

Current status and application of fine screening technology in China

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Abstract. The paper presents data on the design and technical parameters of high frequency vibrating screens, which are produced by Chinese manufacturer – company Landsky Tech Ltd. The technology of high frequency vibration is widely used at mining and metallurgical industries to separate fine and ultra-fine particles from the flow of dry material or pulp. The paper contains different types of screening systems, description, advantages and disadvantages of equipment and test results from mineral processing plants.

1. Introduction

China remains the undisputed leader in the field of production and beneficiation of a broad spectrum of ores and non-metallic minerals, mining and chemical products. Since 2000 China government introduced so called «five-year plans», which promoted rapid development of extraction and mineral raw materials processing industries. Intensive growth has affected almost all types of ores and non-metallic minerals. High iron ore concentrate and cement production growth rates (3-3,5 times since 2000) should be mentioned as well. As of 2015, China remains the leader in the field of production and beneficiation of a wide range of minerals and some minerals extraction volumes exceed the total world figures.

Huge volumes of extraction and processing of mineral raw materials, as well as a tendency to increase their production, starting in 2003, led to the formation on the whole territory of China a major mining and processing companies and small independent companies requiring effective and at the same time, high-performance equipment. Grinding process is considered to be one of the most energy-intensive cycles in mineral raw materials processing, particularly closed «mill-classifying equipment» cycles. Processing of refractory ores with thin grain structure is a standalone problem which requires highly efficient classifying equipment. In addition, the development of the market of building materials and chemical industry since the early 2000-s has required the development of technologies of dry fine screening using high-efficiency equipment, as well operating in closed circuit with a impact or ball mills.

This article provides an overview of the technology application status in fine screening in China.

2. Statement of the problem

The technology of fine screening has a long history of application in the mining production, but only in the last decade a process of fine screening has been widely implemented to mineral processing



technological scheme of different countries: Russia, Brazil, USA, Canada, Mexico, Asian countries. This technology is claimed to improve the concentrate quality and reducing the cost of processing ore.

Preconditions for the emergence and development of fine screening technology in China:

1. Private rural and medium processing plants, springing up all across the country, require productive and, at the same time, low-cost machines.

2. Raw materials with a thin impregnation of minerals (up to 63 μm) should be processed as well.

3. The search for ways of increasing the degree of extraction of valuable components.

4. Improving the efficiency of the whole factory, to reduce factories energy consumption.

The current situation with the search of highly efficient equipment for dry and wet screening and classification, both in China and around the world gave impetus to the development of technologies and equipment fine screening.

3. Presentation of material and results

«Landsky» is known as one of the largest China companies in the domain of research, development and manufacturing of technologies and equipment for fine screening. It was formed in August 1997 and has been operating successfully to the present, satisfying the requirements of the domestic market and consumers abroad. Since its inception, the company Landsky received about 40 patents for inventions, useful models and methods of fine screening. Vast experience in the field of screening of mineral raw materials, industrial testing and processing, and the largest chemical enterprises in China allowed to identify 5 series of screens to successfully sort the fine material in the range from 10 mm to 0.044 mm (in exceptional cases on test plants up to 0.030 mm):

1. Multideck multi-vibrating screen for fine screening of DxF type.

2. High frequency vibrating screen with vibration transmitted only on the screening surface of Series (MVS) and single-deck high-frequency screen with a complex type vibration (series FMVS).

3. Linear high frequency screen for a fine screening DxZ type.

4. Circular rotary vibrating screen HYS type.

5. High performance linear vibrating screen with a rectilinear form deck (LKSB type) and banana shape decks (LKBB).

The most widely used in industry received *multi-decks multivibration screens for fine screening*, which is the patented product of the company Landsky. Screens use only one source vibrations – two vibration motor, to obtain the dual type vibration consisting of linear vibration on the deck the screen and vibration of the sieve generated by the blows of a sieve on a number of oscillating rods; vibration parameters can be changed through the frequency of pre education. Screens of this type have several advantages, such as:

1. A unique type of vibration.

2. Low energy consumption.

3. High grating efficiency.

4. High performance.

5. The simple structure of the screen and operation.

This equipment is mainly used for screening and dehydration of fine ores, coal, nonmetal materials.

The screens are designed with 1 to 5 decks relatively to the desired performance at the factory. Dewatering screens are mainly used for dewatering tailings, quartz sand and coal slurries and basically have one screen. Multivibration screen are used at China's largest mining and processing enterprises engaged in the extraction and concentration of iron, titanium, ore and polymetallic raw materials. Ten largest steel companies in China use both single- and multideck-screens in their closed grinding cycles.

The application of 6 screens of D5Z1216 type at the processing plant of the concern Daxigou Mining Group allowed to achieve the efficiency of screening the cell of 0.2 mm to an average of 88.97 % when working in a closed circuit with a ball mill with a capacity of 800 t/h of iron ore. The performance of the screens is presented in table 1.

Table 1. The performance of the screens D5Z1216 at the processing plant Daxigou Mining

Group					
Screen number	The content of the class -0,074 (-200), %			Yield of undersize, %	Efficiency, %
	Feeding	Oversize	Undersize		
1	59.12	17.28	76.04	71.20	91.58
2	75.43	33.70	83.28	84.17	92.93
3	55.91	22.61	70.52	69.51	87.67
4	58.66	22.53	75.89	67.71	87.60
5	60.47	25.00	76.72	68.58	87.01
6	58.64	23.00	76.21	66.98	87.05
Average	61.37	24.02	76.44	71.36	88.97

Mneral processing plant of Ma Steel group is designed to process up to 1 million tonnes of iron ore annually. Technological scheme includes three stages of crushing with the output of the non-magnetic fraction after each stage and one stage of regrinding with beneficiation of undersize product at magnetic separator with low magnetic field strength. To improve the efficiency of operation of the mill in closed circuit with hydrocyclones, a decision was made by the introduction of fine screening. The efficiency gains amounted to about 10% of the cell 0.1 mm and the average effectiveness is at the level of 71,84%. The performance of the screens is presented in table 2.

Table 2. The performance of the screens D5Z1014 at the processing plant of Ma Steel Group

Screen number	The content of the class -0,074 (-200), %			Yield of undersize, %	Efficiency, %
	Feeding	Oversize	Undersize		
1	82.5	70.7	92.6	83.88	60.48
2	85.5	71.9	92.6	65.70	71.16
3	81.4	61.6	90.7	68.04	75.81
4	84.5	68.2	92.9	65.99	72.55
5	85.5	67.9	91.1	75.86	80.83
6	88.3	78.6	93.8	63.82	67.79
Average	84.62	69.82	92.28	65.88	71.84

The performance of the screens D5Z1014 at the processing plant Shi Rengou shows similar rates of screening compared to world leader technology fine screening – Derrick company. The average work of screening equipment of Landsky company is 45,96% for the 0.1 mm cell against 49,62 % when working on the Derrick screens Stacksizer 2ST48-90W-5STK. Common performance indicators are presented in table 3.

Table 3. Comparative performance of screens Landsky D5Z1014 and Derrick 2ST48-60W-5STK at the processing plant Shi Rengou

Screen number	The content of the class -0,074 (-200), %	Yield of undersize, %	Efficiency, %	Solid content, %
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	Feeding	Oversize	Undersize			
	25.00	17.40	59.50	18.05	42.96	65.27
	23.30	15.40	57.90	18.59	46.19	58.52
	25.90	15.40	56.80	52.36	55.62	62.34
	24.40	16.60	60.70	17.69	44.00	63.32
Landsky	23.00	14.40	59.50	19.07	49.33	61.43
D5Z1014	23.00	15.00	59.90	17.82	46.40	61.39
	24.20	15.30	57.00	24.34	50.27	61.71
	22.90	16.50	56.30	16.08	39.53	60.54
	23.10	16.60	57.60	15.85	39.53	58.80
	19.00	12.10	58.90	14.74	45.71	36.60
Average	23.38	15.47	58.41	18.46	45.96	61.69
	24.90	15.70	49.10	27.54	54.32	61.12
Derrick	19.00	12.20	44.60	20.99	49.27	61.81
2ST48-	18.30	12.40	44.10	18.61	44.85	60.55
60W-	19.60	13.20	46.10	19.45	45.75	62.46
5STK	18.60	11.10	44.00	22.80	53.93	59.56
Average	20.08	12.92	45.58	21.88	49.62	61.25

Screens series MVS of Landsky company for dry and wet screening of ores and non-metallic materials. The main feature of these screens is the use of electromagnetic vibrators (between 8 and 12), that transmit vibration to the sieve surface only. The main features of the screens:

1. The vibration is transmitted only on the screening surface, the frame remains stationary.
2. Adjustable high frequency vibration of 50 Hz (3000 min⁻¹) with an amplitude of 1-2 mm allows to screen material in the range from 3 to 0.043 mm.
3. The vibration intensity is 8-10g, which is 2-3 times higher than ordinary vibrating screens.
4. The specific productivity of screens reaches 3.75 – 6.5 t/h*m².
5. The angle of inclination of the screening machine can be easily changed depending on the required parameters of the screening.
6. Low power consumption – each electromagnetic vibrator consumes about 0.25-0.3 kWh .
7. The performance of the screen can be single-deck and double-deck with decks arranged in parallel on the same level or below each other in a modular design.
8. Strong vibrations cycles can be used to clean the sifting surface from the stuck grains.

Dry screening for fine classification (-10 mm) is used to prepare coal, building materials, materials of chemical industry, fertilizers, etc. In this case, the screen can be performed in one and two-channel form. Screen for wet screening can be performed in two ways: for classification and dehydration of the material. Screen for the classification can be performed as a cascade (1-2 deck), while the screen for dehydration is mainly single-deck and is applied to tailings, quartz sand and coal slurries

On the Gongchangling iron ore factory tests were carried out using two types of screening surfaces: metall and polyurethane. In general, the grating efficiency for PU panels is bigger and reaches up to 90% (Table. 4).

Table 4. The performance of vibrating screens MVSZ at the Gongchangling concentrator

Screen number	Type of screening	Feeding	Oversize product	Undersize product	Screening
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	surface	% solid	Con. of -0.044 mm, %	Extraction, %	Con. of -0.044 mm, %	Extraction, %	Con. of -0.044 mm, %	Extraction, %	efficiency, %
1	Metal. (0.10)	27.74	81	60.59	63	50.95	90	65.89	74.07
	PU (0.10)	27.74	81	60.59	37	26.16	89	65.61	92.97
2	Metal. (0.10)	37.67	78	59.82	65	45.86	90	63.31	60.00
	PU (0.10)	37.67	78	59.82	38	37.97	90	66.24	88.76
3	Metal. (0.10)	47.92	78	62.96	65	57.59	90	68.36	60.00
	PU (0.10)	47.92	78	62.96	38	55.84	90	67.29	88.76
4	Metal. (0.10)	41.3	66	56.4	61	53.05	82	65.19	29.58
	PU (0.10)	41.3	66	56.4	35	43.83	89	66.73	77.41

A separate group can be distinguished for *single-deck high-frequency screen to a complex type vibration (series FMVS)*. The main feature of the screens is a combination of two systems that create vibration: linear and electromagnetic exciters. High intensity and frequency of vibration (50 Hz) generated by electromagnetic exciters allows one to sieve the material with high efficiency, while a linear exciter generates vibration with a large amplitude but less frequency (16 or 25 Hz) and force allowing one to disintegrate the material and to transport it freely across the length of the screening surface. This combination is the best for fine screening and more effective than vibration caused by a single source.

Screens series FMVS are used for processing of tin ore with a maximum efficiency of 87.41% (Table. 5).

Table 5. Technical specifications of the vibrating screens series FMVS

Screen number	% solid.	Con. of -0.044 mm in feeding, %	Con. of -0.044 mm in undersize, %	Con. of -0.044 mm in oversize, %	Efficiency, %
1	15.50	53.15	28.06	61.01	87.41
2	16.46	47.24	21.59	58.57	86.00
3	9.76	91.85	27.10	84.05	82.92
4	13.07	57.33	24.04	73.71	86.17
5	5.16	61.45	23.25	92.40	83.07
6	11.91	51.41	24.17	82.40	74.98
7	14.29	49.04	21.86	76.42	77.63

Screens of this type are widely used in the field screening of ores, preparation of coal for beneficiation, screening of building and chemical materials etc. Similarly, they are used for dry fine screening (-10 mm) of coal, materials for the brick industry, chemical industry, production and sorting

of fertilizers etc. the surface of the screening can be performed in single- and double-deck design.

Screens are widely used in coal industry for dewatering of coal sludge and coal preparation for further beneficiation. Screens show a high grade of extraction, efficiency of screening, and reduces grinding material in the oversize product (3-10%) at high throughput. While using hydrocyclones with screening system with a curved sieve screens, a series of FMVS can be used to create complex extract of coal slurries after jiggling machines for subsequent beneficiation by flotation or tailings of magnetic separators.

The next group – *high frequency linear screens of DxF series*. High frequency vibrating screens with linear vibration type series are suitable for low density slurries, the solid extraction and dewatering, and slurries with low content of positive material for scalpers and protective screening. Depending on the application, screen deck is placed with the inclination of -10° to $+15^{\circ}$. Maximum volumetric throughput can be achieved on screens with a negative angle of inclination of the deck that leads to the formation of pool at feeding side. Hydrostatic pressure promotes the oversize class through a sieve, while the vibrating motion of the deck effectively dehydrates and transfer oversize material to the discharge side. The screens are mostly equipped with one or two vibrating motors of Martin Engineering.

For beneficiation of hard-processing iron ore mined in the mines of the group Shibao Mining Group, a few screens were tested for fine screening. Work of screens Landsky showed a high grade of efficiency up to 80% (average 75.35%) with the aperure of 0.1 mm, and the performance indicators on all 8 screens are almost identical and almost twice the performance of the screens of other Chinese companies (table 6).

Table 6. The performance of the Landsky 2DZ1014 screens at the Shibao Mining Group

Number of screen	The content of the class -0,074 (-200), %			Yield of undersize, %	Efficiency, %
	Feeding	Oversize	Undersize		
1	90.00	77.00	98.00	61.90	67.41
2	91.00	80.00	96.00	68.75	72.53
3	91.00	80.00	96.00	68.75	72.53
4	91.00	80.00	97.00	64.71	68.97
5	92.00	73.00	98.00	76.00	80.96
6	93.00	70.00	97.00	85.19	88.85
7	94.00	76.00	97.00	85.71	88.45
8	87.00	73.00	98.00	56.00	63.08
Average	91.13	76.13	97.13	70.88	75.35

Rotary screens circular series HYS is a new patented product of Landsky for a dry high-frequency fine-screening. Assembly of screen boxes are designed to simulate motion for the type of manual screening, and the complex ladder structure, driven by electric motors. This type of circular parallel motion in screen provides the best way to move material in the screen surface, allowing to increase the possibility of sieving of the material and, thereby, increase the effectiveness of screening. Screen group can be modeled based on the wishes of the customer with different numbers, one screen can be used for the production of various size products.

Vibrating screens of this series have many advantages: simple operation, reliable performance and high efficiency of screening (98%). Vibrating screens are mainly used for dry screening of fine materials, production of non-ferrous sand, building materials, quartz sand and other industries.

Linear-vibrating LKSB and LKBB type screens are used to perform important sorting task in the industry because of its reliable performance and stable design. These screens are used primarily for

preliminary screening and for sorting on different mineral processing factories. High performance sieves are used for sieving of gravel, sand, coal and ore and crushed material with dry and wet method of screening in the mining industry.

Key features:

1. Proceedings under the patented German technology enterprise of China.
2. The key components are imported.
3. The average service life of the screen box is 15 years.
4. The Screen box is manufactured with the width up to 5.1 m.
5. Protection of bottom deck of polyurea coating.

Maximum vibration amplitude for these screens is 16 mm at the maximum frequency of rotation of directed exciters is 1000 rpm (25 Hz).

A special model of vibrating screens – «banana screens» – is used for almost any separation process: classification, washing, dewatering, wet screening and screening of finely divided material. Thanks to sets of deck plates are mounted under different angle, and thus they form the shape of a banana; this type of screens can process large volumes of bulk materials with a high content of fine particles with the greatest speed. Used in this type of screens, the effect of "thin bed" allows one to provide the best separation efficiency at high throughput compared to conventional linear vibration screens of the same size.

Mounted on mineral processing factory Chengde Tianbao Mining Co., the screen 2LKSB1545 operates in closed circuit with a cone crusher. Separation occurs on two decks with a cell size of 30x30 and 20x20 mm. The separation efficiency on the decks screen is 87-88% and 85%, respectively. The average grating efficiency on the linear vibrating screens in the processing of bulk materials with irrigation with size up to 1 mm is 80-85% (table 7).

Table 7. Performance in closed circuit with a cone crusher vibrating screens LKSB at the processing plant Chengde Tianbao Mining Co.

Fraction, mm	Feeding		Undersize product		Oversize product		Efficiency	
	Yield, %	Weight	Yield, %	Weight	Yield, %	Weight	Upper deck (30 mm)	Bottom deck (20 mm)
-80+40	3.00	24.00	-	-	5.80	24.00		
-40+30	13.00	104.00	-	-	25.15	104.00		
-30+20	22.60	180.80	-	-	43.72	180.80		
-20+15	13.40	107.20	15.57	60.15	11.38	47.05	87-88%	85%
-15+10	16.1	128.8	26.06	100.67	6.8	28.13		
-10+5	12.40	99.20	21.95	84.82	3.48	14.38		
-5+0	19.50	156.00	36.43	140.79	3.68	15.21		
Total	100.00	800.00	100.00	386.43	100.00	413.57		

4. Conclusion

On the basis of the foregoing, it can be concluded that today China has all the modern technology and equipment for fine screening, which can successfully replace the traditional system of classification of ores and non-metallic materials both in the existing schemes and at new mineral processing factories. In addition, China can compete in its parameters with modern classifying equipment manufacturers.

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