.87% Cr_2O_3, where 48.28% of Cr_2O_3 are distributed. In this fraction, the liberation degree of chromite is greater than 76%.

Figure 5 shows the grade of the chromite concentrate, in the fraction below 60 mesh, by varying the feed and under the following conditions: (P60–50 G), (P70–75 G) and (P80–100 G).

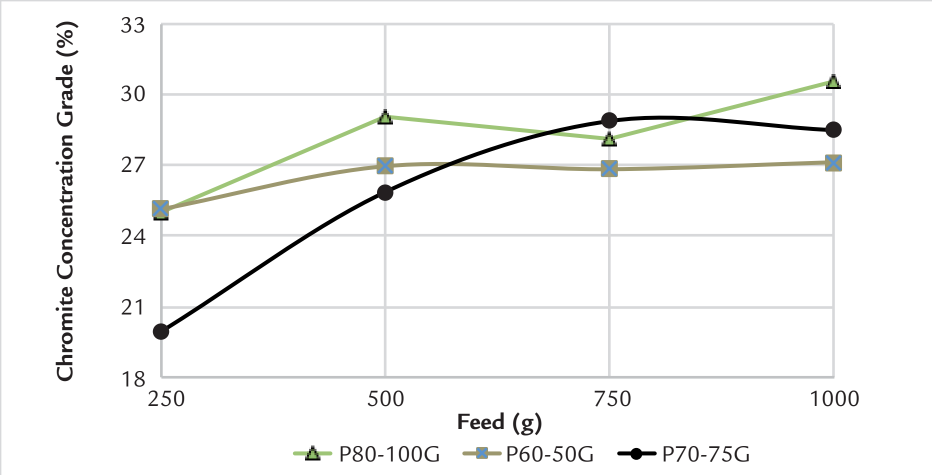

Figure 5
Chromite concentrate grade as a function of the feed mass in the below 60 mesh fraction.

The results have shown that the chromite reject increased from 10.87% Cr_2O_3 to 27.14% (P60–50 G), 28.50% (P70–75 G) and 30.59% (P80–100 G) for feed of 1000 g. Table 1 shows the mass reduction of the chromite concentrate.

Centrifugal Acceleration	Pressure (kPa)	Initial Feed (g)	Concentrate(g)
50 G	60	1000	18.28
		750	21.64
		500	17.98
		250	23.05
75	70	1000	29.92
		750	27.66
		500	25.59
		250	21.42
100	80	1000	22.85
		750	25.76
		500	30.49
		250	23.14

Table 1
Mass decrease in chromite reject.

From Table 1, it can be noticed that these pressure levels with these accelerations are inadequate due to the large amount of mass removed in the process, thus affecting the metallurgical recovery in all mass quantities tested.

Figure 6 shows the recovery values of Cr_2O_3 as a function of feed for the following conditions: (P60–50 G), (P70–75 G) and (P80–100G).

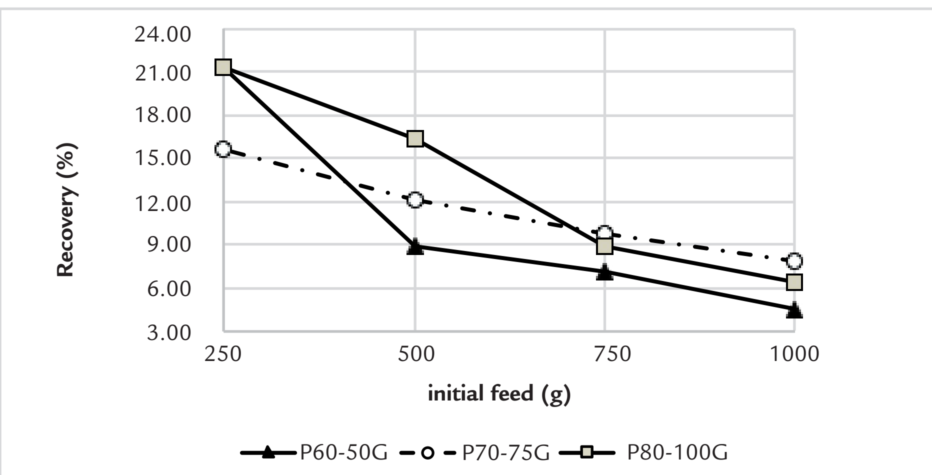

Figure 6
Recovery as a function of the feed mass in below 60 mesh fractions for 60, 70 e 80 kPa pressures and its rescpective accelerations (50, 75 e 100 G).

The medium to high pressures (60–80 kPa) with relatively low accelerations (50–100 G), which showed the best results in the chromite tailings with a wide granulometric range (Figure 2), do not reach significant values with the material in below 60 mesh.

In order to raise the recovery in the particle-size distribution and maintain a high grade, 250 grams of chromite concentrate were tested from low to intermediate acceleration level (100–150 G) with a low to medium pressure (40–60 kPa). Figure 7 shows the grade of the 100 G and 150 G tests.

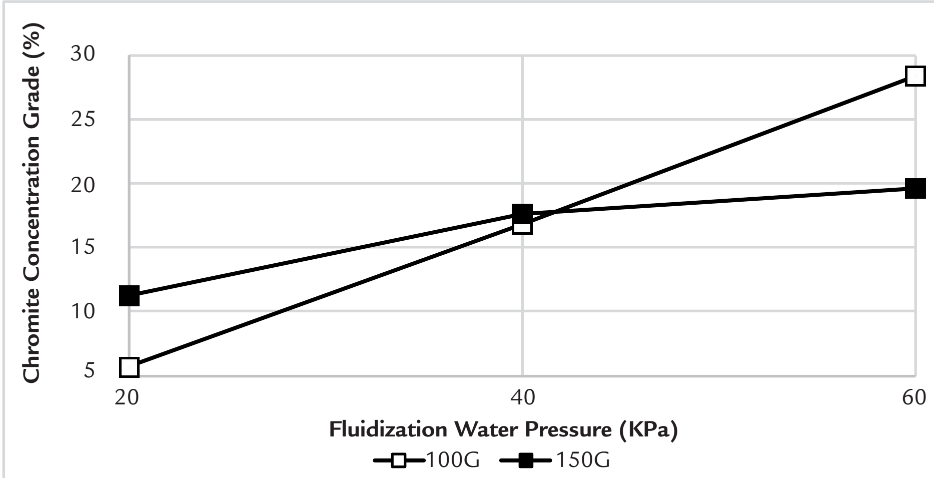

Figure 7
Chromite concentrate grade as a function of the fluidization water pressure in the below 60 mesh reject (two acceleration levels).

Figure 8 presents the results from the metallurgical recovery in the specified conditions.

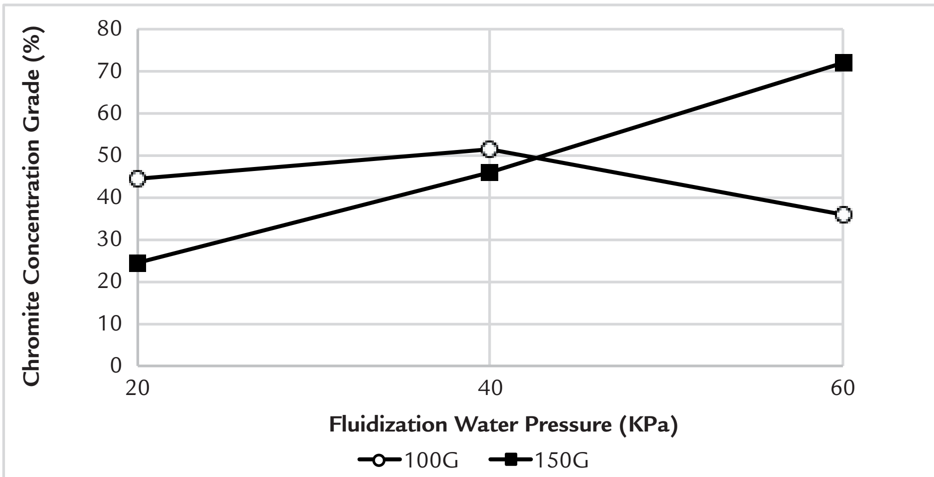

Figure 8
Recovery as a function of the fluidization water pressure in a below 60 mesh reject (two acceleration levels).

4. Conclusions

When studying the behavior of the chromite tailings in a Falcon SB–40 centrifugal concentrator, it was verified that:

• The coarser material presents better results at smaller accelerations (50 a 100 G) with medium to high pressures (60 to 80 kPa), while the finer material has a better performance at low to intermediate centrifugal acceleration (100–150 G) with low to medium pressures (40 to 60 kPa);

• The equipment produces a large mass discard, serving better for a preconcentration than a proper concentration. Since 90% of the chromite is above 200 mesh, a good option is to preconcentrate the reject and then use it in traditional gravimetric equipment, such as an oscillating table or spirals;

• High centrifugal accelerations, such as 200 G, can trap the lighter and thicker particles, preventing better performance for the grade;

• The best results were 150 G at 60 kP in below 60 mesh, where a recovery of 72% with a grade of 28.38% and 250 g of mass was achieved.

Acknowledgments

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