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Scaled-up laboratory research into dry magnetic separation of the Zhezdinsky concentrating mill tailings in Kazakhstan

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Abstract

Purpose. Development of the rational technology for processing manganese-bearing tailings of the Zhezdinsky concentrating mill in the Republic of Kazakhstan aimed to obtaining manganese concentrate for smelting the silicomanganese.

Methods. An integrated methodology of research is used in the work, which includes an analysis of modern scientific developments and the experience of their use by mining-and-metallurgical enterprises. Experimental study of the tailings material composition has been made. A research scheme has been drawn up, including dry re-grinding of the mature tailings from concentrating mill with subsequent air classification, the products of which are beneficiated by means of dry magnetic separation in a separator with a constant strong magnetic field. Granulometric and fractional compositions of the feedstock and separation products have been studied.

Findings. Based on the granulometric and fractional composition analysis of the Zhezdinsky concentrating mill mature tailings, it has been determined that the manganese minerals contained in them are very finely disseminated and belong to easily beneficiated materials. For a more complete recovery of manganese into the concentrate, dry re-grinding and air classification techniques have been included in the beneficiation scheme. Scaled-up laboratory research on tailings beneficiation has been conducted under the scheme: dry grinding to a grain-size of less than 1 mm, screening with division into classes of 0.5-1.0 mm and 0.0-0.5 mm, and then air classification. Air classification products are beneficiated using dry magnetic separation. It has been revealed that the use of air classification during the magnetic field induction of 0.5 T allows to increase the magnetic fractions yield by 7.5% and the manganese recovery by 9.42%. Analysis of the magnetic separation results of fine classes indicates the possibility of obtaining manganese concentrate with the required quality even without using the air classification. This greatly simplifies the beneficiation scheme for mature manganese-bearing tailings at the Zhezdinsky concentrating mill.

Originality. It has been determined that dry re-grinding of the concentrating mill mature tailings to a grain-size of less than 1 mm, followed by air classification, makes it possible to fully disclose the manganese minerals. With subsequent dry magnetic separation this leads to an increase in the magnetic fraction yield and in the manganese recovery.

Practical implications. The optimal technology development enables obtaining manganese concentrate with the required quality for the subsequent production of ferromanganese or silicomanganese during metallurgical treatment.

Keywords: *tailings, granulometric composition, grinding, separation*

1. Introduction

Nowadays, the mining-and-metallurgical complex is one of the basic industries in the Republic of Kazakhstan, which plays an important role in the formation of macroeconomic indicators of the country. Therefore, the steady development of the national economy as a whole will largely depend on the future development of the mining-and-metallurgical complex [1].

A high level of economic development in most countries rich in natural resources is achieved through the intensification of their mining and processing into finished products with high added value cost, as well as the supply to the international markets of not only the metals themselves, but also the competitive metal products [2]-[4].

The main problems of the mining-and-metallurgical complex are: depletion of the raw material base, low integrity of the used raw materials, a high degree of wearing the basic production assets, a high degree of environmental pollution and technological lag behind the leading world countries[1], [5], [6].

One of the acute problems for the recent years is the necessity to replenish and expand the raw materials base at existing enterprises by means of involving in the processing of new medium deposits with small reserve and low content of useful components [7], [8]. In most cases, new explored

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deposits are located far from the existing metallurgical centres of the republic, namely, in arid regions where there are restrictions on water consumption, which complicates the application of traditional processing methods [9]-[11].

One of the additional sources to replenish the raw materials base at the existing enterprises is technogenic waste accumulated in special dumps or tailings for many years of large enterprises functioning [12]-[15]. In recent years, much attention has been paid to the involvement of technogenic wastes or technogenic mineral raw materials in processing in order to provide a raw material base at existing enterprises, thereby ensuring environmental safety [16]-[18].

Currently, there is a steady demand for manganese products. This is conditioned by the growth of the steel and metallurgical industries. At the same time, there is a shortage of manganese raw materials at the metallurgical enterprises of Kazakhstan and Russia, a shortage of manganese concentrates also affects the CIS countries, China, and others. Manganese is the most widespread alloying element. About 95% of it is produced in the form of ferroalloys and is used in steel melting. Under the shortage of high-quality lump raw materials for the stable ferroalloy plants operation, the availability of their reliable raw material base is becoming paramount. When solving this issue, it becomes particularly relevant to involve in production of manganese ore fines, which is off-grade in fractional composition and formed at the stage of mining, transportation and beneficiation [19]-[21].

Today, the Kazakhstani producers are active suppliers of manganese concentrates to Russia. The reserves of rich oxidized manganese ores are depleted, and the extraction and beneficiation of refractory oxide-type ores on an industrial scale in the Republic of Kazakhstan have not yet been sufficiently developed. Under these conditions, special waste dumps (tailings) of concentrating mills, which have been developed over decades, can serve as a source of high-quality manganese concentrate, which after lumping can be used in steel production both domestically and as an export item [22].

One of the largest technogenic deposits in the Republic of Kazakhstan is the tailing dump of the Zhezdinsky concentrating mill, located in the Ulytau District of Karaganda region. Study of the material composition of mature manganese-bearing tailings has revealed that manganese minerals are represented by braunite, psilomelane, less commonly manganese black and coronardite. Non-metallic minerals are represented by quartz and feldspathic rocks. Non-metallic minerals are 65-70% in free grains with a grain-size of +0.016-1.5 mm with a predominant size +0.5-1.5 mm [23].

Based on the analysis results of the previous research on the material composition and technological tests for the ability of the manganese-bearing tailings to beneficiation, it has been determined that the manganese minerals contained in the tailings are finely disseminated [24]. To increase the recovery of manganese into manganese concentrate, a more complete disclosure of the manganese minerals aggregates is necessary, which can be achieved by re-grinding. Therefore, the task set is to develop a beneficiation scheme, including the technique of dry re-grinding to grain-size of less than 1 mm, followed by air classification, the products of which are beneficiated by dry magnetic separation. In addition, the method of scaled-up laboratory research should be applied.

2. Materials and methods of research

The research material is manganese-bearing tailings of the Zhezdinsky concentrating mill. An integrated methodology of research has been implemented in the work, including an analysis of existing scientific developments and the experience of their use at mining-and-metallurgical enterprises. In addition, experimental study of granulometric and chemical analysis of the mature manganese-bearing tailings has been conducted. Scaled-up laboratory research has been performed on mature tailings beneficiation at the Zhezdinsky concentrating mill by the method of dry magnetic separation.

The results of research conducted by the authors in the works [23]-[24], made it possible to study the material composition of the mature manganese-bearing tailings of the Zhezdinsky concentrating mill and to determine the categories of the beneficiation ability of the studied technogenic raw materials. The mature manganese-bearing tailings of the Zhezdinsky concentrating mill have a grain-size of less than 5 mm. The yield of a class with a grain-size of less than 1 mm is more than 90%. In this class, from 85 to 91% of manganese is concentrated, while the highest manganese content is observed in the class of -0.071+0 mm, which is equal to 31.84%. This evidences that the mature tailings of the concentrating mill contain finely disseminated manganese minerals. For a sufficiently efficient recovery of manganese from mature tailings, a complete disclosure of manganese minerals is necessary by including dry grinding technique into the beneficiation scheme.

The mature manganese-bearing tailings of the Zhezdinsky concentrating mill belong to gravitationally easily beneficiated materials. This is confirmed by fractional analysis results that indicate a high recovery of manganese into the heavy fraction, which amounted to 96% with a manganese content of 30%.

The main metal-containing minerals have densities, at an average, in the range of 4.5÷5.0 g/cm^3, while non-metallic rock-forming minerals, such as feldspathic rocks, quartz, kaolinite, dolomite rock and others, have densities in the range of 2.6÷2.9 g/cm^3. In order to verify and use the easy beneficiation property of tailings, it is proposed to include an air classification technique into the beneficiation scheme.

Manganese and other ore minerals contained in the studied tailings are weakly magnetic and can be effectively recovered from the tailings by dry magnetic separation into manganese concentrate [25]-[27].

Based on the analysis results of the research conducted by the authors of the works [28]-[32], using the dry magnetic separation technique to beneficiate the natural and technogenic materials and with account of the easy gravitational beneficiation ability, and for necessity of a more complete aggregates disclosure of manganese-bearing minerals, the following research scheme is proposed, presented in Figure 1.

Manganese-bearing tailings with a grain-size of -5.0+0.0 mm are exposed to fine dry grinding to a grain-size class of -1.0+0.0 mm. This is followed by the screening technique, where they are divided into classes of -1.0+0.5 mm and -0.5+0.0 mm. The products of screening are supplied to the air classification technique, where the separation of minerals takes place at the velocities of equal fall. Chamber products of air classification are fed to a dry magnetic separation to obtain manganese concentrate and tailings [24].

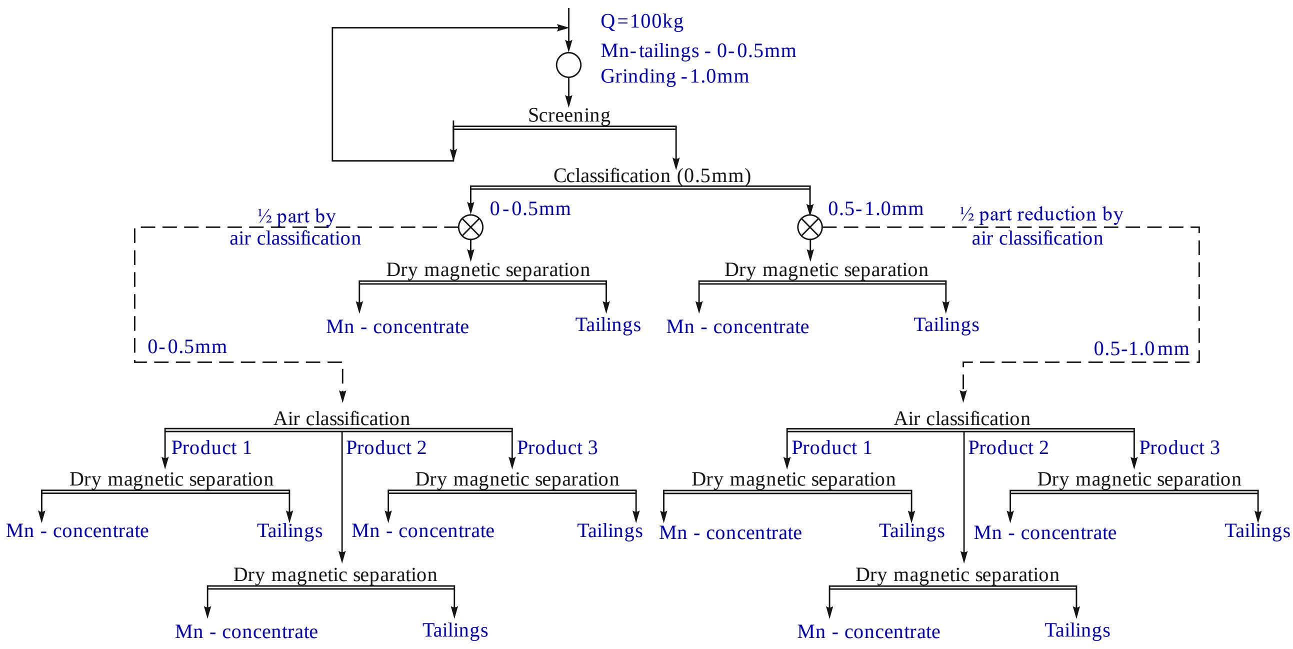

Figure 1. Scheme of scaled-up laboratory research on the beneficiation ability of manganese-bearing tailings of the Zhezdinsky concentrating mill

Use of dry grinding will make possible a more complete disclosure of manganese-bearing minerals aggregates, and air classification is the technique of preliminary concentration of minerals in the product, which are fed to dry magnetic separation. It is assumed that this will extract most of the non-magnetic particles before using dry magnetic separation and to reduce the load on the magnetic separation technique. It is possible to expect an increase in recovery of manganese into the concentrate and in its output.

Preparation of manganese-bearing tailings for research: averaging, quartering, sampling for analyses and conducting the research itself, as well as conducting chemical, phase and fractional analyses, performed in the branch laboratories of the Zh. Abishev Chemical-Metallurgical Institute of the republican state enterprise "National Centre on Complex Processing of Mineral Raw Materials of the Republic of Kazakhstan".

3. Results and discussion

The results of dry screening, when grinded to a particle size of less than 1 mm, have shown that the yield of a class with a grain-size of -0.5+0.0 mm is more than 70%, in which 72.53% of manganese is concentrated. The obtained samples after dry screening of 1.0+0.5 mm grain-size class and of -0.5+0.0 mm grain-size class with a Mn content of 9.19% and 10.36%, respectively, are supplied to air classification in a horizontal air separator (Table 1).

Table 1. Dry screening results

Initial sample	Yield, %	Content, %			Recovery, %		
		Fe	Mn	SiO_2	Fe	Mn	SiO_2
-1.0+0.0	100.0	2.41	10.01	55.60	100.0	100.0	100.0
-1.0+0.5	29.92	2.55	9.19	47.63	31.66	27.47	25.63
-0.5+0.0	70.08	2.35	10.36	59.00	68.34	72.53	74.37
Total	100.0	2.41	10.01	55.60	100.0	100.0	100.0

To select the air flow velocity, necessary for horizontal movement and settling of mineral particles with different specific gravities and sizes, the final velocities have been calculated of the particles fall of ore and non-metallic minerals in the air medium [24].

Through the transparent walls of the separator, the process of moving and settling particles into the receiving chambers of the separator is monitored. The precipitated portions of the samples are extracted from three receiving chambers. The weights and volumes of the products obtained are being determined. The separation products are supplied for granulometric and chemical analyses.

When conducting the granulometric analysis of air classification products, the class of -0.5+0.0 mm has been scattered into the following classes: -0.5+0.315 mm, -0.315+0.16 mm and -0.16+0.0 mm.

Granulometric analysis results of air classification products are presented in Table 2.

The data in Table 2 show that in the product No. 1, settled in the first chamber of the separator, there is a slight increase in the manganese content in the grain-size class of -0.16+0.0 mm. In the products of the second and third chambers, there is a significant increase in manganese recovery in the class of less than 0.16 mm to 67.91% and 73.90%, respectively.

When comparing the data in Tables 1 and 2, it can be seen that air classification is the technique of preliminary concentration of manganese minerals into the products supplied for the beneficiation into the magnetic separator. The manganese content in products 1, 2 and 3 is higher than in the source material by more than 3%.

Table 2. Granulometric composition of air classification products of -0.5+0.0 mm grain-size class

Product	Class, mm	Yield, %	Content, %				Recovery, %			
			Fe	Mn	SiO_2	Al_2O_3	Fe	Mn	SiO_2	Al_2O_3
No. 1	Initial	100.00	2.17	14.14	52.80	11.27	100.00	100,00	100.00	100.00
	-0.5+0.315	32.62	1.82	12.11	56.01	11.83	27.36	27.94	34.60	34.24
	-0.315+0.16	39.43	1.97	12.55	55.73	11.66	35.80	35.00	41.62	40.79
	-0.16+0.0	27.95	2.86	18.75	44.92	10.07	36.84	37.06	23.78	24.97
	∑	100.00					100.00	100.00	100.00	100.00
No. 2	Initial	100.00	2.27	14.14	52.80	10.76	100.00	100.00	100.00	100.00
	-0.5+0.315	11.84	1.56	7.64	61.26	11.66	8.14	6.40	13.74	12.83
	-0.315+0.16	38.94	1.79	9.33	60.42	11.46	30.71	25.69	44.56	41.47
	-0.16+0.0	49.22	2.82	19.51	44.73	9.99	61.15	67.91	41.7	45.70
	∑	100.00					100.00	100.00	100.00	100.00
No. 3	Initial	100.00	2.44	14.98	52.94	9.88	100.00	100.00	100.00	100.00
	-0.5+0.315	6.00	1.91	5.80	68.88	11.59	4.70	2.32	7.81	7.04
	-0.315+0.16	36.31	1.86	9.81	61.78	10.98	27.68	23.78	43.27	40.35
	-0.16+0.0	57.69	2.86	19.19	45.72	9.01	67.62	73.90	49.82	52.61
	∑	100.00					100.00	100.00	100.00	100.00

All products obtained as a result of air classification, as well as the feedstock of this technique, that is, samples with a grain-size of -0.5+0.0 and 1.0+0.5 mm, have been examined by dry magnetic separation.

Scaled-up laboratory research on magnetic separation of tailings are performed on a belt separator RS-V 12/10-12.018 at different values of the magnetic field induction. Table 3 shows the results of dry magnetic separation for the first chamber product of the air classification.

The data in Table 3 show that with increasing magnetic field intensity from 0.5 to 1.2 T, there is an increase in the yield of magnetic fractions from 42.5 to 61.0% and the recovery of manganese into it from 79.83 to 89.52%. At the same time, there is a decrease in the manganese content from 26.56 to 20.75%. This tendency also persists in the dry magnetic separation of the second and third chambers products of the air separator.

Table 3. Dry magnetic separation results of air classification product with a grain-size class of -0.5+0.0 mm (Product No. 1)

Induction, T	Product	Yield, %	Content, %				Recovery, %			
			Fe	Mn	SiO_2	Al_2O_3	Fe	Mn	SiO_2	Al_2O_3
0.5	Initial	100.00	2.17	14.14	52.80	11.27	100.00	100.00	100.00	100.00
	Magnetic fraction	42.50	3.32	26.56	34.62	8.85	65.02	79.83	27.87	33.37
	Non-magnetic fraction	57.50	1.32	4.96	66.23	13.06	34.98	20.17	72.13	66.63
	Total	100.00					100.00	100.00	100.00	100.00
0.7	Initial	100.00	2.17	14.14	52.80	11.27	100.00	100.00	100.00	100.00
	Magnetic fraction	57.00	3.06	22.22	41.16	11.27	80.38	89.57	44.43	57.00
	Non-magnetic fraction	43.00	0.99	3.43	68.24	11.27	19.62	10.43	55.57	43.00
	Total	100.00					100.00	100.00	100.00	100.00
1.2	Initial	100.00	2.17	14.14	52.80	11.27	100.00	100.00	100.00	100.00
	Magnetic fraction	61.00	2.95	20.75	40.83	11.52	82.93	89.52	47.17	62.35
	Non-magnetic fraction	39.00	0.95	3.80	71.53	10.88	17.07	10.48	52.83	37.65
	Total	100.00					100.00	100.00	100.00	100.00

The results of dry magnetic separation at a magnetic field intensity of 0.5 T testify that tailings re-grinding and the use of air classification before magnetic concentration make it possible to increase the magnetic fractions yield by 7.5% and increase the manganese recovery into the magnetic fraction by 9.42% compared with the results of research conducted by the authors in the work [23].

The primary tailings are exposed to magnetic separation after re-grinding to a grain-size of less than 1 mm. This separation results are presented in Table 4.

The data in Table 4 show that when separating with a magnetic induction of 0.5 T without using air classification, the manganese concentrate is obtained with a manganese content of 26.00% with the recovery of manganese into it up to 69.64%. The yield of manganese concentrate is 30%.

As a result of processing the research data, the dependences have been obtained of beneficiation technological parameters on the magnetic field intensity for different air classification products and feedstock.

Figure 2 presents the dependences of the magnetic separation technological parameters of the first chamber product on the magnetic field induction. It can be seen that with a magnetic induction of 0.3 T, it is possible to obtain a manganese concentrate with a yield of 45.0% and a content of 32.8% of manganese upon recovery of 80%.

Similar dependences of the magnetic separation technological parameters have been obtained during the beneficiation of the 2 and 3 chambers products of the air classification.

Figure 3 presents the dependences of the magnetic separation technological parameters on the magnetic field induction during tailings beneficiation with a grain-size of -1.0+0.00 mm without the use of air classification.

Table 4. Dry magnetic separation results of regrinded primary product with a grain-size class of -1.0+0.0 mm

Induction, T	Product	Yield, %	Content, %				Recovery, %			
			Fe	Mn	SiO_2	Al_2O_3	Fe	Mn	SiO_2	Al_2O_3
0.5	Initial	100.00	1.90	11.20	58.40	10.84	100.00	100.00	100.00	100.00
	Magnetic fraction	30.00	2.20	26.00	37.00	8.10	34.70	69.64	19.00	22.42
	Non-magnetic fraction	70.00	1.77	4.81	67.58	12.01	65.30	30.36	81.00	77.58
	Total	100.00					100.00	100.00	100.00	100.00
0.7	Initial	100.00	1.84	11.23	58.37	10.84	100.00	100.00	100.00	100.00
	Magnetic fraction	42.00	2.42	22.14	41.37	10.55	55.24	82.80	29.77	40.88
	Non-magnetic fraction	58.00	1.42	3.33	70.68	11.05	44.76	17.20	70.23	59.12
	Total	100.00					100.00	100.00	100.00	100.00
1.2	Initial	100.00	1.84	11.23	58.37	10.84	100.00	100.00	100.00	100.00
	Magnetic fraction	61.00	2.39	16.90	55.11	11.12	79.23	91.80	57.59	62.58
	Non-magnetic fraction	39.00	0.98	2.36	63.48	10.40	20.77	8.20	42.41	37.52
	Total	100.00					100.00	100.00	100.00	100.00

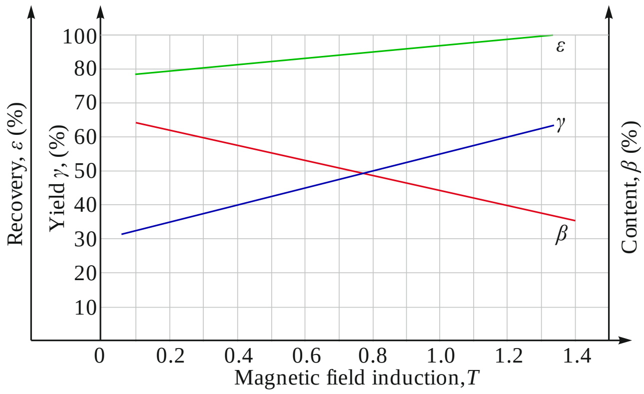

Figure 2. Dry magnetic separation results of a product of -0.5+0.0 mm grain-size class of the air separator first chamber

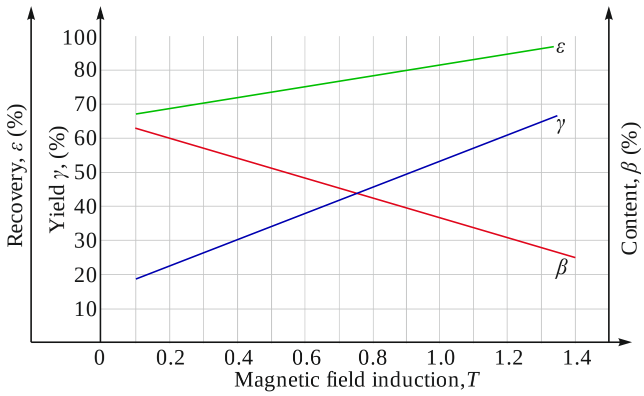

Figure 3. Dry magnetic separation results of the primary product of -1.0+0.0 mm grain-size class

When comparing the results of beneficiation experiments of re-grinded tailings in a magnetic field and subsequent air classification before magnetic concentration of -1.0+0.0 mm grain-size class with the magnetic concentration without the use of air classification, the following conclusions can be drawn: using the air classification, although it slightly increases the concentrate yield and increases the manganese recovery into it, at the same time complicates the technological scheme of processing. To involve the mature manganese-bearing tailings in the processing, it is more preferable the technological scheme of processing, which includes regrinding of manganese-bearing tailings of less than 1 mm, followed by magnetic separation. This greatly simplifies the processing technique and increases the technological process functional reliability.

If to compare these results with the research results presented by the authors in the work [23], given the similar values of magnetic field induction, it can be stated that the inclusion in the technological scheme of the tailings regrinding to a grain-size of less than 1 mm makes it possible to increase the manganese concentrate yield by 6% with a manganese content of 30% and increase recovery by 4%.

Based on this research results, a new technology for processing the mature manganese-bearing tailings of the Zhezdinsky concentrating mill is proposed, which includes dry re-grinding of tailings to a grain-size of less than 1 mm, followed by dry magnetic separation under a constant strong magnetic field.

According to the authors of this research, it is necessary to conduct work on creating a mobile pilot plant equipped with a separator with a constant magnetic field and strong magnetic induction in order to finally solve the problem of involving mature tailings in processing. The industrial tests should be conducted directly at the technogenic deposit.

4. Conclusions

The main scientific and practical results have been obtained as a result of the work performed.

During the experiments on the magnetic separation of the air separator chamber products under magnetic induction of 0.5 T, manganese concentrate has been obtained with a content of 26.56% manganese with a yield of 42.56% and recovery of 79.83% manganese. The tendency of increasing the manganese content in the concentrate with a decrease in the magnetic field magnetic induction is determined.

By processing the research results of tailings beneficiation by dry magnetic separation with interpolation method, the technological parameters of beneficiation have been determined at a magnetic field induction value of 0.3 T.

In the case of dry magnetic separation with preliminary air classification of -0.5+0.0 mm class, the yield of manganese concentrate will be 30.70% with a manganese content of 36.20% at 78.26% of its recovery into concentrate. At the same time, during dry magnetic separation of -1.0+0.5 mm class, the yield of manganese concentrate will be 23.60% with a manganese content of 30.00% at 70.00% of its recovery into concentrate.

In the case of dry magnetic separation of tailings without preliminary air classification of -1.0+0.0 mm class, a manganese concentrate is obtained with a yield of 26% with a manganese content of 30% and a manganese recovery of 69.64%.

The research results analysis evidences that dry grinding of mature tailings to a grain-size of less than 1 mm ensures the complete disclosure of ore minerals. This makes possible to obtain manganese concentrate with the required quality by dry magnetic separation even without the use of air classification technique. This greatly simplifies the beneficiation scheme for mature manganese-bearing tailings of the Zhezdinsky concentrating mill.

Therefore, for processing the mature tailings of the Zhezdinsky concentrating mill, it is recommended the simplest beneficiation technology in terms of maintenance and exploitation, which includes the technique of dry grinding of tailings to a grain-size of less than 1 mm, followed by magnetic separation under a magnetic field with an induction of 0.3 T.

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Укрупнено-лабораторні дослідження сухої магнітної сепарації хвостів Жездінської збагачувальної фабрики, Казахстан

А. Мустахімов, А. Зейнуллін

Мета. Розробка раціональної технології переробки марганцевовмісних хвостів Жездінської збагачувальної фабрики республіки Казахстан для отримання марганцевого концентрату для виплавки силікомарганцю.

Методика. У роботі використовувалася комплексна методика досліджень, що включає аналіз сучасних наукових розробок і досвіду їх використання гірничо-металургійними підприємствами. Проведено експериментальні дослідження речового складу хвостів. Складено схему дослідження, що включає сухе доподрібнення лежалих хвостів збагачувальної фабрики з наступною повітряною сепарацією, продукти якої збагачуються методом сухої магнітної сепарації у сепараторі з постійним сильним магнітним полем. Вивчено гранулометричний та фракційний склади вихідної сировини й продуктів сепарації.

Результати. На основі аналізу гранулометричного та фракційного складу лежалих хвостів Жездінської збагачувальної фабрики встановлено, що мінерали марганцю, що містяться в них, дуже тонковкраплені й відносяться до легкозбагачуваних матеріалів. Для більш повного вилучення марганцю в концентрат у схему збагачення були включені операції сухого доподрібнення й повітряної сепарації. Проведено укрупнено-лабораторні дослідження збагачення хвостів за схемою: сухе подрібнення до крупності менше 1 мм, просіювання з поділом на класи 0.5-1.0 і 0.0-0.5 мм, які надходять на повітряну сепарацію. Продукти повітряної сепарації збагачуються сухою магнітною сепарацією. Встановлено, що застосування повітряної сепарації при індукції магнітного поля 0.5 Тл дозволяє підвищити вихід магнітної фракцій на 7.5% і збільшить витяг марганцю на 9.42%. Аналіз результатів магнітної сепарації тонких класів вказав на можливість отримання марганцевого концентрату необхідної якості навіть без застосування повітряної сепарації. Це значно спрощує схему збагачення лежалих марганцевовмісних хвостів Жездінської збагачувальної фабрики.

Наукова новизна. Встановлено, що сухе доподрібнення лежалих хвостів збагачувальної фабрики до крупності менше 1 мм, з подальшою повітряною сепарацією, дозволяє повністю розкрити мінерали марганцю, що призводить при подальшій сухій магнітній сепарації до підвищення виходу магнітної фракції та збільшення вилучення в ній марганцю.

Практична значимість. Розробка оптимальної технології дозволяє отримати марганцевий концентрат необхідної якості для подальшого отримання в металургійному переділі феро- або силікомарганцю.

Ключові слова: *хвости, гранулометричний склад, подрібнення, сепарація*

Укрупненно-лабораторные исследования сухой магнитной сепарации хвостов Жездинской обогатительной фабрики, Казахстан

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Цель. Разработка рациональной технологии переработки марганецсодержащих хвостов Жездинской обогатительной фабрики республики Казахстан для получения марганцевого концентрата для выплавки силикомарганца.

Методика. В работе использовалась комплексная методика исследований, включающая анализ современных научных разработок и опыта их использования горно-металлургическими предприятиями. Проведены экспериментальные исследования вещественного состава хвостов. Составлена схема исследования, включающая сухое доизмельчение лежалых хвостов обогатительной фабрики с последующей воздушной сепарацией, продукты которой обогащаются методом сухой магнитной сепарации в сепараторе с постоянным сильным магнитным полем. Изучены гранулометрический и фракционный составы исходного сырья и продуктов сепарации.

Результаты. На основе анализа гранулометрического и фракционного состава лежалых хвостов Жездинской обогатительной фабрики установлено, что содержащиеся в них минералы марганца весьма тонковкрапленны и относятся к легкообогатимым материалам. Для более полного извлечения марганца в концентрат в схему обогащения были включены операции сухого доизмельчения и воздушной сепарация. Проведены укрупнено-лабораторные исследования обогащения хвостов по схеме: сухое измельчение до крупности менее 1 мм, грохочение с разделением на классы 0.5-1.0 и 0.0-0.5 мм, которые поступают на воздушную сепарацию. Продукты воздушной сепарации обогащаются сухой магнитной сепарацией. Установлено, что применение воздушной сепарации при индукции магнитного поля 0.5 Тл позволяет повысить выход магнитной фракций на 7.5% и увеличит извлечение марганца на 9.42%. Анализ результатов магнитной сепарации тонких классов указал на возможность получения марганцевого концентрата требуемого качества даже без применения воздушной сепарации. Это значительно упрощает схему обогащения лежалых марганецсодержащих хвостов Жездинской обогатительной фабрики.

Научная новизна. Установлено, что сухое доизмельчение лежалых хвостов обогатительной фабрики до крупности менее 1 мм, с последующей воздушной сепарацией, позволяет полностью раскрыть минералы марганца, что приводит при последующей сухой магнитной сепарации к повышению выхода магнитной фракции и увеличению извлечения в ней марганца.

Практическая значимость. Разработка оптимальной технологии позволяет получить марганцевый концентрат требуемого качества для последующего получения в металлургическом переделе ферро- или силикомарганца.

Ключевые слова: *хвосты, гранулометрический состав, измельчение, сепарация*

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