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RECOVERY OF MANGANESE FROM SLIMES BY HIGH–INTENSITY MAGNETIC SEPARATION*

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Abstract: Production–scale application of the high–gradient magnetic separator VMS 100/2 to the recovery of manganese from the plant tailings is described. It has been found that in one–stage separation the concentrate containing 25 to 28% Mn can be obtained, with the recovery of 65.6%. In a two–stage process the grade of the concentrate was 31.7% with the recovery of 55.8%. The final cleaning of the manganese concentrate yielded a product with the grade of 35 to 41% Mn.

INTRODUCTION

The exhaustion of the high–grade oxide ores and gradual introduction into the beneficiation process of the increasing volumes of the low–grade oxide and mixed and carbonate manganese ores results in the reduction of the efficiency of beneficiation, when the previously developed technology and conventional equipment is used. The basic losses of manganese are then associated with slimes. Investigations carried out from 1970 to 1980 by the Mekhanobrcherment Institute showed that one of the perspective methods of increasing the efficiency of beneficiation of difficult–to–treat manganese ores is the high–intensity magnetic separation of the slimes.

However, apart from obvious expediency, this new technology was not timeously introduced because of low mechanical and technological reliability of separators available locally and from abroad.

Introduction of this new technology started only after a high–intensity magnetic separator VMS had been developed by the Mekhanobrchermet Institute and Ore Research Institute (Czechoslovakia) [1 – 3].

PILOT AND PRODUCTION–SCALE TESTS

Laboratory and pilot–plant tests of the manganese slimes were performed using samples collected from the tailings dams and also from circuits of the existing beneficiation plants of the Marganetsk and Ordzhonikidze GOK (the State Beneficiation Complexes). These tests carried out on the experimental 2x5 prototype of the VMS separator showed a possibility of efficient recovery of fine ore particles, giving a concentrate containing approximately 30% of manganese by mass [4, 5].

Results obtained from these pilot–plant trials carried out in the Mekhanobrcherment Institute were used as a basis for development of the production–scale separator VMS 100/2. Magnetic induction in the working volume of the separator was 1 Tesla [3, 4]. The main advantage of the design of the VMS 100/2 separator is its relatively low energy consumption. It is achieved by employing a steel–clad electromagnetic system, a compensation of magnetic forces acting on the wheel which carries the matrix, and also by high efficiency of the flushing of the matrix.

The production–scale circuit for the treatment of the slimes, which included the VMS 100/2 separator, was installed in 1988 in the Tchkalov beneficiation plant of the Ordzhonikidze GOK. According to the flowsheet, the slimes with particle size smaller than 500 μm, deslimed at – 10 μm, were fed into the separator. Distribution of manganese according to size fractions, during the production–scale trials, in shown in Table 1.

The machine was used for separation in one or two stages, with cleaning of the magnetic fraction from the first stage. It was established that the throughput of the separator was up to 120 t/h of solids (up to 60 t/h per wheel). The magnetic induction had to be equal to 0.8 to 1.0 Tesla, the concentration of solids in the feed into the first stage 30 ± 5%, the consumption of the rinse and flush water 100 m^3/h.

Table 1. Granulometric composition of the feed slimes and distribution of manganese in to size fractions

Size fraction, mm	Distribution (%)		Grade (%Mn)		Recovery (%Mn)
	Range	Mean value	Range	Mean value	
+ 0.5	0.3-5.8	3	25.4-30.5	28.7	7.5
- 0.5+0.16	10.0-49.2	23.5	17.3-28.8	21.7	44.4
- 0.16+0.044	28.0-63.6	49.2	4.9-6.8	6.5	27.8
- 0.044+0.01	10.4-33.3	24.3	8.6-10.8	9.6	20.3
Feed	-	100	10.2-14.2	11.5	100

The analysis of the products from the first stage, shown in Table 2, indicated that the size fraction + 160 μm can be recovered with high efficiency and the concentrate with mass yield of manganese exceeding 34% was obtained. The magnetic product with the mass yield of manganese of 28 to 29% was obtained from size fractions finer than 160 μm.

Table 2 Distribution of manganese according to size fractions of the magnetic product from the one–stage separation

Size fraction, mm	Grade (%Mn)	Recovery (%Mn)
+ 0.5	31.2-35.9	41.2-89.1
- 0.5+0.16	29.8-36.4	56.9-83.3
- 0.16+0.044	23.3-28.4	43.6-80.1
- 0.044+0.01	19.7-29.1	30.6-46.4

The results of the tests showed that in one–stage separation the magnetic product with the mean concentration of manganese of 28.6 ± 0.6% can be obtained, with sufficient reproducibility.

In two–stage separation, products with quantitative results equivalent to concentrates of the second kind were obtained. However, according to to the statistical analysis, these products were characterised by the mass concentration of manganese in the magnetic product of 32.5 ± 0.7%.

It follows from the analysis of the feed slimes and of the separation products (Table 3) that the quality of the magnetic products depends on the presence of minerals unliberated from quartz, and also on the existence of liberated particles of quartz, clay and hydro–oxides which have magnetic susceptibility close to that of the manganese minerals. During the magnetic separation, considerable removal of quartz from the slimes occurs, while clay is removed with insufficient efficiency.

Table 3 Chemical and mineralogical composition (%) of the feed and of the magnetic product from two–stage separation

Size fraction, mm	Mn	SiO2	P	Oxides	Carbo-nates	Clusters	Quartz	Clay	Iron hydro-oxides
Feed									
+ 0.5	28.5	26.5	0.174	55	3	30	5	5	2
-0.5 +0.16	16	58.5	0.112	35	3	10	45	4	3
-0.16 +0.044	9.1	74	0.072	25	-	3	65	5	2
-0.044 +0.02	11.3	59.7	0.14	30	-	-	50	20	-
-0.02 +0.01	12.8	44.1	0.118	30	-	-	20	50	-
Input	11.5	61.8	0.087	28.6	1	5.3	66.8	6	2.3
Magnetic product									
+ 0.5	34.4	20.6	0.182	75	1	15	3	3	3
-0.5 +0.16	32.7	24.4	0.163	75	1	5	10	4	5
-0.16 +0.044	29.7	30.4	0.152	75	-	-	14	5	6
-0.044 +0.02	24.9	20.9	0.186	65	-	-	17	18	-
-0.02 +0.01	26.1	28.1	0.218	65	-	-	10	25	-
Input	31.7	29.8	0.163	74.7	0.7	3.6	10.8	5.3	4.9

During the production–scale trials, the VMS 100/2 separator operated for more than 1400 hours while the control investigations were carried out for 260 hours. According to the surveying measurements, 1325.8 tonnes of the magnetic product with the average mass concentration of manganese of 31.7% were produced during the control investigation. Recovery of manganese amounted to 55.8%.

In order to obtain the conditioned concentrate, the flowsheet of magnetic beneficiation was supplemented with the flotation cleaning of the magnetic product. In one–stage separation the concentration of manganese in the magnetic product amounted to 25.4% to 27.2%, with the recovery of 68.4 to 72.1%. The flotation cleaning of the magnetic product increased the grade of the concentrate to 35 to 41%, with the recovery of 65 to 85%.

CONCLUSIONS

High technological efficiency of the VMS 100/2 separator was thus proved and the VMS separators can thus be recommended for implementation in other plants for beneficiation of manganese.

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