

**DEVELOPMENT AND COMMERCIAL TEST OF *SLON-2000*
VERTICAL RING AND PULSATING HIGH-GRADIENT
MAGNETIC SEPARATOR**

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Abstract

Slon-2000 vertical ring and pulsating high-gradient magnetic separator is an efficient industrial equipment for processing weakly magnetic minerals. It has been recently developed at the Ganzhou Non-Ferrous Metallurgy Research Institute. A six-month commercial testwork to process low-grade hematite ore was completed in Chong Changeling Mineral Processing Plant in 1995. compared with WHIMS-2000 wet high-intensity magnetic separator, the grade of the concentrate is by 7.21% higher the grade of the tailings lower by 5.41% and the iron recovery higher by 7.36%. Particularly, the matrix is always clean so that the matrix clogging usual in the WHIMS - 2000 machine has been overcome.

INTRODUCTION

As the mining scale of oxidised iron ore increases and reserves of rich iron ores decreases, the minerals processing industry is facing problems with treating low-grade and finely disseminated oxidised iron ores. High-intensity magnetic separation has a very important position in the processing of oxidised iron ore. Unfortunately, most high-intensity magnetic separators face a problem of matrix clogging.

Such a problem is, for instance, serious in processing in beneficiation of the hematite ore in Gong Changeling Mineral Processing Plant of Anshan Iron and Steel Company. The grade of the mined ore was about 30% Fe in 1980s and has dropped to about 28% Fe in 1990s, with annual rate of decrease of about 0.2% Fe.

There are five wet high-intensity magnetic separator installed at the plant. Their ring diameter is 2000 mm (WHIMS-2000), with grooved plates as matrix. The separators are used as roughers for - 2 mm hematite. Because the feed contains many coarse particles and some strongly magnetic particles such as magnetite and maghemite, the matrix can be very easily clogged. This happens even when the gaps between the grooved plates is set to 3.5 mm which results in unstable beneficiation results and in demanding maintenance.

In order to solve these problems, a contract was signed between Gong Changeling Mining Company and Ganzhou Nonferrous Metallurgy Research Institute (GNMRI). It was agreed that GNMRI designs and builds *SLon-2000* Vertical Ring and Pulsating High-Gradient Magnetic Separator. It was also agreed that GNMRI delivers the separator to Gong Changeling Mineral Processing Plant in order to carry out commercial tests for a period of six months. The aim of the tests was to compare the results with those obtained with WHIMS-2000. The target of the testwork was that *SLon-2000* must eliminate the matrix clogging and that the grade of the tailings must be lower by 2% than the tailings produced by WHIMS-2000.

STRUCTURE AND PRINCIPLES OF OPERATION OF *SLON-2000*

SLon-2000 magnetic separator consists of the pulsating mechanism, the energising coil, magnetic yoke separating ring, the feed and product boxes, as is shown in Fig. 1. Its operating principles are as follows: while the direct electric current flows through the energising coil, a magnetic field is built in the separating zone. Stainless steel 5 mm rods were used as a matrix in these commercial tests.

The ring with the magnetic matrix rotates around its horizontal axis. A slurry fed from the feed box enters the matrix located in the separating zone. Magnetic particles are attracted from the slurry onto the surface of the matrix and are then

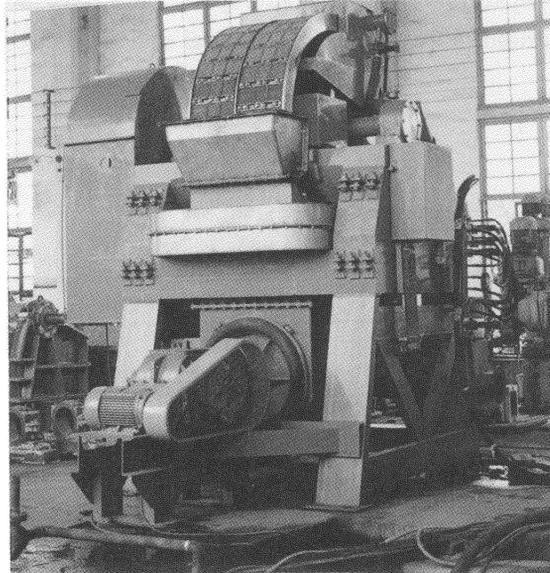


Fig. 1 *SLon-2000* vertical-ring and pulsating high-gradient magnetic separator

brought to the top of the ring where the magnetic field is negligible. Magnetic particles are then flushed into the concentrate box. The non-magnetic particles pass through the matrix and enter the tailings box under the combined force of the slurry pulsation, gravity and hydrodynamic drag.

Since the ring rotates in the vertical plane, direction of the flush is opposite to that of the feed, relative to each segment of the matrix. The pulsating mechanism drives the slurry in the separating zone up and down keeping particles in the matrix section in a loose state at the time. Magnetic particles can thus be more easily captured by the matrix and the non-magnetic particles can be more easily dragged to the tailings box through the segment of the matrix.

Therefore, the opposite flushing and pulsation help to prevent the matrix clogging, and the pulsation help to purify the magnetic product. These measures guarantee

that the *SLon-2000* separator possesses an advantage of higher ratio of beneficiation, higher efficiency and considerable flexibility. The main specifications of the *SLon-2000* separator and the plant operational data in this commercial testwork are summarised in Table 1. The electrical and magnetic specifications are listed in Table 2.

Table 1. Specifications of *SLon-2000* separator

Parameters	Designed data	Applied data
Ring diameter*width (mm)	2000*900	
Background field (T)	0 to 1.0	0.85
Energizing current (A)	0 to 1080	800
Energizing voltage (V)	0 to 76	52
Energizing power (Kw)	0 to 82	41.6
Driving motor (Kw)	5.5 + 7.5	
Pulsating stroke (mm)	0 to 30	14
Pulsating frequency (min ⁻¹)	0 to 300	300
Pressure of water (MPa)	0.3 to 0.5	0.3
Water consumption(m ³ /h)	100 to 200	180
Feed size (mm)	0 to 2.0	0 to 2.0
Feed solid density (%)	10 to 45	35 to 45
Slurry throughput (m ³ /h)	100 to 200	100 to 170
Ore throughput (t/h)	50 to 80	60 to 70
Mass of machine (t)	50	
Dimensions (L*B*H, mm)	4200*3500*4300	

COMMERCIAL TESTS

The Ore and the Flowsheet

The ore is the Anshan-type iron ore containing mainly magnetite, maghemite and hematite intergrown with quartz and other gangue minerals. It contains very little sulphur, phosphorus and other harmful gangue minerals. Crystal size of the

Table 2 Electrical and magnetic data of *SLon-2000* separator

Energizing current (A)	Energizing voltage (V)	Energizing power (Kw)	Background field (T)
100	8.0	0.80	0.109
200	15.2	3.04	0.230
300	20.0	6.00	0.342
400	26.0	10.4	0.453
500	33.8	16.9	0.580
600	39.6	23.8	0.694
700	46.0	32.2	0.781
800	52.0	41.6	0.851
900	58.0	52.2	0.918
1000	64.0	64.0	0.975
1080	71.0	76.7	1.026

iron minerals is mainly from 0.037 mm to 0.125 mm, and the average size of quartz is about 0.13 mm. The grade of the mined ore is about 28.4% Fe.

As the mined ore contains low percentage of iron it is very important to discard as much gangue as possible, and as early in the process as possible. Since it contains very low concentrations of harmful elements, it is relatively easy to use magnetic and gravity methods to concentrate the iron minerals. Schematic diagram of the hematite beneficiation is shown in Fig. 2 in which flowsheet the *SLon-2000* separator was installed in parallel with WHIMS-2000 separator to carry out the commercial tests.

The ore is ground by two primary D2700×3600 ball mills to about -2 mm (about 40% - 200 mesh). four D1050×L2100 medium intensity drum permanent magnetic separators (MIMS, the average magnetic field on the drum surface is 0.18 to 0.20 Tesla) are used to remove magnetite and a portion of maghemite. The non-magnetic product from MIMS containing mainly hematite and a portion of maghemite is fed in parallel into the *SLon-2000* and WHIMS-2000 separators. These separators discard immediately most of the final tailings.

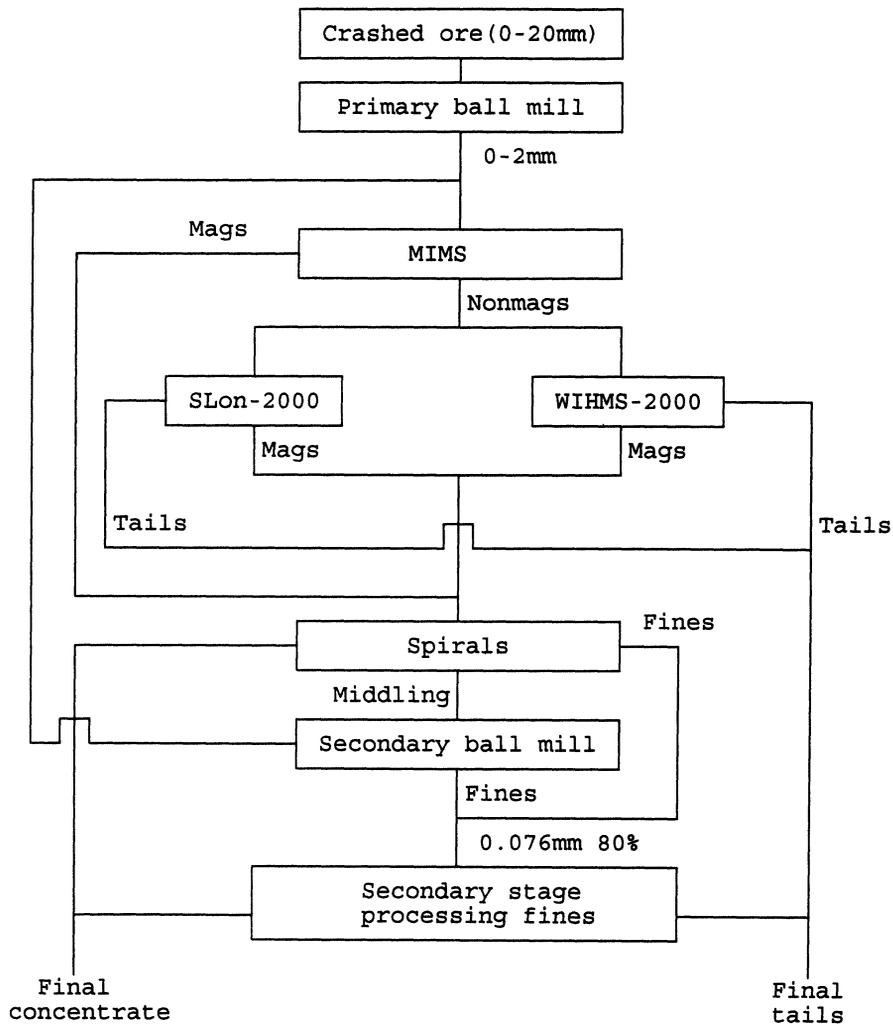


Fig. 2 A simplified flowsheet use in the commercial tests

The magnetic fractions from MIMS, *SLon-2000* and *WIHMS-2000* are further cleaned to the grade of 63.5% Fe by spirals and other separators. The middlings from the spirals are further ground by a secondary D2700×3600 ball mill and returned to join the MIMS feed.

An advantage of this flowsheet is that the *SLon-2000* separator and the WHIMS-2000 separator can discard approximately half (by mass to the primary ball mill feed) of the final tailings in the coarse stage, so that all of the following equipment and the processing costs can be reduced. The feed characteristics of *SLon-2000* and WHIMS-2000 are shown in Table. 3.

Table 3 The feed into the *SLon-2000* and WHIMS-2000 separators

Grade (Fe%)	FeO (%)	Solid density (%)	Size (0.076 mm %)
25.34	2.25	39.2	50.5

Determination of the *SLon-2000* Operating Parameters

In order to optimise the operating parameters of *SLon-2000*, conditional tests of the background magnetic field, pulsation and the ore throughput were done, as is shown in Tables 4, 5 and 6.

Table 4 Results of *SLon-2000* background magnetic field tests

Background field (T)	Grade (Fe%)			Mass of mags (%)	Recovery of iron (%)
	Feed	Mags	Tails		
0.78	22.48	36.53	8.32	50.19	81.57
0.85	22.48	35.88	7.96	52.01	83.01
0.92	22.48	34.72	7.70	54.70	84.48
1.00	22.48	34.6	7.41	55.42	85.31

As the background magnetic field increases, the recovery of iron increases while the grades of the mags and the tailings decrease. Reasonable background magnetic field is 0.85 T for this type of an ore, and the corresponding energising current is 800 A, voltage 52 V and power 41.6 kW.

Table 5 Results of the *SLon-2000* pulsation tests

Pulsation		Grade (Fe%)			Mass of mags (%)	Recovery of iron (%)
Frequency (mm)	Stroke (mm)	Feed	Mags	Tails		
0	0	23.32	34.71	8.27	56.92	84.72
300	14	23.32	39.55	7.91	48.70	82.60
Difference		0	+4.84	-0.36	-8.22	-2.12

Table 5 shows that the slurry pulsation increases the grade of the mags by 4.84% Fe, and reduces both the grade of the tailings by 0.36% and the mass of the mags by 8.22%, compared to a situation when no pulsation was used in the same *SLon-2000* separator. The fact the the recovery with pulsation is slightly lower is a results of the fact that the grade of the mags is higher.

Table 6 Results of the *SLon-2000* throughput tests

Feed			Grade (Fe%)			Recovery of iron (%)
Volume (m ³ /h)	Throughput (t/h)	Solid density (%)	Feed	Mags	Tails	
105.0	55.2	38.3	25.76	40.40	9.50	82.53
117.2	61.2	38.7	27.33	41.85	10.39	82.45
130.6	76.9	41.5	28.18	44.98	12.70	76.54
166.5	102.4	43.7	29.76	45.62	13.33	78.00

The throughput tests demonstrated that the *SLon-2000* separator can treat up to about 100 tons per hour of such a hematite ore, as can be seen in Table 6. To get better tailings and consider its tonnage, it is more advantageous to set the throughput to 60 to 70 tons per hour.

Comparison Tests with WHIMS-2000

During the commercial tests the *SLon-2000* separator ran for six months in parallel with the WHIMS-2000 separator, from September 1, 1994 till February 28, 1995. Its installation on the plant is shown in Fig. 3. The efficiency of beneficiation, operating hours, water and electricity consumption were compared with WHIMS-2000. The employed operating parameters of *SLon-2000* are shown in Table 1 while the test results are summarised in Table 7.

Table 7 The average comparative results of 6-month tests

Separator	Grade (Fe%)			Mass of mags (%)	Recovery of iron (%)
	Feed	Mags	Tails		
SLon-2000	25.94	41.21	10.74	49.89	79.25
WHIMS-2000	25.94	34.00	16.15	54.85	71.89
Difference	0	7.21	-5.41	-4.96	7.36

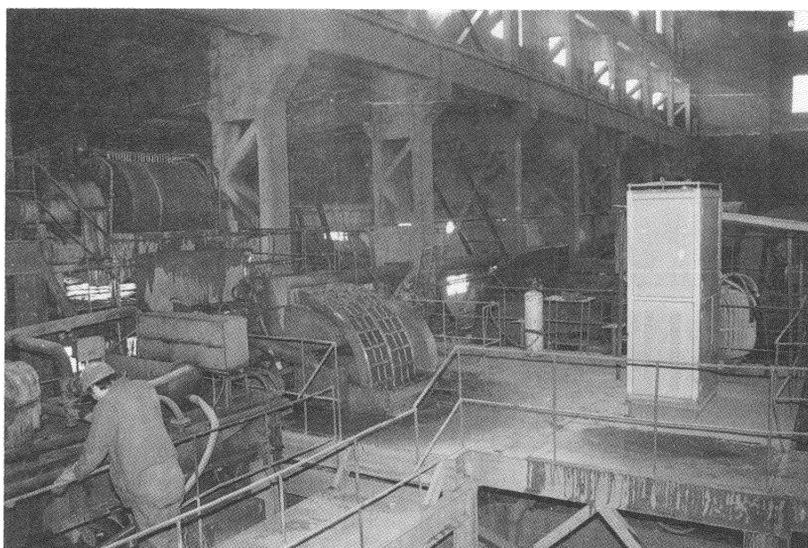


Fig. 3 *SLon-2000* in operation in Gong Changling Mineral Processing Plant

Table 7 shows that the *SLon-2000* separator can achieve a much higher grade and the recovery into the mags, much lower grade of the tailings and lower mass yield into the mags than WHIMS-2000. A higher grade of the mags is mainly due to the contribution of its pulsating mechanism. a lower grade of the tailings and a higher recovery of iron is mainly due to the fact that the matrix is always kept clean and that the magnetic force acting on the iron mineral particles is stronger. The lower mass yield into the mags is favourable for the subsequent processing procedure and the secondary ball mill.

Table 8 Comparison of the operating time in six months

Separator	Calendar time (h)	Ball mill work time (h)	Operat. time (h)	Operat. ratio (%)	Matrix and ring problem (h)	Other problem (h)
SLon-2000	4344	4270	4220	98.8	0	50
WHIMS-2000	4344	4270	3351	78.5	793	126
Difference	0	0	+ 869	20.3	-793	-76

The operating time and the availability of *SLon-2000* are 4220 hours and 98.8%, respectively, in the 6-month commercial test, as is shown in Table 8. It is 869 hours and 20.3% higher than with WHIMS-2000 separator. The matrix clogging and the ring problem are the major problems affecting the operation of the WHIMS-2000 separator. It has been demonstrated that the magnetic matrix of the *SLon-2000* separator is always kept clean which is very important for maintaining high availability and for reducing the maintenance work.

Table 9 shows that *SLon-2000* and WHIMS-2000 consume the same amount of water ($3 \text{ m}^3/\text{t}$) for each ton of ore treated. Table 10 indicates that *SLon-2000* consumes only 0.86 kWh per ton of feed, 0.26 kWh less than WHIMS-2000.

Table 9 Comparison of water consumption

Separator	Ore Throughput (t/h)	Water Consumption (m ³ /h)	Unit Water Consumption (m ³ /t)
SLon-2000	60	180	3
WHIMS-2000	40	120	3

Table 10 Comparison of electricity consumption

Separator		Installed power (Kw)	Measured power (Kw)	Unit power consumption (Kwh/t)
SLon-2000	Energizing	82	41.6	0.86
	Driving	5.5 + 7.5	4.1 + 5.6	
	Total	95	51.3	
WHIMS - 2000	Energizing	52	26	1.12
	Driving	25	18.8	
	Total	77	44.8	
Difference		+ 18	+ 6.5	-0.26

CONCLUSIONS

The six-month commercial testwork in processing low-grade hematite ore in Gong Changeling Mineral Processing Plant demonstrated that the *SLon-2000* vertical ring and pulsating magnetic separator is a reliable and efficient equipment for processing weakly magnetic minerals. The separator increased the grade of the magnetic concentrate by 7.21% Fe and the recovery of iron by 7.36%. Its throughput is 50% higher compared to the WHIMS-2000 wet high-intensity magnetic separator.

Because the ring of the separator rotates vertically, allowing the magnetic fraction to be flushed in a direction opposite the that of the feed, and because the pulsating mechanism keeps the slurry in the separation zone pulsating, the matrix

is always kept clean. Onerous problem of matrix blockage that exists in wet high-intensity magnetic separators with a horizontal ring is thus eliminated. The maintenance work is thus considerably reduced and the availability of the separator increased.

The commercial tests fully satisfied the conditions of the contract signed between Gong Changeling Mining Company and Ganzhou Nonferrous Metallurgy Research Institute.

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