HOT
Process For Environment

THE MAGIC
MINERAL PROCESSING

TOWARDS UNDERSTANDING THE A.I., AND

SMART PROCESSING

/ Heng Huang

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TOWARDS UNDERSTANDING THE FUTURE SMART PROCESSING

About Authors

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Deyong Wu, Co-Founder and Chief AI Algorithm Engineer of HOT (Chengdu) Industries Co Ltd, Deyong has nearly 20 years of experience in data analytics, software architecture, and artificial intelligence algorithm programming. He has successfully developed vital technologies such as intelligent algorithms applied for Sensor-based XRT Ore Sorting, Predictive Maintenance (AI Machine Health), and an X-Ray Ash-Moisture Analyzer. In addition, Deyong won the champion in the national college student mathematical modeling competition (as first author) during his university years.

Youlin Deng, R&D Director, Mechanical Engineer of HOT (Chengdu) Industries Co Ltd, Youlin has nearly 20 years of experience in the R&D of precision instruments and high-end manufacturing and mechanical design experience for large-scale process facilities (heavy equipment). He has successfully developed vital technologies such as Sensor-based XRT ore sorting, X-Ray Ash-Moisture Analyzer, and XRF Slurry On-Stream Grade Analyzer.

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How Are Mineral Processing Plants Contributing to A Lower-carbon World?

The processing plant is transforming to be different in the future. The primary drive is that improved value outcomes constantly change. Recently, change has been driven by the demand for more efficient water and power use and reducing greenhouse gas emissions. Only in the last two to three years have mining companies come to us saying that they need a greenhouse gas evaluation on their projects. For most projects, we are looking at greenhouse gas emissions.

Rapid progress for the mining industry is a reasonably fast change in approach, and it all needs to be managed carefully. However, the bottom-line objective remains unchanged: improved shareholder value within the environmental, social, and governance frameworks set by the government and society.
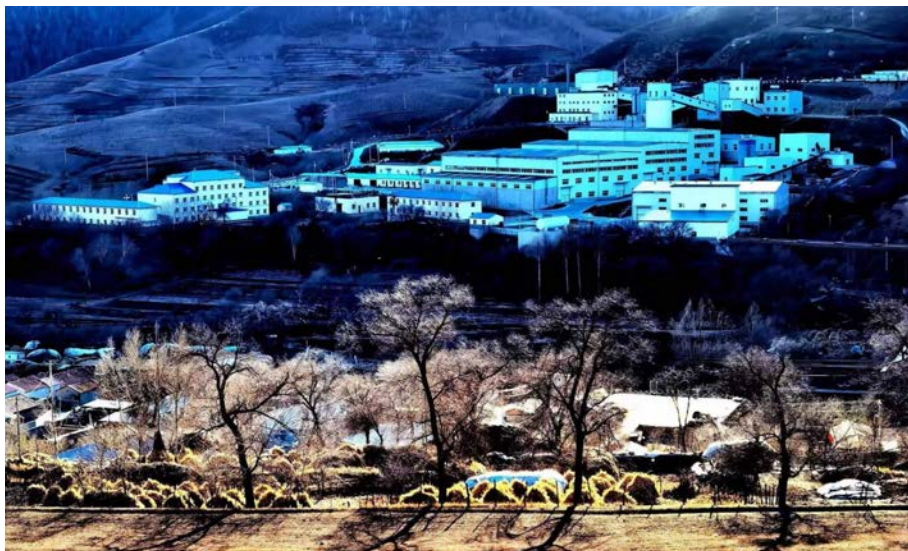
Unwilling to deny that energy and water consumption is more urgent than others.

Low energy efficiency and massive water consumption have become the predominant issue in numerous processing plants worldwide, especially in China, Mongolia, and other water-deficient areas. There are fundamental social reasons for this. Processing projects can have an actual and perceived impact on the water supply for rural regions. As a result, there is a move to increase the use of sensor-based sorting methods like XRT and CCD color or bulk sorting for pre-concentration that can discharge many rejects at the very beginning. With this technology, mineral processing plants can save much energy for grinding, flotation, and tailing systems. Indeed, it also helps to minimize water consumption.
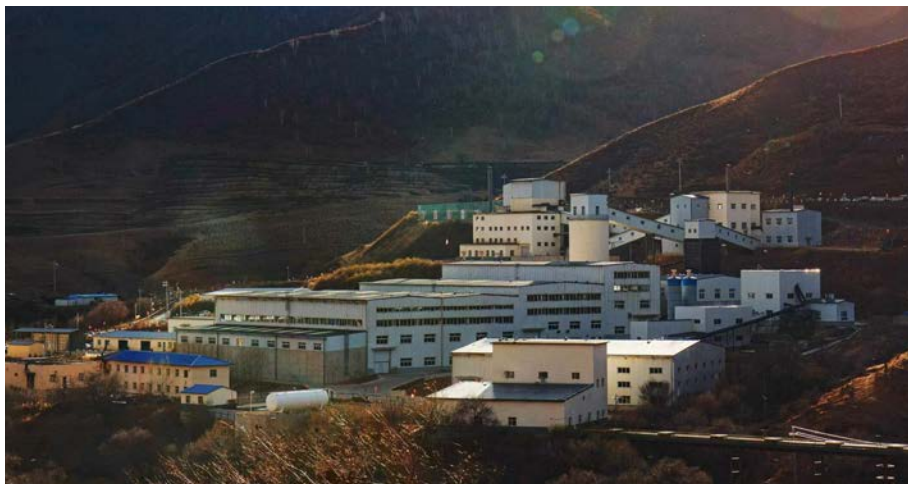
HOT is already seeing changes across the whole mining and processing chain, from screening to tailing. We are endeavoring to develop more environment-friendly technology to improve concentrate yield during processing.

The Innovation Trends—Latest in Sorting Tech Development by HOT

Developed from an ambitious Start-Up during the last decades, today HOT (Chengdu) Industries Co., Ltd (the former HOT Mining) provides cutting-edge innovations for the minerals processing industry that satisfies planet-friendly by ore pre-concentration and ore grade control, such as utilizing X-Ray Transmission Sensor-Based Sorting, CCD Optical/Color Sorting, AI Magnetic Resonance (MR) Sorting, and real-time elements analyzers like LIPS (Laser-induced Plasma Spectroscopy), X-Ray Penetration and X-Ray Fluorescence technology.

The minerals processing industry faces challenges in improving efficiency, benefit, and mine life. Matrix® CCD Ore Color Sorter and SorterX® Sensor-based XRT Ore Sorter are our revolutionary innovations enabling intelligent and effective mineral separation. The CCD Ore Color Sorter and Sensor-based XRT Ore Sorter are a duet of photoelectric sorting technology.

The SorterX® Ore Sorter is a sensor-based XRT ore sorter that combines X-Ray transmission (XRT), image recognition, and AI algorithm technology. SorterX® Ore Sorter features precise detection and ejection, especially for smaller particle sizes. SorterX® Ore Sorter shows excellent separation performance that can realize a 99% metal recovery rate, 90% discarding rate, and 40-380t/h capacity among the proven data from our users. In addition, it has made great strides in pre-discarding and pre-concentration to reduce the cost for subsequent processes and prolong the mine service life in an environmentally friendly manner.

The CCD Ore Color Sorter uses photoelectric detection technology to automatically sort out the heterochromatic particles in the granular material according to the difference in the optical properties of the material. As a result, after color separation, the ore has high purity and uniform color, which significantly improves the utilization rate of the ore and doubles its value. In addition, the CCD Ore Color Sorter can achieve the accuracy of one-time sorting, reaching more than 99% by proven data.

HOT Industries is one of few players that have successfully applied its Intelligent XRT Sensor-based Ore Sorter into nonferrous metals, ferrous metals, nonmetals, and coal mines. It has been implemented in typical minerals such as tungsten, tin, antimony, gold, copper, lead-zinc, coal, etc. Nowadays, HOT Industries has explored the Color Sorter + XRT Sensor-based Ore Sorter combo solution for Lithium sorting and recovery.

As a witness and participant in mineral processing, HOT Industries brings creativity to slight capacity separation and bulk sorting. AI Magnetic Resonance (MR) Sorting is a high-efficiency solution to improve the grade and output for size sorting minerals such as iron. The AI MR sorter uses the developed magnetic resonance sensing and ore sorting technology to improve the ore grade and production, which enables a large sorting capacity at 3,000~10,000 t/h. The sensor can continuously detect the iron grade, identify low-grade ore, and eject it through the actuator. The MR sorter will continually discard the low-grade ore to avoid entering the subsequent separation process, which can reduce the operation cost and improve production efficiency. Compared with XRT technology, AI Magnetic Resonance pre-discard sorting technology can further enhance the processing capacity.

HOT INDUSTRIES aims to build a comprehensive sorting solution for the mining industry, from intelligent processing equipment to quality/elements measuring devices and relevant AI-embedded systems. To support and enhance the minerals sorting, HOT Industries has also developed Laser-induced Plasma Spectroscopy (LIPS) Online Elemental Analyzer, an X-Ray Coal Ash Moisture Analyzer, and XRF Online Ore Pulp Grade Analyzer to measure and report the critical quality element in the mineral separation process, even to be fed measuring data back to PLC or intelligent control system in the processing plant. With the above minerals quality/elements measuring and report technologies, the whole minerals sorting system will be more reliable and intelligent to avoid the hysteresis of manual measurement.

Why Do Sensor-based Sorting Technologies Like XRT Skyrocket in China?

The Proportion of Coal Preparation Technologies in China (right picture 2005, left picture 2022)
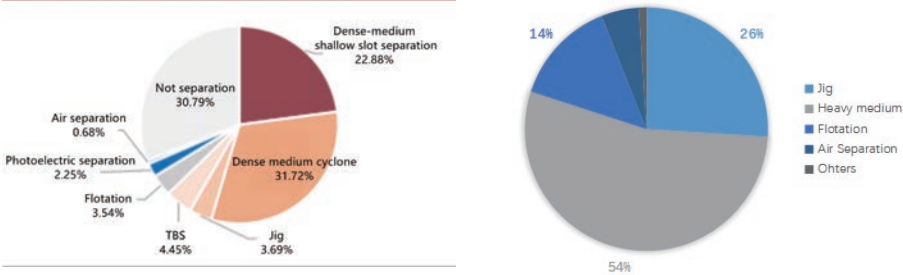
This pie chart depicts the evolution of methods for coal preparation from 2005 to 2022 in China.

Overall, the dominant processing technology is still the dense medium that includes the dense medium cyclone and bath. It cannot be ignored that the water-free method existed in 2022 which was not shown in 2005.

Obviously, the proportion of coal preparation methods on dense medium remains almost the same at about 54%, which is still the predominant process technology. In contrast, the jigging process has plummeted dramatically from 26% to 3.69%. The other coal concentrate methods have had slight changes during the past 18 years.

Nowadays, the innovative cutting-edge technology that integrated Artificial Intelligence into lump coal separation has been playing a crucial role in the coal

preparation industry in China. In 2005, nobody knows the XRT Sorting or called water-free separation. But engineers have approached the dream washes the coal without water. Thus, this method takes an important part in coal preparation now. In 2022, the raw coal that is processed by XRT accounts for 2.25% of all raw coal production in China, which is about 90 million tons per annual.

Why is XRT Sorting rapidly gaining popularity?

Apart from India, coal jigging machines have gradually been replaced by dense medium baths (vessels) and dense medium cyclones in many countries due to their low separation accuracy and low degree of automation. Therefore, the leading water-based and XRT Sorting technologies are currently dominated by dense medium baths (vessels) and optical-electronic sorting equipment.

1. From the perspective of sorting accuracy, XRT Sorting is close to the dense medium bath (vessel).

The rate of gangue in coal and coal in gangue is an essential indicator of sorting machine accuracy. Currently, both of these indicators for XRT Sorting are between 1-3%, which is close to the accuracy of heavy-medium shallow slot equipment and higher than other equipment, such as dynamic jigs and jumping jigs.

2. From an economic perspective, XRT Sorting has lower production costs and higher product sales output.

The economic efficiency of intelligent XRT Sorting equipment mainly lies in reducing the cost of coal sorting per ton and increasing the output of unit product sales.

1) From the perspective of sorting costs, XRT Sorting mainly reduces sorting costs through two methods: reducing labor costs and shortening the process flow. On the one hand, XRT Sorting does not require personnel to be on duty, so labor costs are significantly reduced. On the other hand, it requires fewer equipment units, and the initial investment cost for the entire process is lower— additionally, spare parts and maintenance costs, electricity consumption, and no water or medium consumption.

Investment in XRT Sorting equipment is significantly lower. In addition, XRT Sorting equipment has a smaller footprint and lower plant space requirements than dense medium baths (vessels).

Also, XRT Sorting can be portable, the above 3D design show how XRT is assembled in a container.

2) From the perspective of product sales output, XRT Sorting produces coal with lower moisture content. As a result, it avoids the production of secondary coal sludge, which enables higher tonnage of coal sales output. On the one hand, the heavy-medium shallow slot process uses water, which increases the moisture content of the lump coal it sorts and reduces its heating value compared to the lump precision coal produced by XRT Sorting. On the other hand, the heavy-medium shallow slot process is prone to making coal sludge. Coarse coal sludge has a low heating value and can only be blended into the final coal sales. In contrast, fine coal sludge has an even lower heating value and can cause blockages when blended into products, so it is usually dried before being processed. In times of poor market conditions, it may be directly discarded.

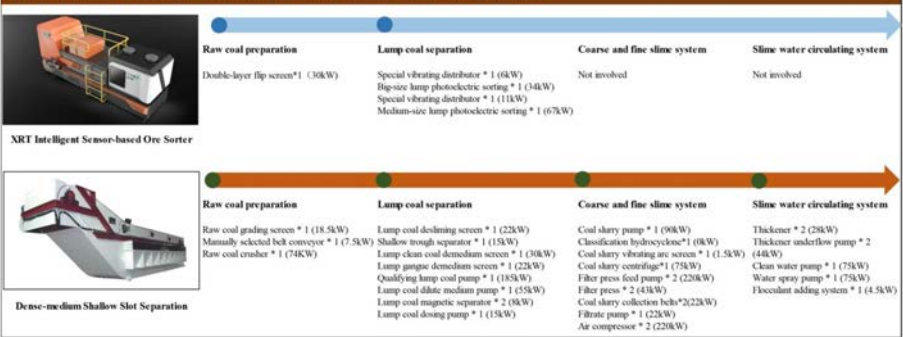Fig 6. Comparison of Intelligent Ore Sorting and Dense-medium Shallow Slot Separation

Table 2. Comparison of Production Costs of Intelligent Ore Sorting and Dense-medium Shallow Slot Separation

Item	Intelligent Ore Sorting			Dense-medium Shallow Slot Separation		
	Cost Indicators		Process cost (10000 yuan/year)	Cost Indicators		Process cost (10000 yuan/year)
Power rate	Installed power (kW)	538	125.4	Installed power (kW)	1372	380.9
	Annual power consumption (kW h/a)	1567748		Annual power consumption (kW h/a)	4760870	
	Electricity charge (yuan/kWh)	0.8		Electricity charge (yuan/kWh)	0.8	
Labor	Production personnel	17	255	Production personnel	34	510
	Per capita cost (10000 yuan/year)	15		Per capita cost (10000 yuan/year)	15	
Auxiliary materials	Medium water consumption and drug consumption (10000 yuan/year)		/	Medium water consumption and drug consumption (10000 yuan/year)		53.39
Maintenance	Spare parts (10000 yuan/year)		75.28	Spare parts (10000 yuan/year)		195.68
Depreciation	Depreciation (10000 yuan/year)		236.78	Depreciation (10000 yuan/year)		380.37
Total	Total(10000 yuan/year)		692.48	Total(10000 yuan/year)		1520.31
	Cost per ton of coal (yuan/ton)		2.31	Cost per ton of coal (yuan/ton)		5.07

The social, economic, and environmental value of mineral pre-enrichment is shown in the following figure:

Therefore, XRT Sorting is now widely used in the pre-concentrate field of coal, lead-zinc, tungsten, molybdenum, copper, phosphate, and spodumene (Lithium).

Will XRT Sorting Technology Sweep Out Other Conventional Processing Methods?

The XRT sorting technology that integrated artificial intelligence and X-Ray Diffraction Topography into the coal and minerals pre-concentrate is soaring in China. To take its benefits into consideration, some experts and advocators who are active in China's coal mining industry beat the drum for this cut-edge innovation that would supersede the conventional coal preparation methods absolutely. To what extent do we agree or disagree?

The rapid development of XRT sorters' market demand and installation has already transformed the way the mineral processing industry works (For example, please refer to the below conceptual design of a coal preparation plant that only selected XRT will be delivered in South Gobi, Mongolia). For sort of purposes, there are some professionals and business leaders who have claimed that this state-of-art invention would replace the traditional coal preparation methods completely. However, we can only agree that this is the greatest innovation in recent 10 years, but the other coal-washing technologies will still be dominant in this industry.

Firstly, the main function of XRT is for pre-discharging which means only lump coal and gangue can separate by it. But the particle size of raw coal can range from 0 mm to 300 mm, even much bigger, whereas XRT can only process the materials whose dimension is between 12 mm ~ 300 mm. Because the fine coal still needs to be recovered, especially the precious coking coal, the traditional coal preparation technologies shall play a crucial role for this purpose. For instance, we need centrifuges and filter press for de-watering, as well as TBS (coal slurry separator) and flotation to yield more fine clean coal. Thus, XRT cannot sweep other methods out.

Another point to consider is that XRT is relatively expensive for some mines that are not large-scale production. They can adopt some kinds of old-fashion machines with affordable costs, such as jigging, three-products gravity-feeding dense medium, or even by hand selection. Therefore, the major target market of XRT shall focus on middle-large size mines. On the other hand, all the existing 'old' technologies will have their own market.

In conclusion, while it is true that XRT can bring tremendous benefits for mines, such as contribution to carbon neutral, saving OPEX, and gorgeous technology, XRT is still just one major choice for the whole mineral processing industry. That's why the other technologies will still hold the leading position in the coal preparation industry.

The Critical Processing Steps of Sorting
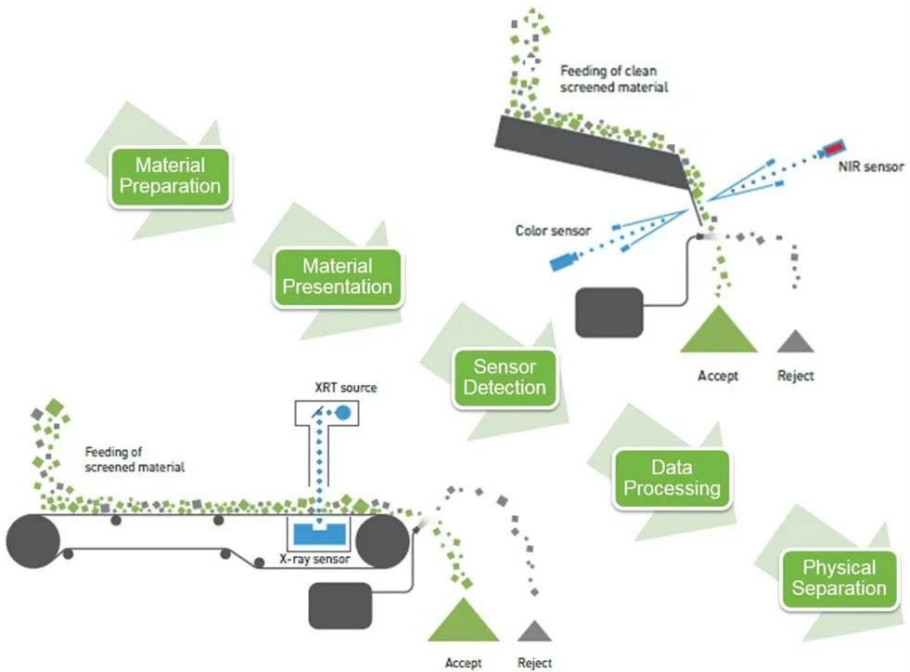
The diagram illustrates the critical processing steps of DE-XRT (Dual-energy X-Ray transmission) and CCD (CCD Color Optoelectronic) sensor-based ore sorting technologies.

Initially, all the raw materials, or called raw ores need to be prepared by vibrating feeders, which could help them to queue in mean distribution on the conveyors or chutes. The following stage is sensor detection all feeding minerals are detected by X-Ray, NIR, or sort of "sources", like UV and leaser.
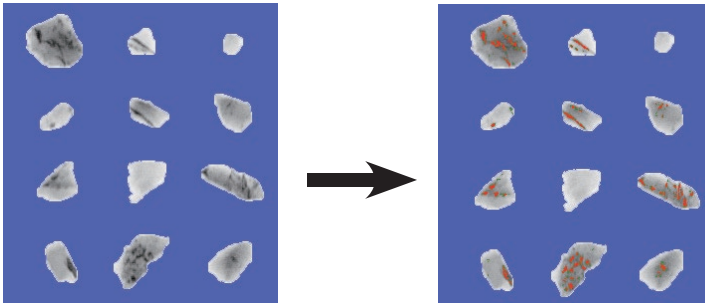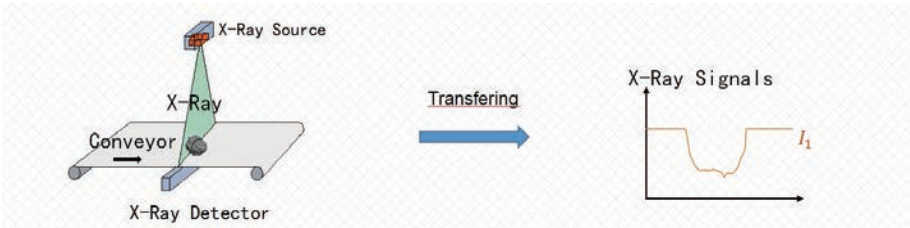
Because the concentrates and rejects are differing in their atom densities, when they are conveyed to the X-Ray zone, these features can be monitored by X-Ray detectors that are analyzed by the artificial intelligent algorithm in real-time. All the analysis is used for the discharging mechanism that is assembled by hundreds of high frequency solenoid valves. Entering the final phase, all the concentrates and tailings are ejected by valves which are pumped pressured air by air compressors.
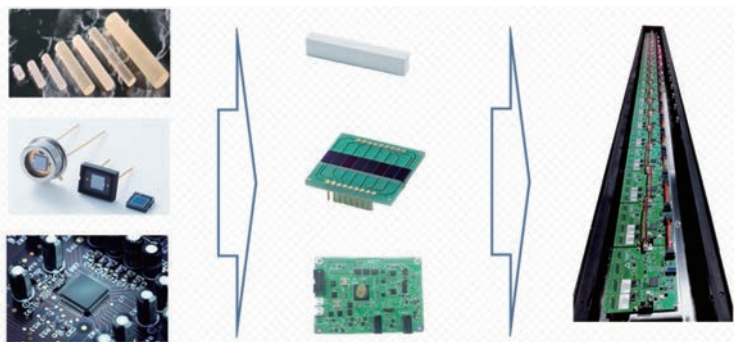
X-Ray Detectors, By HOT Industries

In total, it takes five phases that are done in seconds to separate the useful ores from raw materials. Thanks to the three core technologies X-Ray detection, AI Algorithm and High frequency solenoid valves, the environment-friendly ore pre-concentrate can come true.

INDUSTRIAL MINERALS

Phosphate- silia removal, lime-stone-silica removal, quartz up-grade, MgQ-silica removal, fluorite pre-conc., talc pre-conc., lithium pre-conc., barite pre-conc.,

DIAMONDS

Kimberlite-waste removal, diamond ROM conc., diamonds final recovery, emeralds ROM conc., rubies ROM conc.

FERROUS METALS

Iron ore grading, hematite pre-conc., manganese pre-conc., chromite pre-conc.

NON-FERROUS METALS

Copper, zinc, gold, nickel, tungsten, silver, platinum group metals

FUEL

Coal waste dumps

SLAG

Stainless steel slag, ferrosilica slag, ferro chrome slag

The Megatrend and Challenges of Sorting for Coal——What Are the Critical Concerns?

Coal Preparation (Coal Washing) is the fundamental technology for the efficient and clean utilization of coal. The conventional wet Coal Preparation (Coal Washing) technology heavily relies on water resources. Dry Coal Preparation (Coal Sorting) technology, due to its features such as no water consumption, low cost, and no pollution, provides a practical approach for clean and efficient screening and upgrading of coal resources and transformation and development of the coal industry. The working principle, research status, and industrial application progress of wind selection, compound dry selection, photoelectric selection, and heavy medium dry selection technologies were analyzed in detail, and the advancement of domestic and international Dry Coal Preparation (Coal Sorting) technologies was combed. Based on understanding the progress of selection technology, the current dry selection technologies have limited feeding granularity, high water requirements, and low intelligent degree. The trend of Dry Coal Preparation (Coal Sorting) technology development prospects and the focus of next-step research is pointed out, including breaking through the theoretical bottleneck of good Coal Preparation (Coal Washing), realizing Dry Coal Preparation (Coal Sorting) for all particle sizes, developing efficient Coal Preparation (Coal Washing) and drying cooperative technology, solving the problem of raw coal water restriction, accelerating the development of dry fines selection technology, reducing the processing cost of high-quality coal such as coking coal, carrying out research on the theory of machine amplification of separator, realizing continuous large-scale separator equipment and comprehensive utilization of coal-associated solid waste resources, providing a reference for research on Dry Coal Preparation (Coal Sorting) technology.

In addition to the conventional Coal Preparation (Coal Washing) demand, large-scale upgrading utilization of low-quality coal with high ash, sulfur, and high water content is a significant challenge that needs to be solved urgently for the sustainable development of the coal industry in most coal-producing countries in Asia. The traditional wet Coal Preparation (Coal Washing) technology heavily relies on water resources; 0.1 to 0.3 m3 of water is consumed per ton of coal, and the water content of the sorted products is about 10%, which partially offsets the advantage of increased calorific value after selection, and the quality improvement effect after the section is not apparent; the high water content of coal products makes it difficult to store, and transport and coal slurry water are easy to freeze and difficult to dispose of. Therefore, researching efficient Dry Coal Preparation (Coal Sorting) technology can compensate for the deficiencies of existing wet Coal Preparation (Coal Washing) technology, increase the selection ratio of coal resources in Asian countries, and promote the efficient and clean utilization coal resources in Asia.

With the development of science and technology, the research hotspots at home and abroad mainly focus on intelligent Dry Coal Preparation (Coal Sorting) technology. Intelligent Dry Coal Preparation (Coal Sorting) technology is divided into three categories: X-Ray identification, gamma-ray identification, and intelligent identification based on color difference. The principle is that there is a significant difference in the absorption and scattering degree of X-Rays and gamma rays between coal and gangue. Therefore, the information obtained by related detectors has substantial differences, which helps to get images with a more significant distinction. Thus, coal and gangue will show pictures with pronounced differences and then effectively separate coal and gangue. The selection precision of intelligent dry separators for lump coal is relatively high. Its advantage lies in simplifying the process flow, replacing artificial picking

of gangue, significantly compressing labor cost, and successfully achieving industrial application of 300 to 25mm lump Coal Preparation (Coal Washing) with a processing capacity of 380t/h, effectively reducing the gangue carrying rate. Much domestic Coal Preparation (Coal Washing) plants have conducted industrial selection tests.

Outlook and Challenges of Sorting Technology

There are still bottlenecks in the development of sorting technology, such as narrow particle size, high water content, and so on, which need to be solved urgently. Therefore, concisely the existing sorting technology is necessary to provide technical reserves for future development.

Sorting (Water-Free) for coal separation of whole particle size

Water-Free separation technology mainly focuses on lump coal sorting, including wind separation, dry medium-heavy separation machines, and XRT Sorting separation. It has been found that sorting technology can reduce raw coal ash and sulfur content and improve the calorific value. However, in the wind separation process, as the particle size decreases, the difference in the velocity of different density particles on the separator gradually decreases, and the difficulty of particle separation increases. In air-dense fluidized bed separators, due to the decrease of coal particle size, surface force and fluid force are enhanced, the effects of density-based separation of coal are weakened, and the sorting efficiency of fine coal is low. Therefore, efficient screening operations are needed as support. Further process optimization must be considered to speed up the Water-Free separation research and improve the adaptability to the selected raw coal.

HOT has conducted experimental studies on composite Water-Free separation machines for fine coal separation to analyze the mutual influence between coal motion and bed surface design and provide a theoretical basis for developing the separator. The new mineral-efficient separator developed by scholars has a processing capacity of 1,050 t/h, a sorting particle size of 1-13 mm, and an E of 0.128-0.232 g/cm3. It is mainly used for the coarse selection of fine coal.

At the same time, due to the similar particle size, shape, and other characteristics of coal and gangue in fine coal, only relying on re-selection or photoelectric separation technology has low sorting accuracy. Therefore, it is necessary to introduce an external force field to improve the sorting efficiency of fine coal to enhance the physical property difference between coal and gangue to improve the sorting effect. The related technologies mainly include vibrating fluidized bed introducing mechanical vibration force field, pulsed fluidized bed raising airflow vibration, and magnetic stable fluidized bed forming magnetic field, but the fine coal separation technology is still in the small-scale separator research in the laboratory; it is necessary to accelerate the expansion of the separator research further, realize the fine selection of coal in full particle size.

Research on the Mechanism of Capacity Amplification of Sorting Separator

The large-scale equipment can meet the increasing demand for coal sorting ratio and improve the competitiveness of Water-Free separation equipment. However, there is a mechanism of flow field behavior transformation during the continuous amplification process of the Water-Free separation system, which causes deviation from the existing theoretical models and experimental conclusions, and increases the influencing factors. Therefore, it is urgent to compare the

corresponding model parameter relationships of different size equipment, study the parameters of varying size sorting equipment and the influence of feed properties on the sorting efficiency, explore the mechanism of weakening the disturbance factors, and put forward the correction mechanism of the critical control parameters in the amplification process.

Currently, numerical simulation is a standard method for research on equipment magnifying and has been applied in the chemical industry, metallurgy, and other fields. However, the more particles, the higher the computing power requirements, and the simulation of equipment magnification also have limitations. Therefore, HOT proposed a coarsening model in Water-Free separation to reduce the particle calculation number, package and treat particles with similar force characteristics, and reduce the calculation amount. It is suitable for the simulation of industrial equipment magnification. It has been used to amplify air-dense medium fluidized bed, realizing the semi-industrial level of Fluidization simulation, as shown in the figure below. In the future, based on this method, the magnification research of other Water-Free separation technology equipment can be conducted to provide theoretical support for the establishment of the correlation from laboratory to industrialization equipment. The current simulation technology is still in development, and the computing method and dynamic model need to be further optimized to meet the needs of different working conditions.
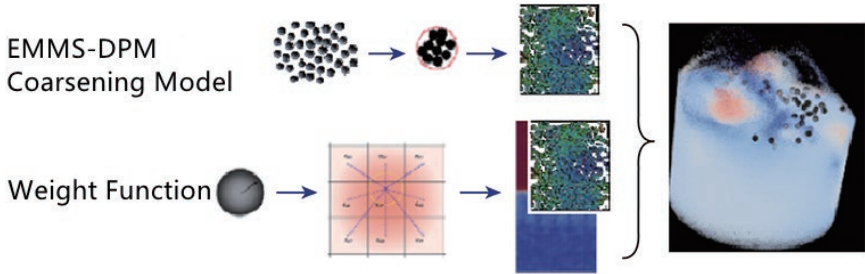
Simulation diagram of coarse grained model
Picture Source, Dr. Yong Zhang, China University of Mining and Technology, 2019

In conclusion, the bottlenecks of sorting technology are briefly explained, and the development trend of coal sorting technology prospects. Finally, it is pointed out that the future research points of sorting separation can start from "broadening the feed particle size and improving the stability of the separator" to improve the beneficiation and utilization of low-quality coal in Asia.

Exploring the Mysteries of Ore Sorting
——AI-embedded Ore Sorting Technology Shines at Two Lead-Zinc Mines
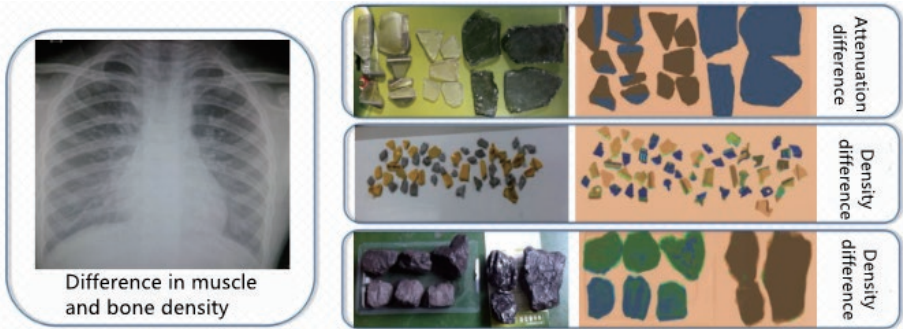
Taking an X-Ray of the ore: Detecting the internal ore content, distinguishing between concentrate and tailings at a glance (sub millisecond response), and accurately sorting!

Gansu VESTA lead-zinc mine is a recognized jet-sedimentary modified ore deposit, one of the representative ore deposits in the western Qinling area. The lead-zinc ore body is in the clastic rock and carbonate contact zone, with sphalerite, galena, limonite, and chalcopyrite as the primary metal minerals. The ore structure is mainly banded reticulated, mottled, and angular gravel. After more than 30 years' mining activities, the banded ore-free ore is rare, currently dominated by sparse reticular and vein-like structures, which allows for high X-Ray rejection. HOT XRT Sorter intelligent sorting equipment was introduced in 2022 with a targeted selection to improve the level and efficiency of the exploitation and utilization of mineral resources further to improve the ore grade of the mineral processing plant.

After one month of transformation and construction, HOT XRT Sorter intelligent sorting equipment was immediately put into production operation. Since it has been running for two months, the performance of the equipment is stable, and the sorting indicators are beyond the expectation of customers:

Through X-Ray sorter pre-concentration, the ore grade entering the mineral processing plant can be effectively improved, the amount of ore entering the crushing and milling system can be significantly reduced, the production cost of ore dressing can be reduced, the production capacity of the mineral processing plant can be improved, and at the same time, the number of tailings entering the tailings pond can be reduced, the service life of the tailings pond can be extended, and the environmental pollution can be minimized d. It truly realizes the double promotion of economic development and environmental protection, makes a lengthy contribution to the enterprise's high-quality, green, environmental, and scientific development, and the predicted single HOT XRT Sorter can directly create an economic benefit of CNY 150 million for the mine. It is reported that the mine has adjusted its profit targets according to the operation data of the X-Ray sorter.

Recently, in Tibet ZhongXin Mining, HOT XRT Sorter has been installed for three months that the sorter's performance is also excellent and highly recognized by the cooperation partner.

The Sorting Performance On-Site (ZhongXin Mining):

√ Processing capacity of 75t/h (mine requirements 50t/h)
√ The operation rejection rate of 41.15% (Mine requirements 35.50%)
√ Lead-zinc tailings comprehensive grade below 0.28%

√ Tin tailings grade below 0.10%

HOT XRT Sorter can improve the comprehensive utilization efficiency of mineral resources, which is the key to the high-quality development of the mining industry and the specific action to practice the ecological civilization idea.

Through the intelligent sorting equipment for ore pre-concentration, it can effectively realize ore grade enrichment, reduce cost of the following process like gravity separation, froth flotation, tailing treatment and so on, improve beneficiation recovery rate, enhance the comprehensive utilization efficiency of mineral resources of mining enterprises and the risk resistance ability of enterprises, and truly achieve practical unity of resources, ecology, and approach highly ESG (Environment, Social and Governance) performance!

XRT Helps Sustainable Development of Phosphate Mines

As a non-renewable mineral resource, phosphate mines' sustainable development and utilization are directly related to food security, human survival, and growth. China's phosphate resources are mainly marine sedimentary deposits, with abundant reserves ranking fourth in the world. However, a few rich and many poor ores have different grades of phosphate resources, as shown in Table 1.

Table 1 Resource Reserves of Phosphate Rock of Different Grades

P_2O_5 grade	Ore Reserves		P_2O_5 Reserves	
	Reserves(100 million tons)	Proportion (%)	Reserves(100 million tons)	Proportion (%)
≥30%	16.6	9.39	5.3	16.67
25%~30%	21.2	12.02	5.7	18.11
20%~25%	27.3	15.48	6.1	19.22
15~20%	60.1	34.09	10.5	33.04
10%~15%	21.9	12.45	2.9	9.13
5%~10%	4.8	2.74	0.4	1.23
2%~5%	24.4	13.83	0.8	2.6

Note: Data is from China Mineral Reserves Database

The average grade of China's phosphate rock (P2O5) is about 17%, much lower than Morocco (33%) and the United States (30%). Besides a few rich ores that can be directly used to produce phosphate fertilizers and yellow phosphorus, most phosphate rock needs to be processed through beneficiation, resulting in high beneficiation costs.

Types of phosphate mines:

According to the content and type of vein minerals, phosphate rock can be divided into calcareous, siliceous, and calcareous-siliceous phosphate rock.

China's phosphate rock is mainly sedimentary, accounting for about 70% of the total reserves. Due to vein minerals such as calcite, fluorite, and quartz in the minerals, the grade of phosphate rock is low. In addition, the ore is tightly embedded, the cementation symbiosis is common, and the mining is problematic, resulting in high development and utilization costs. The characteristics of China's phosphate resources are large reserves, relatively concentrated distribution; many low-grade phosphate ores, few rich ore resources; many colloidal phosphate ores, and difficult mining and selection; sedimentary phosphate deposits are the primary deposit types. Therefore, to improve the economic value of phosphate mining and utilization, it is necessary to have a deep understanding of the characteristics of phosphate resources, choose an excellent pre-rejection process, improve the floatation grade of phosphate rock, and continuously optimize the reagent system and process plan.

Application of XRT Sorter in phosphate mines

A particular phosphate mine in Yichang used the XRT Sorter, with a processing capacity of 60t/h and a feed particle size of 10-50mm. The grade of block ore (P2O5) was 13.8%-15.7%, the grade of optically selected concentrate (P2O5) was 26.5-27.8%, and the grade of optically selected tailings (P2O5) was ≤7.0%.

The original ore was sorted by optical selection to separate phosphate concentrate and tailings. The optical selected phosphate concentrate product met the sales requirements of commercial phosphate mines in Yichang, Hubei Province, for external sales. In addition, this process does not require floatation or reselection, and the tailings rejection rate is high, directly obtaining phosphate concentrate products.

Mine Supervisors Are Inspecting The Ore Quality After Pre-Concentration

The project uses an optical selection process and dry selection equipment, which does not require water, only compressed air. The discharged dust-containing waste gas can meet environmental emission standards after being treated by a bag-type dust collector and a water mist dust removal system. This process has no ecological problems or risks, the optical selection process technology is mature, the equipment is simple and reliable, and the economic benefits are good.

| The Concentrates | The Tailings |

A specific phosphate mine in Leibo, Sichuan, used the XRT Sorter, with a processing capacity of 55/h and a feed particle size of 10-50mm. The grade of block ore (P2O5) was 20.0%, and the grade of optically selected concentrate (P2O5) was ≥23.2%. As a result, the rejection rate reached 19.8%, effectively improving the grade of ore entering the selection, significantly reducing the amount of ore entering the fine crushing and grinding mills, reducing the production cost of beneficiation, and increasing the production capacity of the beneficiation plant. At the same time, it can reduce the number of tailings entering the tailings pond, extend the service life of the tailings pond, and reduce environmental pollution, genuinely realizing the dual promotion of economic development and ecological protection for enterprises to achieve green, environmental protection, high-quality, and scientific development.

In conclusion, HOT XRT Sorter, innovatively used in the beneficiation of medium and low-grade phosphate rock, can realize the pre-selection of incompletely dissociated ores by pre-rejecting a certain proportion of waste rock, reduce the processing volume of downstream processes, and be safe and environmentally friendly, saving energy, reagents, and water resources. It can also be used to select valuable waste rock for secondary recovery, which is worth promoting and applying in the beneficiation of low-grade phosphate rock worldwide. Furthermore, HOT XRT Sorter solves the pollution control problems in the mining, sorting, stacking, and transportation of phosphate mines, providing a new way to achieve clean production, recycling, and pollutant reduction in mines.

XRT Sorters Are Avengers for Refractory Fluorite Mineral

A difficult-to-select fluorite mine in Inner Mongolia has introduced HOT XRT Sorter, transforming fluorite lump ore from traditional manual selection and conventional processing to AI separation.

Through HOT XRT Sorter, fluorite lump ore can be sorted into concentrate, middling, and waste rock. The concentrate is directly sold as metallurgical-grade lump ore, while the waste rock is sold as sand and gravel aggregates. The middling is re-ground and re-selected, which can significantly reduce the amount of wet separation and greatly improve the economic benefits of the mine.

Run-Of-Mine Ore

This difficult-to-select fluorite mine is a sedimentary transformed fluorite deposit, with the primary ore type being fine crystal block-like (sugar-like) fluorite ore. The ore color is grayish, making distinguishing ore grade by color challenging. Moreover, obtaining 97% grade fluorite powder through flotation is not easy, which belongs to a difficult-to-select fluorite mine.

HOT provides sampling guidance, free trials, on-site surveys, engineering design, installation, commissioning, and other services for this mine.

A three-product sorting process is used on-site. One piece of equipment achieves photoelectric sorting of 20-80mm (other particle sizes can be selected according to demand) fluorite ore blocks, selecting concentrate, middling, and tailings. Based on the high-grade ore grade in the original ore, the algorithm package can be chosen to obtain block concentrate with a grade of 60-80%, and the grade of middling is between that of concentrate and tailings. The concentrate is sold directly, the middling is re-ground and re-selected, and the tailings grade is 2-5%, sold as sand and gravel aggregates.

| Middling | Concentrate | Tailing |

Benefits of applying HOT XRT Sorter to the fluorite mine:

1.Taking 80% fluorite ore blocks and 97% flotation fluorite powder as examples, the two prices are similar. However, suppose 80% fluorite lump ore is directly selected from the original ore, compared with grinding and setting 97% fluorite powder. In that case, the yield will significantly increase (about 1.4t of 80% fluorite lump ore is selected to produce 1t of 97% fluorite powder). Photoelectric sorting costs less than CNY 5/t, much lower than flotation, and the benefits are much higher than flotation.

HOT XRT Sorter can pre-discard low-grade ore (2-5%) on-site during the crushing stage, with a discard ratio of 15-30% (related to the original ore grade). This part does not need to be re-ground and re-selected, saving processing costs. The on-site waste rock has a high hardness and can be sold as sand and gravel aggregates while reducing the discharge of tailings, which has comprehensive advantages.

Leading The Revolution of Real-time Coal Quality Analysis

Introduction

Ash content is one of the essential indicators to measure the quality of coal products. Therefore, online ash content detection technology is critical to achieving efficient online testing and rational application of coal.

Latest Application Case

HOT applied the own coined X-Ray Ash Moisture Analyzer on the JiangZhuang fine coal conveyor belt, realizing intelligent control of product index, ensuring the recovery degree of fine coal resources, stabilizing product quality, increasing the recovery rate of fine coal by 0.5%, reducing three positions and labor force, and generating margin CNY 10 million annually.

Why Develop X-Ray Ash Moisture Analyzer?

Ash content is an important indicator to measure the quality of coal products. In addition, to real-time control, the quality of coal products, rapid detection methods, and equipment have been widely used in coal, coking, steel, power generation, and other related industries. For example, steel mills must strictly control the ash content of coking fine coal. According to the data, for every 1% increase in acceptable coal ash content, the ash content of coke will increase by 1.328%; for every 1% increase of coke ash content, the blast furnace ratio will increase by 2.057%, the furnace utilization rate will decrease by 3%, and at

the same time, the quality of pig iron will also be reduced. There are four rapid detection methods for coal ash content: radiation measurement, image processing mapping, photoelectric mapping, and weighing method.

Among them, the radiation measurement method is the most widely used by coal enterprises. Radiation measurement can be divided into two categories: active radiation measurement and passive radiation measurement. Dynamic radiation measurement mainly uses the principles of low-energy gamma-ray backscatter, high-energy gamma-ray absorption radiation, and dual-energy gamma-ray transmission. Therefore, gamma radiation source needs to be used inevitably, but due to their penetrating solid ability and rugged shielding, there are significant security risks. In addition, the test conditions of low-energy gamma-ray backscatter are complex and are generally challenging to meet on-site; the high-energy gamma-ray transmission is greatly affected by the high atomic number of elements and heavy fractions residue in coal. Passive radiation measurement measures the gamma rays released from the radioactive elements (potassium, cesium, thorium, uranium, etc.) during the decay process in coal and uses the correlation between them and the ash content to measure the ash content of coal. The primary defect of passive radiation measurement is that the natural radioactive elements deposited in coal are very few, so this method often cannot detect the sedimentary sandstone in coal, thus limiting its generality. Only when the natural gamma-ray emission content of potassium, thorium, and uranium released by coal and the mineral content of coal have a reasonable correlation is the passive radiation measurement suitable for use.

Given the radiation hazards, great management difficulties, low measuring accuracy of active radiation measurement, and the limitations of passive radiation measurement, HOT (Chengdu) Industries Co., Ltd. has independently coined the X-Ray Ash Moisture Analyzer. This ash meter adopts a class III X-Ray

device, which has less harm to human health and the environment, its radiation can be controlled, and its measuring accuracy is better than that of conventional radiation measuring instruments. The X-Ray Ash Moisture Analyzer integrates intelligent detection, recording, display, control, and other technologies used to measure and control the change in coal ash content. It is an excellent blessing for industries with high accuracy requirements.

The X-Ray Ash Moisture Analyzer (Picture 1) mainly comprises a thickness compensation system, ash detection system, radiation protection system, temperature control cooling system, automatic alarm system, and X-Ray Ash Moisture Analyzer platform software. The ash detection system consists of the X-Ray source and linear array detector, and the temperature cooling system uses industrial air conditioning heating and cooling system.

The detection principle of an X-Ray Ash Moisture Analyzer is based on Beer-Lambert Law:
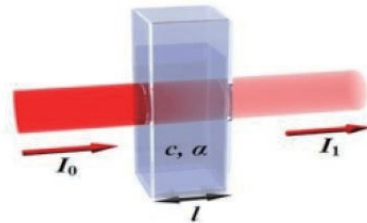
here: $A = \log_{10} \dfrac{I_0}{I_t} = \log_{10} \dfrac{1}{T} = K \cdot l \cdot c$

And this formula can be transferred as below.

$$I = I_0 \, e^{-\mu T},$$

In which I0 and I are, respectively, the incident and transmitted ray intensity; μ is the mass absorption coefficient; T is the thickness of the tested object.

Since the narrow X-Ray beam transmits substances according to the exponential decay law, the X-Ray Ash Moisture Analyzer has a thickness compensation system and real-time detection of coal sample thickness during the test. The thickness value is entered into the ash calculation algorithm model.

As shown in Figure 1, when the coal sample enters the X-Ray Ash Moisture Analyzer testing area, the X-Ray dual-energy source emits high-energy X-Rays and low-energy X-Rays. The receiver at the bottom of the tape receives the attenuation value after the high-energy X-Rays, and low-energy X-Rays transmit the coal sample and then send it to the control host. According to the preset model, the control host calculates the coal sample ash.
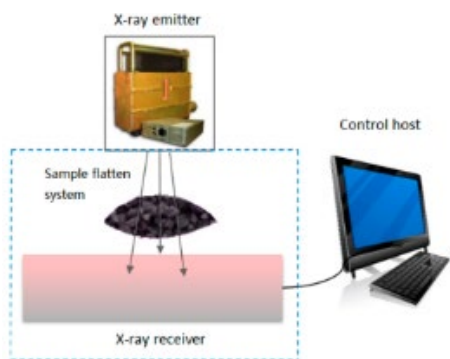
Unlike the traditional gamma ray ash meter double-source single-point sampling detection, the X-Ray Ash Moisture Analyzer adopts fan-shaped detection, so the detection area is vast. In addition, the X-Ray Ash Moisture Analyzer can also adjust and optimize itself according to the field coal characteristics through a self-learning algorithm, thus significantly improving the detection accuracy.

X-Ray Ash Moisture Analyzer Testing Effect

The particle size of heavy medium coal in the coal preparation plant of JiangZhuang Coal Mine is below 50mm, and the width of the belt conveyor is

1200mm. According to the production practice, the HOTGPX® X-Ray Ash-Moisture Analyzer was selected. From January 2 to February 22, 2023, the ash meter detected 108 groups of data. The ash meter detected ash, artificial assay ash curve, and two ash absolute errors are shown in the following Figure. It can be seen from the Figure that the minimum ash of the fine coal is 9.40% (artificial assay value), and the maximum is 11.39% (artificial assay value). In production, the ash content of the fine coal products should be controlled between 10.50%-11.00%, so when the ash content of the fine coal is lower than the required ash content, the yield of the fine coal will inevitably be reduced. In comparison, when the ash content of the fine coal is higher than the required ash content, the quality of the fine coal will be unqualified. Due to the severe lagging of the artificial assay results, it is impossible to guide the production (adjustment and control of separation density, referred to as "density control") in an exhibition.
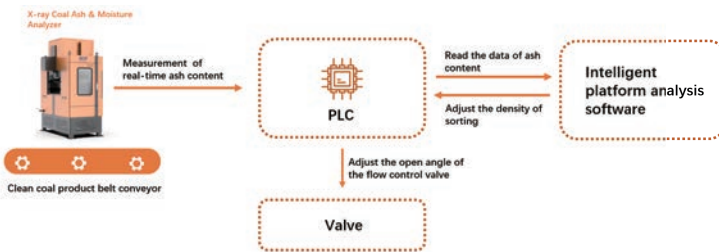
This Figure shows that the ash detected by the ash meter and the artificial assay ash are almost consistent, and the maximum and minimum absolute errors of the two are 0.47% and -0.48%, respectively. Therefore, the probability of fundamental error between the artificial assay ash and the ash detected by the ash meter being less than 0.25% is 78.45%, and the standard deviation (σ) is:

$$\sigma = \sqrt{\frac{1}{n} \sum_{i=1}^{n} (x_i - x_0)^2} = 0.20\%$$

According to this, the probability that the absolute error between the artificial assay ash and the ash detected by the ash meter is less than σ is 67.77%, and it is less than 2σ is 95.65%.

How Is Tech Transforming the Mineral Processing? —Dynamic Density Control for Dense Medium Process

Dense medium separation is currently the dominant process for **coal preparation (coal washing)** worldwide and is also the primary process for some **phosphorus and lithium beneficiation** plants. Ensuring the effect of dense medium processing is an essential guarantee for the quality and recovery rate of concentrate products in these beneficiation plants.

HOT has developed an intelligent control system for the entire process of dense medium separation, covering wide-range control of both suspension density and slurry content, intelligent setting control based on an online ash analyzer, monitoring, and management of balance at each bunker of the dense medium separation process and purification and recovery process of the medium, forming a closed-loop and optimal control of the entire process of dense medium method. In addition, the industrial internet platform is used to realize remote operation and intelligent decision-making of the dense medium separation process.

Product Features:

•Developed intelligent control algorithm of dual-variable wide-range control (state invention patent) for suspension density and slurry content.
•Developed density intelligent setting based on SPC (Statistical Process Control) technology based on an online ash analyzer.
•Developed full-process control of dense medium separation (balance of buckets, online monitoring, and management of medium purification and recovery).
•Developed remote operation of dense medium separation process based on big data and artificial intelligence technology.

System Advantages:

•Adapts to changes in coal quality, working conditions, and density fluctuations, with stable control fluctuations of 0.005g / cm3 under steady state control.
•Significantly improve product stability, increase product recovery rate by 0.5-2%, and achieve significant economic benefits.
•Realized remote operation of dense medium separation process to ensure the healthy function of dense medium separation process.

Successful Cases:

The Intelligent Suspension Density Intelligent Control System of JiangZhuang Coal Preparation Plant helps to achieve intelligent and high precision sorting with a precision of ±0.003kg/L!

JiangZhuang Coal Preparation Plant successfully stabilized the two-product suspension density of the dense medium cyclone to ±0.003kg/L, with the control accuracy reaching the top level in China.

JiangZhuang Coal Preparation Plant adopts a two-stage two-product dense medium cyclone re-selection process. The density control of the re-washing section directly affects the ash content and recovery rate of finished coal products. Therefore, it is crucial to stabilize the suspension density, which is the core of the entire coal selection production process. Due to the low degree of automation of various control valves, large capacity circulation of composite tanks, etc., the density feedback needed to be faster, and the adjustment time was long. Operators need to manually control in real-time with high intensity and high frequency to maintain the stability of the separation density and avoid

washing out high-ash products, resulting in low efficiency of density control operations and high labor intensity of workers. Therefore, this CHPP, jointly with the HOT science and technology team, researched and developed the intelligent control system of suspension liquid density. Firstly, the medium circulation control process was improved. Then, the switch valves, such as the diverter and make-up water valves, were modified into electric-controlled pneumatic linear regulating valves. After the valve action, rapid and accurate feedback was obtained, and the adjustment time was shortened.

Second, Java programming language was used to customize the development of intelligent control algorithms. Finally, OPC communication technology was used to directly read related real-time parameters such as composite and dilute tank level l, primary re-wash separation density, coal amount, pump operation current, etc., from the field PLC, comprehensively established the density control system valve opening prediction model, and then obtained the optimal result through the artificial intelligence algorithm and sent it to the PLC for precise control, to achieve the requirement of high precision control of suspension liquid density, and solve the problems of density inertia overshooting and waveform oscillation encountered in traditional PID algorithm when dealing with solid coupling and considerable lag of dense medium control.

The key to the suspension density intelligent control system lies in precision. The original design of this factory adopted the FMG60 radioactive isotope density meter produced by E + H Company in Germany, with high sensitivity and measurement accuracy of 0.001kg/L. Combined with the perfect coal washing.

Margin Soared by AI-embedded Dynamic Density Controlling for Dense Medium System!

To effectively reduce manual sampling, guide the operator to adjust the density, and solve the problem of the extensive and lagging manual test, an intelligent density control system based on an X-Ray ash analyzer was developed and connected to the production system to adjust the production parameters directly. They randomly sample the ash data within 48h of the above-detected ash data, according to the preset density control algorithm for density control adjustment judgment. As shown in the figure below, the judging result of 0 indicates that the fine coal ash is within the target range; Judging result 1 demonstrates that the fine coal ash is slightly higher and needs to be adjusted down by one density step; Judging result 2 indicates that the fine coal ash is more elevated and needs to be adjusted down by two density steps; Judging result -1 demonstrates that the fine coal ash is slightly lower and needs to be adjusted up by one density step; Judging result -2 indicates that the fine coal ash is more down and needs to be adjusted up by two density steps.
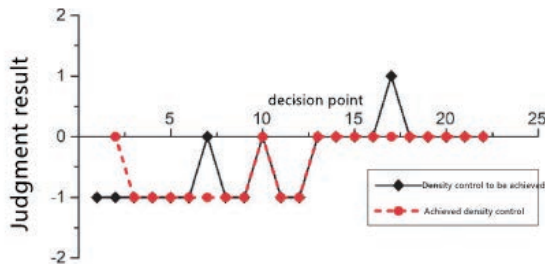
The Table below shows a comparison table of ash content detected by an ash analyzer and human manual density adjustment. The below Table shows that in the 21 times of human density adjustment decisions, the intelligent density

control system based on an X-Ray ash analyzer has 18 findings consistent with human decisions, with an accuracy rate of 85.71% and no reverse decisions.

No.	Comparison items	Statistics
1	Checking times	21
2	Correct times	18
3	Error times (no reverse)	3
4	Reverse error times	0
5	Accuracy	85.71%
6	Reverse error rate	0

The Table below calculates the economic benefits after applying the intelligent density control system based on X-Ray ash-moisture analyzer in this plant. As shown in Table 4, due to the large scale of this plant, only one product ash content control (average ash from 10.53% to 10.63% and stably maintained) can achieve an increase of CNY 48.68 million in annual sales revenue. In addition, the intelligent density control system based on an X-Ray ash analyzer can also effectively reduce manual sampling work and human input in production.

Production index	Comparison items
Annual processing capacity/10000 tons	1830
Average ash content of product	10.53 (before application), 10.63 (after application)
Clean coal yield/%	17.49 (before application), 17.82 (after application)
Annual clean coal output/10000 t	325.80 (before application) 331.88 (after application)
Sales unit price (tax included)/(yuan · t⁻¹)	800
Annual clean coal output increase/10000 t	6.08
Increase in annual sales revenue/10000 yuan	4868

X-Ray ash-moisture analyzer can not only avoid the radiation hazards of active ash analyzers but also make it safer to use and adopt the fan-shaped detection mode; the detection area is vast, and it can more accurately reflect the real-time fluctuation of ash content, and the detection accuracy is higher, which breaks through the limitation of the application of passive ash analyzer. Furthermore, through self-learning, the X-Ray ash analyzer can adjust and optimize itself

according to the characteristics of the field coal, significantly improving the detection accuracy and applicability of the use. In addition, the intelligent density control system based on an X-Ray ash-moisture analyzer can also effectively reduce the amount of manual sampling work and timely guide the density adjustment in coal selection production, solving the problem of the extensive and lagging manual test.

Currently, the series of ash analyzer products can meet the ash detection requirements of all coal products. HOT's X-Ray ash analyzers have been widely used in coal selection plants in China, with the intelligent density control system creating considerable economic benefits for coal preparation plants.

Does XRD (Dual Energy X-ray Diffraction) Outweigh the XRF and γ in Analyzing Coal Ash Content?

Background:

Coal is a significant energy and chemical engineering resource in the world. The reasonable development and utilization of coal resources have meaningful significance to the economy and environment of the world, especially for countries with extensive production and consumption of coal, such as China. Ash content is a crucial evaluation parameter of coal quality and a standard that guides the reasonable utilization of coal. However, the conventional ash content measurement is to heat the coal in a muffle furnace at a temperature higher than 800 °C, which causes increased consumption of energy and time. Additionally, timely adjustment of operating parameters in the coal preparation plant could not be achieved due to the delay of ash content result that was usually obtained after several hours. Therefore, coal industry researchers need to seek real-time ash content measurement techniques.

Thus, HOT (Chengdu) Industries Co Ltd has developed real-time ash content measurement, which is the fundamental condition for the timely adjustment and intelligent control of operating parameters in the coal preparation and utilization industry. In the present work, a real-time ash content analyzer based on dual-energy X-Ray Diffraction was developed. The feasibility of this X-Ray ash content analyzer was validated by the linear relationship between ash content and five characteristic parameters of X-Ray.

Furthermore, the wave filter, tube voltage, and current tube conditions were optimized. So what advantages of XRD outweigh the devices that applied XRF and γ-Ray?

The difference between XRF and XRD

The difference between XRF and XRD is simple: XRF analyzes Chemistry while XRD determines the mineralogy.

XRD identifies and measures the presence and amounts of minerals and their species in the sample and identifies phases.
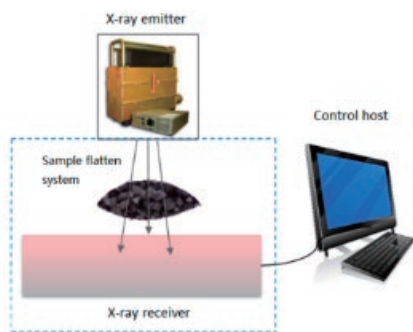
XRF will produce an assay by giving information on the chemical composition of your sample without indicating what phases are present in your sample.
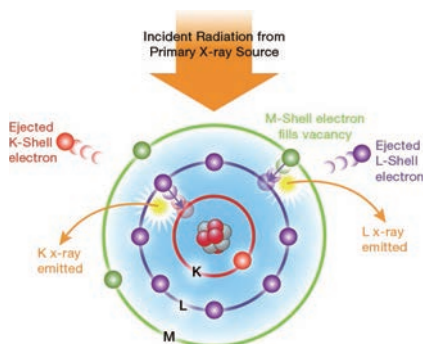
X-Ray Fluorescence (XRF) and X-Ray Diffraction (XRD) Analyzers provide qualitative and quantitative material characterization for detection, identification, analysis, quality control, process control, regulatory compliance, and screening for metals and alloys, mining and geology, scrap and recycling, environmental and consumer safety, education and research, and general manufacturing.

Moreover, X-Ray fluorescence (XRF) is a non-destructive analytical technique used to identify the elemental composition of materials. The XRF analyzer measures the fluorescence (or secondary) X-Rays emitted by the sample after being excited by a primary X-Ray source. Each element in the sample produces a characteristic set of fluorescent X-Rays, also known as a "unique fingerprint." The fingerprint of each component is different, making XRF analysis an excellent tool for quantitative and qualitative measurements.

X-Ray diffraction (XRD) is a non-destructive analytical technique that provides crystal structure information (crystallite size, % crystallinity, etc.), phase identification (e.g., minerals), and quantification of phases present in a sample. Modern XRD equipment is easy to use, can measure samples in minutes, and provides automated, quantitative analysis. As a result, XRD can quickly and efficiently determine coal quality, total ash, and amorphous carbon content in coal without needing standards, monitors, and calibrations.

In addition, X-Ray diffraction (XRD) is one of the most effective non-destructive tools for identifying and characterizing the crystalline structure, polymorphic structure, phase, and crystallinity changes of polycrystalline materials. By measuring the diffraction angle of a primary X-Ray beam according to Bragg's law ($\lambda = 2d \sin\theta$, where λ is the wavelength, d is the spacing between crystal planes, and θ is the diffraction angle), various polycrystalline materials in many

research and industrial applications can be characterized and identified. Overall, XRD and XRF can apply to various demands based on specific requirements.
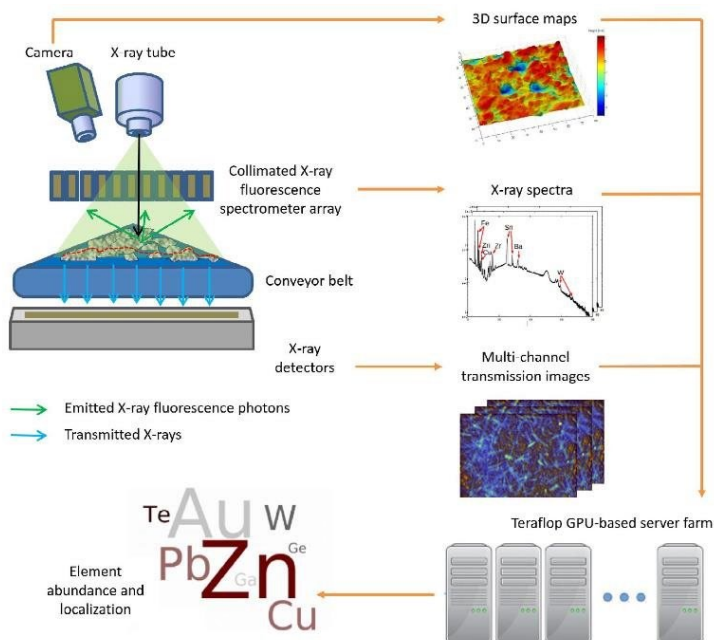
Comparison between XRD and Gamma-Ray ash analyzer:

More secure, easier to manage, and higher detection accuracy

- The X-Ray ash analyzer does not produce radiation after power is off, making maintenance safer.

- The X-Ray device is an electronic device and not a radioactive substance. Therefore, there is no half-life and no special requirements for transportation, storage, and recovery.

- The gamma-ray ash analyzer is a dual-source single-point sampling detection that can only detect a point area on the tape cross-section. If the material distribution on the tape is uneven, the detection accuracy will decrease. The fan-

shaped detection of the X-Ray ash analyzer has a wide detection area, strong sample representativeness, and higher detection accuracy.

- Through the "self-learning" algorithm, the model is continuously automatically corrected to maintain a high level of detection accuracy at all times, and there will be no drifting phenomenon after a period of use.

Comparison with X-Ray fluorescence (XRF) ash analyzer:

- The detection area is vast. The X-Ray Diffraction is fan-shaped detection, and the detection area is extensive. At the same time, the fluorescent reflection is spot detection, and the detection area is small, with a single detection area only the size of a coin.

- Strong sample representativeness. Firstly, when the material's particle size, thickness, and bulk density change, the transmission has less impact, but X-Ray fluorescence detection accuracy is greatly affected. Secondly, in the complex environment of diverse coal types and significant fluctuations in coal quality, there will be differences in the coal quality between the surface and the inside of the coal flow. Only collecting surface signals will affect the detection accuracy.

- Strong environmental adaptability. X-Ray Diffraction technology has low ecological requirements and has been widely used in security checks, medical treatment, mineral sorting, and other environments. However, X-Ray fluorescence detection technology is best applied in a vacuum environment and is sensitive to dust and water vapor, affecting fluorescence reflectivity and reducing detection accuracy.

- Explosion-proof requirements. HOT's X-Ray ash analyzer has passed and obtained an explosion-proof certification. It can choose whether to be explosion-proof according to the actual site conditions.

How to Implant Wisdom into the Flotation by XRF On-Stream Ash Analyzer?

The XRF On-Stream Slurry Ash Analyzer obtains the ash content in the slurry sample directly and online by detecting the slurry sample. The slurry ash online detection instrument adopts X-Ray technology and establishes a corresponding mathematical model according to different coal quality characteristics. The device serves as the "eye" of the flotation system, creating conditions for realizing the intelligent flotation system with fully autonomous operation, high detection accuracy, and minor equipment maintenance.

Product Advantages:

It can realize multi-sampler sampling detection of roughing pulp and tailing pulp.

Increase the recovery rate of fine coal and reduce the consumption of flotation reagents.

X-Ray fluorescence technology is used the type III radiation devices, with power 1/50 of safety inspection device radiation device, which has high safety.

No radiation in the non-testing state; the radiation intensity meets the relevant requirements of national standards in the testing state.

Management is simpler; an X-Ray device is an electronic device (non-radiation source) that must only be filed at the municipal environmental protection bureau. As a result, the certification and utilization are more straightforward.

Also, it improves the flotation operator's working environment and protects workers' physical health.

Working Principle:

The tested slurry enters the device through the sampler. After passing through the slurry sampling, slurry processing, X-Ray fluorescence coal sample testing, data analysis, and other links detects the slurry ash and outputs the data. The whole process runs autonomously and has a low maintenance cost.

Product Performance:

Operating mode: one-button start and stop of the device. It can provide an operating interface for any LAN PC in the central control center for remote start and stop. It can also be interlocked with an intelligent flotation system for opening and prevention.

Output content: single ash test/multiple ash tests/average ash test; if an intelligent flotation system is built simultaneously, feedback dosage adjustment parameters can be output.

Storage cycle: can store all ash data and operation records for one year for the query.

Intelligence: accessing to "coal quality control system" developed by HOT through industrial Ethernet, and directly adjusts the dosage of flotation.

Operations Environment:

Feed requirements: install a sampler on the slurry testing pipeline; the slurry in the channel has representative sampling and a specific flow rate.

Discharge requirements: the device testing and waste slurry are returned to the system by self-flow.

Power supply requirements: 380V, 5kW.

Air source requirements: 0.4MPa~0.7MPa, clean compressed air, to ensure air supply quality.

Water source requirements: 0.1MPa~0.3MPa, clean water, to ensure the water quality.

Cases

Testing of Clean Coal slurry Ash Content – JiangZhuang Coal Preparation Plant

A test for ash content in Clean Coal slurry was performed; a single test took 8~10 min, with an average absolute error (1σ) of less than 0.45%; the accuracy was further improved by applying machine learning algorithms.

Testing of Clean Coal slurry Ash Content – TuCheng Coal Preparation Plant

A test for ash content in Clean Coal slurry was performed; a single test took 8~10 min, with an absolute error(1σ)of 0.42%; higher accuracy could be achieved by taking two or three times test data.

Testing of Tailings Suspension Ash Content – TingNan Coal Preparation Plant

A test for ash content in tailings suspension was performed; a single test took about 35 min, with an absolute error (1σ) less than 2.9%.

What's more about the XRF On-Stream Slurry Ash Analyzer?

The XRF On-Stream Ash Analyzer developed by HOT has high detecting accuracy and a high correlation between testing ash content and assay ash content, therefore realizing the closed-loop control of flotation; it is also the critical sensor for transforming the flotation system to be intelligent.

A complete intelligent flotation system mainly includes an innovative platform, a smart dosing station, a slurry ash online analyzer, auxiliary instruments and instrumentations, and a pipe system.

Based on a large amount of experimental data, HOT has established a mathematical model for calculating the dosage of flotation reagent according to the concentration of input ore pulp, the flow of input ore pulp, and the ash content of froth ore pulp and implemented it into the intelligent flotation system.

In the production process, the dosage of flotation reagents is automatically calculated according to the mathematical model, and the flotation intelligent dosing station accurately quantifies the flocculants of flotation reagents. At the same time, the ash content value of froth ore pulp detected by the slurry ash online analyzer is transmitted in real-time to the intelligent flotation system, which is used to modify specific parameters in the mathematical model. A complete closed-loop flotation smart system with both feedforward and feedback is formed.

The intelligent flotation system consists of four layers: the first layer is the data acquisition layer, which collects the production data of the flotation system in the field; the second layer is the data layer, which stores primary, equipment,

operation, fault, and production data; the third layer is the control logic layer, which implements equipment operation control, dosing control, fault diagnosis, and data analysis based on the data layer data; the fourth layer is the user perception layer, which can complete production monitoring, equipment control, alarm management, equipment maintenance, and report management.

For existing coal preparation plants, an intelligent flotation system can be added. If an automatic dosing system is already at the site, it can be wholly upgraded into a smart flotation system. For new projects, initially, HOT analyzes a large amount of experimental data, modifies the above mathematical model, and then waits until the innovative flotation system is used. After that, according to the laboratory coal assay results and the ash content detection values of the slurry ash online analyzer, it can automatically optimize the mathematical model.

Take Jiang Zhuang Coal Preparation Plant as an example: due to the enhanced control ability of the flotation intelligent system for the ash content of froth products, through the innovative flotation system, flotation dosing adjustment is carried out every 20 minutes or 30 minutes, and the ash content is pulled back to the required range in time, The ash content of the froth is controlled within a narrow range. On the one hand, it dramatically improves the yield of heavy medium coal and eliminates the "backward ash." On the other hand, it enhances the recovery rate of froth. In addition, by reducing the flotation reagent consumption and unmanned watch, the flotation workers are reduced, which reduces costs and increases efficiency in many ways, and the economic benefits are considerable.

Artificial Intelligence Empowering the Nonmetallic Ore Sorting

Application of Artificial Intelligence in the Selection of Nonmetallic Mines!

The CCD Color-Sorting machine can apply to pre-concentration of nonmetallic ore; it is used to identify the differences in physical properties (optical, radioactive, magnetic, electric, etc.) that are easily detected according to the different components of ore and separate the ore or waste rock by specific external features.

Color sorting machines can be classified and compared according to their architecture: belt and trough types. The belt color sorting device has many materials, high color sorting accuracy, low damage, high yield, small take-off ratio, and can be directly packed after selection. The damage to materials is relatively minor, and the damage is negligible. In addition, the speed is controllable, the yield can be adjusted, and the design can be done precisely according to the customer's production, but the cost is relatively high. The trough color sorter is suitable for traditional materials. However, the color sorting effect could be better for materials with significant differences in shape and size. After the color sorting is completed, the material will still be accelerated for a long time, increasing the damage to the material and resulting in a high breakage rate. In addition, the structure of the trough color sorter is fixed, the speed is set, and the output is also fixed.

Application of color sorters in the nonmetallic industry Color sorters can not only be used for the selection of agricultural products but also the selection of

many nonmetallic mines, such as potassium feldspar, heavy spar, quartz sand, fused quartz, calcium carbonate, marble, dolomite, wolframite, and phosphorus ore. Here, we take potassium feldspar and quartz sand as examples to introduce the application of color-sorting machines in nonmetallic minerals.

Application of color sorters in the selection of potassium feldspar Taking the mixture of potassium feldspar and quartz as the sorting object, using the apparent differences of potassium feldspar with reddish flesh color and quartz with transparent or milky white color, color sorters are used for the selection.

Mixed raw ore of potassium feldspar and quartz
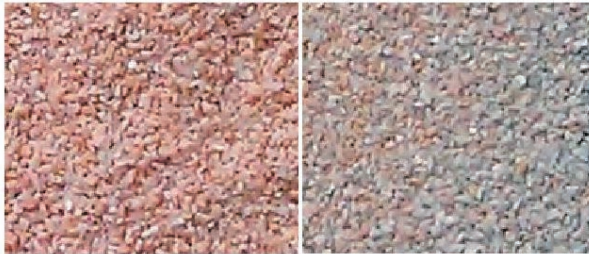
Potassium feldspar   Tailings

For potassium feldspar as the sorting target, the ore particle size is controlled between 3-10mm, and a certain sorting threshold is set for sorting. By measuring the potassium grades of the original ore before sorting and the enriched potassium feldspar after sorting, it was found that the enrichment ratio of potassium was 1.3, and 35% of the waste rock was discarded, which had an excellent sorting effect.

The application of color sorter in quartz sand ore sorting Quartz sand ore in the raw ore, the purer quartz sand is white or milky white, iron impurity or its vein minerals have light yellow, light yellow or light brown and gray color, quartz sand and iron impurities, or vein minerals color difference is the key of color sorting.
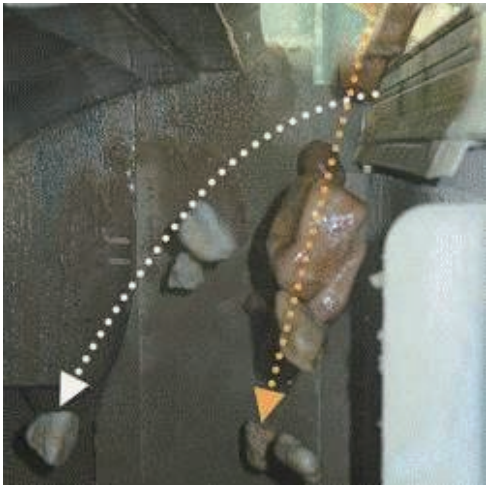
Quartz sand and vein mineral jet separation

Raw ore   Concentrate   Tailings
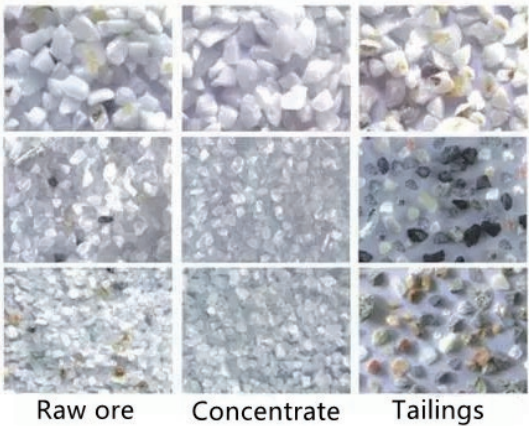
The main factors affecting the color sorting effect are camera resolution, software algorithm for distinguishing color differences, feeding system, and nozzle working performance. The camera is equivalent to the "eyes" of the color sorter. The higher the camera's resolution, the clearer the color sorter will "see" and provide the basis for accurate judgment of the materials the color sorter. The software is equivalent to the "brain" of the color sorter, determining its ability to distinguish color differences. The software algorithm analyzes the data seen by the camera, to a certain extent determining the intelligence of the color sorter and the "ideas" of the color sorter for the materials. The feeding system determines how the material enters the "field of view" of the color sorter and leaves after sorting. Finally, the nozzle is the "hand" of the color sorter, and the command is sent to the nozzle to execute after the "brain" of the color sorter judges the color of the material, so the flexibility and stability of the nozzle finally determine the sorting effect of the color sorter.

CCD Color Sorter Installation Requirements

1.Environmental Requirements

1.1 It is recommended not to install the device in low-temperature, high-temperature, humid or dusty environments. The ambient temperature around the color sorter should be kept within the range of 0-40°C. Before installation, ensure no substantial electromagnetic interference around the machine, such as welding or high-frequency transmission.

1.2 Please avoid installing the device in places with direct sunlight or intense lighting, which will reduce the ability of the light source system to capture signals, resulting in decreased color sorting accuracy, increased carryout rate, and reduced color sorting effect. If unavoidable light enters, it can be blocked with curtains or other light-blocking methods to prevent intense light from shining on the machine.

2.Space Requirements

2.1 Please install the device on a horizontal and stable platform, and use a spirit level to check the machine's status. Adjust the story of the machine to ≤2/1000mm and strengthen the support structure to prevent vibration or tilt from affecting the color sorting effect. It is recommended that the height of the factory building is ≥5m and the width is ≥4m. If the size of the factory building does not meet the requirements, the manufacturer suggests digging a pit.

2.2 There should be enough space around the color sorter operation platform (debugging table) for operation, inspection, maintenance, and repair. There should be a space of 0.5m to 1m around it.

3.Gas Requirements

3.1 The air supply pipeline of the air compressor should be free of contamination and connected with the rubber hose, galvanized pipe, or higher-grade channel.

3.2 Since the air compressor will produce a large amount of noise and vibration during operation, it will have a particular impact on the machine and a specific effect on the hygiene of some high-demand food. Therefore, placing the air compressor separately for a specific space, at a distance of 3m to 9m from the machine, is recommended to reduce air pressure loss.

4.Electrical Requirements

4.1 Please avoid installing the device on the same power supply line as high-power equipment to prevent the voltage of the color sorter power supply from dropping too much due to the sudden start of high-power equipment, which may affect the regular operation of the color sorter.

4.2 The color sorter power supply must use a separate power supply circuit, and the color sorter circuit must not be connected to the air compressor power supply line. A central control switch can be added to the power supply system for safe operation and system protection!

How to Choose the CCD Color Sorter for Quartz Sand?

CCD or XRT? Which one is more suitable for your mine?

For ores with apparent **surface features and significant differences in color, texture, and glossiness,** such as black tungsten, some antimony ores, and non-metallic minerals like calcium carbonate, quartz, and phosphorus, **CCD color sorting** (high-definition image recognition) technology is recommended.

For most ores with **unclear surface features,** such as copper, lead-zinc, tungsten, tin, antimony, molybdenum, gold-silver, sulfur, fluorite, feldspar, coal, etc., accurate knowledge of the internal structure of the ore is necessary for precise waste separation. Therefore, **X-Ray transmission (XRT)** is recommended, which uses the ore density characteristics (size, density, thickness) and relevant components (atomic sequence) to sort waste based on X-Ray reaction differences.

For some mines that **require the recovery of valuable non-metallic minerals,** such as quartz in gangue, a combined process of XRT and color sorting (high-definition image recognition) technology can be considered. First, XRT technology is used to select the ore, and then color sorting (high-definition image recognition) technology is used to choose the quartz or other valuable resources in the gangue. HOT Industries (Chengdu) Co Ltd has delivered some projects with above hybrid method.

Let's focus on quartz sand.

High-purity quartz sand is the primary raw material for producing quartz crucibles for photovoltaic monocrystalline silicon. With the further expansion of the crystal pulling and cell manufacturing process scale and the market opportunities for domestic substitution, its market demand will show a strong trend. However, the current domestic production capacity of high-purity quartz sand applicable to photovoltaic grades is limited, and the direction of crystal pulling development puts higher requirements on the purity of quartz sand. Therefore, finding high-quality quartz sources and improving purification technology is urgent. In addition, the market demand for low-iron quartz sand used in photovoltaic ultra-white glass will also experience explosive growth, and its large-scale supply may encounter bottlenecks. To solve this development bottleneck, developing various quartz raw materials deep processing technologies and improving the grade of quartz raw materials is imperative.

Ore color sorters are mainly used in the quartz stone industry in the following three aspects:

(1) The particle requirements for color sorting of quartz stone particles of 3-8 cm (commonly known as "38 blocks") are limited to particles that large blocks and miscellaneous stones can separate, excluding interlayer ore, black heart, and associated ore.

(2) The color sorting of 0.5-3 cm quartz stone particles includes interlayer ore, black heart, and associated ore.

(3) The color sorting of 4-120 mesh quartz sand can sort not only quartz sand but also natural sand, sea sand, etc. The impurities of the raw materials should be controlled within 5% as much as possible. If the contaminants exceed 5%, they must be color-sorted more than twice to be processed cleanly.

The process flow of ore color sorters in quartz stone beneficiation mainly includes three aspects:

(1) Dry particle selection: First, crush the particles into "38 blocks" for selection, and then crush them again into 0.5-3 cm particles. After water washing, drying, and grading, color sorting is performed.

(2) Wet particle selection: First, crush the particles into "38 blocks", then water washing, and then directly perform color sorting. Second, crush them into the range of 5mm-3cm for color sorting (note: less than 5mm cannot be wet selected).

(3) Quartz sand: Raw materials of quartz sand-namely artificial quartz sand, natural sand, and sea sand-are graded first, usually into 4-6 mesh, 6-8 mesh, 8-16 mesh, 16-26 mesh, 26-40 mesh, 40-70 mesh, and 70-120 mesh. Then, 8-120 mesh materials are magnetically sorted, and color sorted.

Advantages of the Matrix color sorter:

Extensive particle size range: The color sorter can sort particles with a maximum capacity of 8cm and a minimum of 140 meshes.

Adapt to multiple ore types: The range covers nearly a hundred non-metallic minerals such as quartz stone, silica, heavy spar, orthoclase, calcite, fluorite, calcite, gypsum, calcium carbonate, fused quartz, granite, salt, jade, phosphate, talc, silica lime, pebbles, kaolin, etc.

Support diverse selection: The color sorter supports an extensive range of mixed material selection, and materials ranging from 5mm to 3cm can be mixed for selection. The color sorting effect is unexpectedly good, with large output,

and has unique advantages compared to similar equipment.

Strong anti-interference ability: The color sorting effect of the Matrix color sorter is not affected by external environmental factors, whether day or night, winter or summer; the Matrix color sorter is not affected by external light and temperature and operates stably.

New Era Of CCD Color Sorting
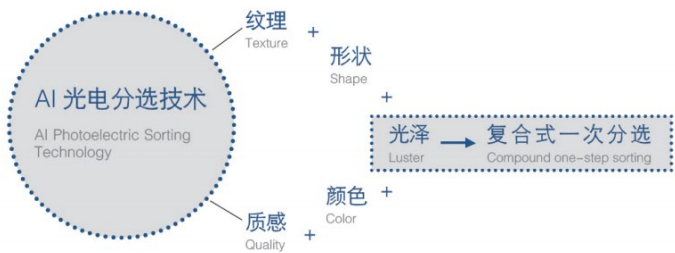
The development from color sorters to AI-embedded sorters represents a significant improvement from 1 to N. While color sorters can only sort based on color, artificial intelligence-based sorters can use visible differences in ore texture, color, shape, glossiness, and other features to extract, learn, model, and sort. This has significantly improved sorting personalization, diversity, and efficiency.

The IIoT-based (Industrial Internet of Things) CCD color sorter management platform

The research on the IIoT-based (Industrial Internet of Things) CCD color sorter management platform is a corporate-level color sorting management platform that combines advanced intelligent control, sensing technology, CCD technology, computer technology, network communication technology, and Web GIS technology based on the Internet of Things.

(1)Color sorter equipment monitoring terminal enterprise: The physical components of color sorter equipment include a feeding mechanism, separation mechanism, photoelectric detection mechanism, signal processing system, and human-machine interface. The hardware parameters involved in the remote monitoring platform mainly come from the CCD camera and the main control board.

(2)Cloud server-side: The cloud server-side is the central module of the system, responsible for connecting and maintaining terminal equipment, storing and processing command information, etc.

(3)Client-side: The client-side system fully embodies the system's multi-element visualization operation concept. It provides users with a diverse monitoring and operating platform. Besides, the devices listed in the figure can also be connected to auxiliary peripherals such as copiers, printers, fax machines, cameras, and large screens.

By calling Google Map Web service API, loading maps, and color sorting devices and their annotation information, users can supervise the production and processing of equipment and adjust parameters anytime and anywhere, providing the best working experience. The data exchange between the client-side real-time monitoring module and the server uses the Internet. The platform also has functions such as remote diagnosis, remote upgrade, equipment archives, operation and maintenance management, and data analysis, further improving and guaranteeing production management efficiency.

The service capabilities and economic benefits of the IIoT-Based color sorter management platform:

(1) Remote interconnection of equipment. Realize the online operation of color sorting equipment, improve efficiency, and save operating costs for mining enterprises.

(2) Real-time extensive data analysis. Mine data is analyzed to guide customers in optimizing processing technology and enhancing customer value.

(3) Remote equipment operation and maintenance. Solve equipment maintenance problems for mining enterprises, reduce downtime, and reduce the human cost of equipment manufacturers while improving service efficiency and capabilities.

New Super Star, the Intelligence Filter Press

HOT has implemented an intelligent filtration system at the Tucheng coal washing plant, which mainly includes modules such as filter press monitoring, automatic feeding, automatic end of the feeding, automatic queue unloading, filtration production statistics, system auxiliary equipment monitoring, etc.

The intelligent filtration system is based on parameters such as time, flow, and pressure, and a pressure transmitter and flow meter are installed on the site filter press. When the feeding requirements or liquid level alarm are reached, the filtration control system will link multiple filter presses. The filter presses will be queued for feeding, realizing automatic and intelligent feeding. The unloading status monitoring device will monitor the filter plate opening and closing according to the filter cake attachment on the filter plate. The system will automatically assist in cleaning the unloading through the vibrator installed on the filter press to achieve automatic and intelligent unloading. It is understood that the system will connect the PLC signal of the filter press to the server background, and the collection control system will be connected with the filtration system, taking the collected filtration system data as the control node. Through the automatic filtration control system, the linkage control between the

filter press and the scraper machine, and the filter press and the filter press can be realized, ensuring that the entire cycle control of the filter press is unmanned.

After the intelligent upgrade of the filtration system, it replaced the traditional personnel on-site control of the filter press operation, overcoming the problems of significant personnel demand, high work intensity, strong experience dependence, and low system efficiency of the coal preparation plant filtration system. The system can automatically feed, automatically judge the end of the feeding, automatically queue for unloading, and perform other functions, improving the filtration system's overall working efficiency.

"There are four filter presses in the coal preparation plant. After the comprehensive intelligence of the filtration system, the same raw coal in washing quantity was used as the basis for statistics. After the intelligentization, the mud produced by each shift increased by 12 boards. As a result, the personnel on duty decreased from 3 to 1, and the production efficiency was greatly improved", Camus Zhang, the R&D Director, introduced.

Now Coal Centrifuge Embraced AI

The research aims to improve the quality of the clean coal by reducing the moisture content, ensuring the operation of the coal preparation plant efficiently, and improving overall margin.

The research mainly focuses on studying the effects of working parameters, structure configuration, and unified force field on the dewatering effect of fine coal, developing a new high-efficiency centrifuge and dewatering technology for fine coal, researching the influence of airflow properties and jet structure on the dewatering effect of fine coal in the material transfer process, and developing the core airflow field generation scheme for air-enhanced dewatering.

The critical designs of the new high-efficiency fine coal centrifuge are created, including a research platform for the essential structures of the new centrifuge, a study of the influence of the sieve basket structure on the airflow flow during the dewatering process, and the development of a high-efficiency feeding structure. The design of the new high-efficiency large-scale fine coal centrifuge is also studied, and an intelligent control system is set up to monitor the airflow parameters in the operation process of the centrifuge.
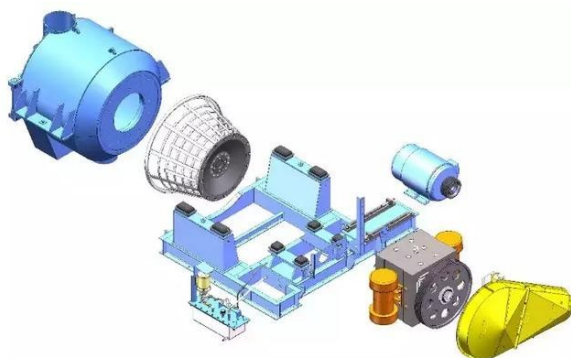
In addition, a predictive maintenance system is built, which monitors the core components of the centrifuge in real time and predicts malfunctions ahead of time to avoid unexpected shutdowns. The solid particle monitoring system is also installed to monitor the solid particle content in the centrifugal liquid and analyze the wear of the sieve basket to replace the worn parts in time and reduce the abnormal shutdowns during production.
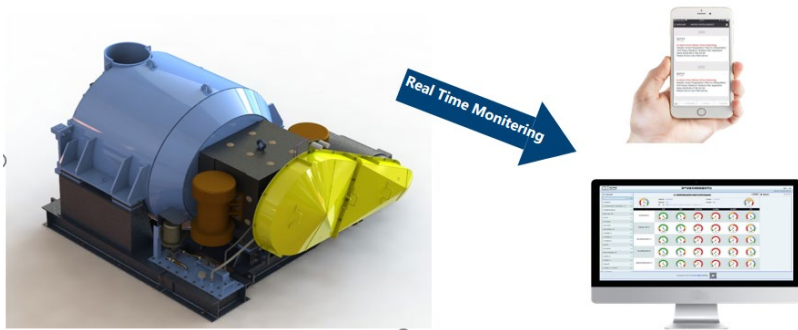
Real-time alerts are sent to production personnel so they can be informed and acted upon in the first instance.

Diagram of cube monitoring points below

Schematic Diagram of Monitoring Points of Cube
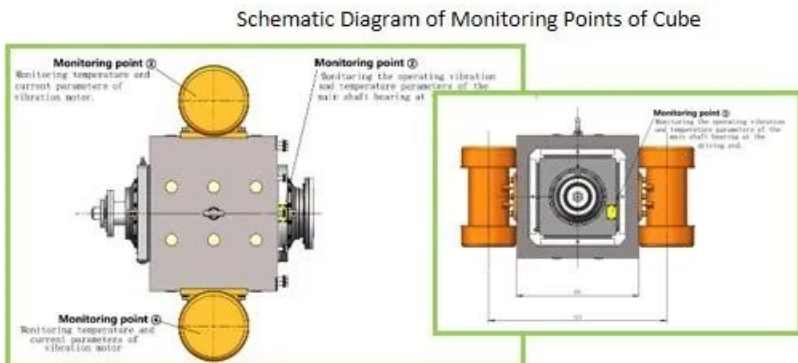
Influencing Factors of De-watering Effect of Horizontal Centrifuge:

Feeding Moisture

The de-watering effect of the horizontal centrifuge is closely related to the feed concentration. Taking the HCC1400 horizontal centrifuge as the research object, the de-watering effect test was carried out by increasing the high-pressure water valve in the feeding hopper and regulating the feed concentration by the high-pressure water volume. The test results showed that with the increase in the feed concentration, the moisture content of the products decreased. On the other hand, when the feed concentration was less than 20%, the moisture content of the product was high, which seriously affected the product quality. At the same time, low-concentration materials also accelerated the wear of the sieve basket, which was not conducive to improving the efficiency of the centrifuge. When it was more than 20%, the product moisture had a negative inverse relationship with the feed concentration. However, the higher the feed concentration, the better because when the feed concentration is too high, it is easy to cause the blockage of the hopper of the centrifuge, which is not conducive to improving the de-watering efficiency of the centrifuge. Therefore, when using the horizontal centrifuge for the de-watering of materials, the feed concentration should be reasonably controlled to ensure that the moisture content of the product reaches the best, which not only can improve the product quality but also can prolong its service life and improve the efficiency of use.

Sieve Basket Slot Width

The sieve basket is the critical component of the horizontal centrifuge, mainly composed of upper and lower flanges, reinforcing ribs, and cone sieves. Fan-

shaped sieves generally weld the sieve. When the sieve basket is working, it has to be seriously impacted by the feed, and if it is misused, it is easy to replace. The size of the sieve slot directly affects the de-watering effect. If the sieve slot is too small or the new sieve basket is returned, the de-watering effect is worse. With the sieve basket, the place gradually increased due to wear and tear, and the de-watering effect tended to increase. The main reason was that the small sieve slot was easy to block the mud and reduced the sieve width, affecting feed moisture passage and increasing product moisture content. Balasu Coal Mine of a specific Selection Plant studied the relationship between sieve slot width and de-watering effect with HCC1400 horizontal centrifuge. The test results showed that when the sieve slot width increased from 0.25mm to 0.35mm, the product moisture decreased from 16% to 12%, and the de-watering effect was improved. But the sieve slot is too large. In that case, it will affect the recovery of the coarse mud, so the reasonable sieve slot of the sieve basket should be determined by taking into account the recovery of the mud and the de-watering effect.

Feeding Particle Size

Material particle size composition affects the permeability of the material layer. For example, when there are more fine particles, they are easy to fill in the coarse particles to form a material layer with good compaction and poor permeability. On the other hand, when there are more coarse particles in the material, the gaps created by the coarse particles are significant. As a result, the difficulty of water passing through the screen basket is significantly reduced, which is conducive to reducing the product's water content, just like fine river sand can form a waterproof layer. In contrast, coarse river sand has good permeability. Theoretical studies and practice have shown that reducing the size of the feed material is beneficial for reducing the water content of the products and improving their quality.

Feeding speed

Tests were conducted on-site to study the relationship between feeding speed and de-watering. With the setting of feed concentration as 30%, the falling height was set at 8m, 6m, 4m, and 2m, respectively, equivalent to changing the feed energy by changing the falling size. The higher the falling height, the faster the feeding speed, so the water content of the tested product can be obtained at different feed speeds. The results showed that when the falling height was 8m, the water content of the product was 27%; when the falling size was 6m, the water content of the product was 21%; when the falling height was 4m, the water content of the product was 15%; and when the falling size was 2m, the water content of the product was 2%. It can be seen that although the falling height is not inversely proportional to the water content linearly, within certain limits, with the increase of the falling size, that is, with the rise of the feeding speed, the water content of the product increases. Given this, to improve the de-watering effect of horizontal centrifuge, the feeding rate should be determined reasonably; that is, the feeding speed can be controlled by changing the falling height.

Methods to improve the de-watering effect of the centrifuge

Reasonable control of feed water, regular cleaning of selected material screens, ensure suitable feed concentration, according to the centrifugal de-watering effect and material concentration research results, should ensure that the feed concentration range is 40%-65%, at the same time, can be according to the need to increase the high-pressure pipe to adjust the feed concentration, but also solve the problem of feed tank plugging caused by a high concentration of material.

From the analysis of feed particle size and centrifugal de-watering effect, it

can be seen that too much fine material is not conducive to improving the de-watering of the centrifuge, so the content of fine material should be strictly controlled. At the same time, to prevent the low permeability material layer formed by fine material from affecting the de-watering effect, the screen gap should be washed regularly according to the needs to ensure the best de-watering effect.

Feed speed has a significant impact on the de-watering effect. To improve the de-watering effect of the centrifuge, the falling height can be appropriately reduced to reduce the feed speed, or the feed tank can be given a sloping buffer tank to mitigate the feed speed properly.

Select the screen basket with the width of the screen gap that meets the de-watering effect according to the needs, and take care to prevent the screening gap from being blocked and affecting the de-watering.

HOT Uses Data To Maximize Your Uptime ——The Revaluation of Maintenances for Screens by Data-Driven and AI

A vibrating screen is a large, heavy piece of equipment widely used in the mining industry. Unfortunately, the difficulty of daily maintenance and upkeep of vibrating screens leads to frequent equipment failures. The fundamental reason for this is that vibrating screens are products that scientifically utilize the destructive power of vibration.

For traditional machinery, unconventional vibrations generated during equipment operation are one of the precursors of equipment failure. However, vibrating screens use vibration to change the material's motion trajectory and achieve screening effects. Although the vibration industry has never stopped designing and researching optimization structures to combat destructive forces, an effective solution has yet to be found. As a result, equipment failures for vibrating equipment still occur frequently.
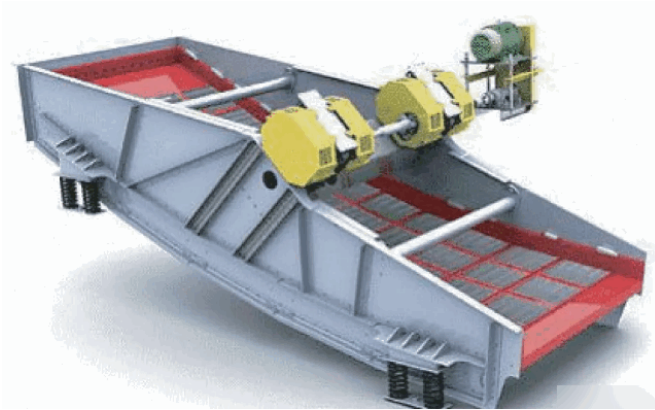
Vibrating screens are usually arranged in the throat of the production process system. If several minor problems during equipment operation cannot be detected promptly, the vibrating screen may cause significant failures. This can result in the entire production system shutting down, causing substantial customer losses. In mining, coal, metallurgy, and other industries, sudden accidents and shutdowns directly affect production schedules. The loss of profits ranges from tens of thousands to millions of yuan. Most importantly, premature failures of vibrating screens during operation will directly threaten the safety of inspection personnel's lives.
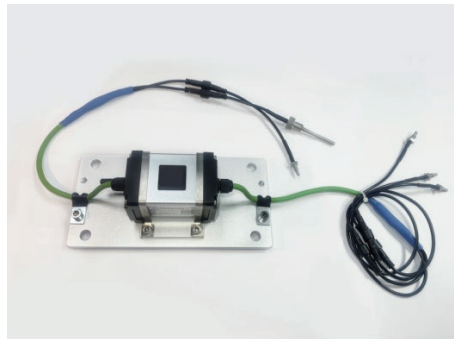
The PHM maintenance system for vibrating screens developed by HOT Industries uses sensor technology, automatic control technology, Internet of Things technology, and big data technology to monitor various operating parameters of vibrating screens in real-time online. In addition, the system uses intelligent extensive data analysis to analyze equipment performance status and provide early warning of faults. In the factory, the system promotes products to the market and offers better services to customers by understanding the usage of the products in the enterprise in real time. For customers, the system can arrange equipment maintenance time reasonably according to equipment operation monitoring, reduce the staffing, material, and financial resources invested in emergency equipment repairs, and improve production efficiency and benefits.
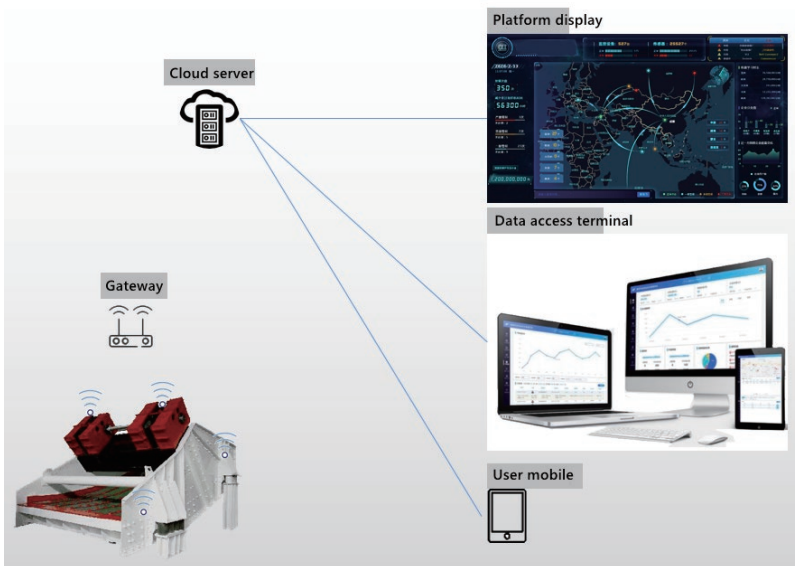
The system functions

1) Monitoring function: continuous status monitoring and browsing historical data.

2) Alarm function: automatic warning, automatic alarm, WeChat push alarm information.

3) Analysis function: equipment condition prediction, maintenance plan push.

4) Auxiliary function: equipment QR code management.

5) Push function: AI algorithm analysis and report generation push to WeChat client.

6) Monitoring parameters: motor vibration temperature, screen body vibration intensity, screen body vibration angle, screen body vibration balance, exciter operating bearing temperature, lubricant temperature, etc.

Real-time online monitoring
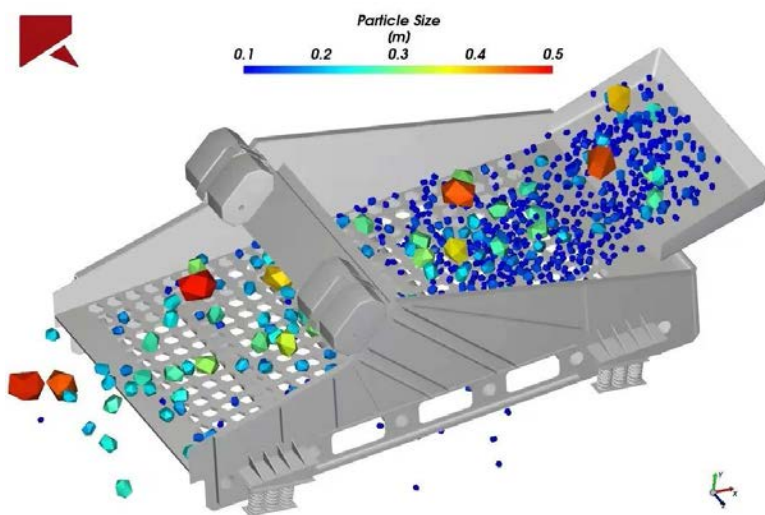
Real-time online monitoring is conducted on the core components of the vibrating screen, primarily focusing on monitoring the motor vibration temperature, vibration balance of the feed inlet before and after the screen, vibrator vibration, four bearing temperatures, and lubricating oil temperature. To ensure accessible data collection and reduce implementation difficulty, on-site

sensors are battery-powered and utilize wireless data transmission. The sensors monitor and collect vibration and temperature data for a particular duration at set intervals and wirelessly transmit the data. A relay is deployed near the vibrating screen to receive data from multiple sensors and send the data to the enterprise cloud platform for data analysis via the on-site or 4G/5G network. Real-time online monitoring can effectively monitor the vibration balance of the screen during equipment operation, uneven feeding, and vibrator bearing faults, allowing timely detection of equipment failures and corresponding measures to avoid accidents.

Continuous state monitoring
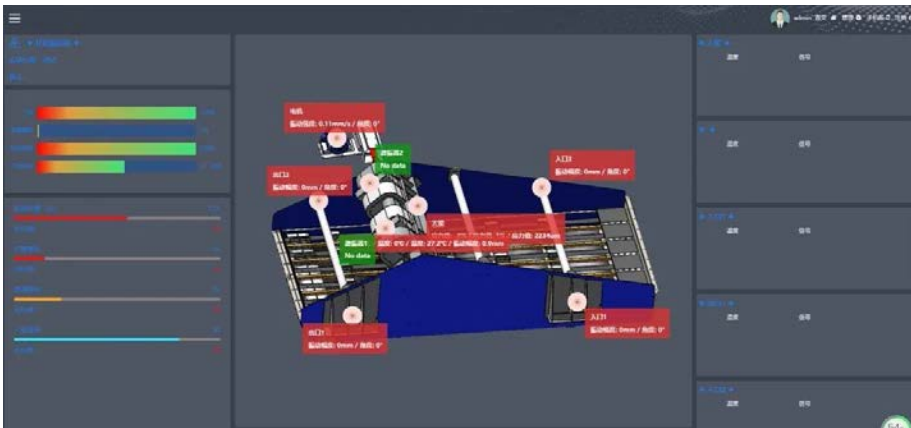
HOT Industries' PHM system utilizes multi-channel state monitoring technology designed explicitly for the vibrator in the vibrating screen. It is cross-connected with the vibrator in the vibrating screen to detect and evaluate phase defects, examine and record bearing and gear vibration, operating oil temperature, and overall machine motion in six degrees of freedom (three translations and three rotations).

Main features: 1) Machine condition visualization. 2) Detailed view of the selected machine status. 3) Real-time push of dashboard data. 4) Responsive web design - dashboard panels adapt to screen resolution and panel interaction. 5) Time zone and language automatically adapt to the client system. 6) Alert push within the threshold limit range.

Cloud platform & cloud services

The cloud platform employs big data, artificial intelligence technology, and other technologies to establish equipment models and algorithms, continuously training and learning to improve the reliability and accuracy of equipment failure warnings. By introducing the model with long-term monitoring data and using real-time data as input, the trend of various monitoring indicators can be predicted and analyzed to determine equipment performance status and predict equipment failures. Fault information is promptly pushed to the relevant personnel through the APP or WeChat public account for timely measures, eliminating faults in the bud.
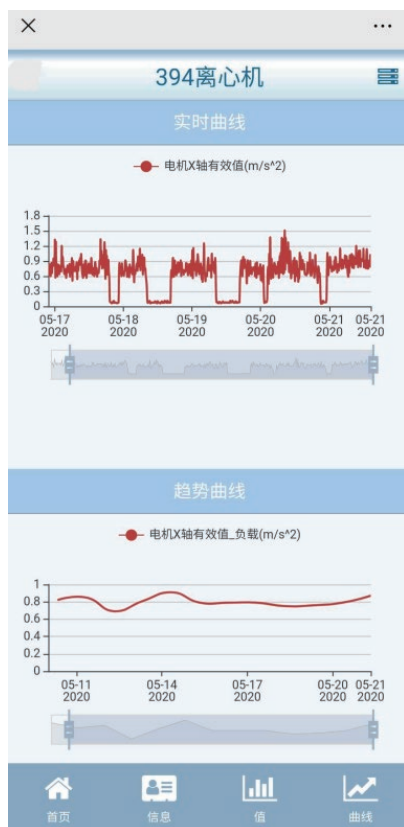
The cloud platform stores equipment monitoring data, allowing users to view equipment operating data and historical monitoring data anytime, anywhere through mobile phones, computers, and other devices. It also provides reliable operating monitoring data to optimize product design and continuously improve product quality for equipment enterprises.

Analysis of data and alert users can integrate into a BI dashboard and WeChat/APP notifications. These warnings enable customers to schedule vibrator replacements one week before a fault occurs, preventing unnecessary process downtime and saving significant maintenance costs.

Using cloud-based intelligent digital services, deviations from normal operations can be detected earlier than ever, far beyond traditional threshold warnings. It combines machine learning technology with traditional machine process knowledge, providing specific dashboards, notification indicators, and access to a machine's fault mode database for quick corrective action. In addition, this service collects and evaluates data from the overall operation, such as vibration, speed, pressure, temperature, etc., and monitors essential measurement values to prevent harm to personnel and damage to machines.

HOT Industries cloud service advantages: 1) Capture process data, including vibration, speed, pressure, temperature, etc. 2) Associate all values through artificial intelligence (machine learning) 3) Machine-specific dashboards for maximum transparency 4) Access to the entire machine's fault mode database for quick corrective action 5) Broad applicability to match various types of vibration screens.

Intelligent services for vibration screens include a data-driven model that predicts normal behavior based on historical data and current machine and process operations. Its powerful new feature is how it handles the differences between measured and predicted values, reflecting the degree of deviation from normal operations. Machine learning algorithms monitor not only individual values but also the correlation of all values, especially the operating mode of the machine or process at any given time.

SLK3661W vibrating screen   Data acquisition instrument   Acceleration sensors
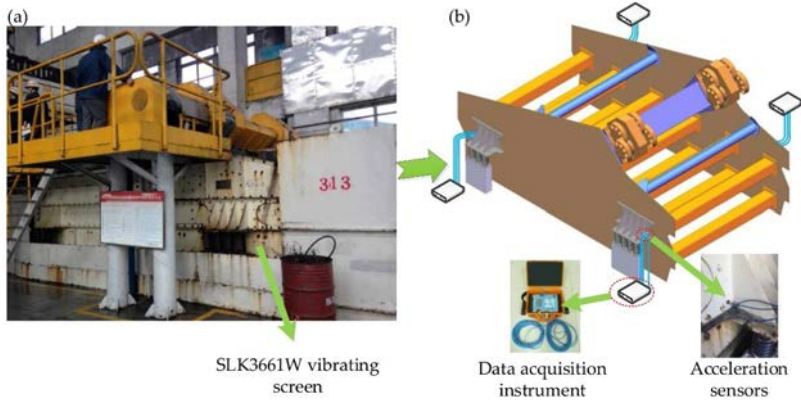
HOT Industries' PHM maintenance system is committed to the smooth operation and intelligent operation of vibration screens, from initial real-time monitoring to industry expert support for historical equipment issues. Customers can access real-time dashboards with KPI information on mobile devices and get all relevant information anytime, anywhere.

Global overall settings and systematic layout optimization enable customers to obtain data interpretation, maintenance suggestions, and maintenance methods on the client side, supplemented by considerable historical data support at various levels, assisting the factory's workforce.

Future research directions: HOT Industries is developing a new type of vibration screen PHM system that can monitor the movement, status, and performance of vibration equipment and the rate of unbalanced vibrators driving vibration screens and feeders. With minimal installation work, a wireless sensor can be installed on the cover of the vibrator using a magnet. Once the vibrator is fatigued, the sensor picks up high-frequency signals from worn bearings and gears.

How Can the Best Machine Learning Algorithm Be Chosen for AI Applications in Mineral Processing?
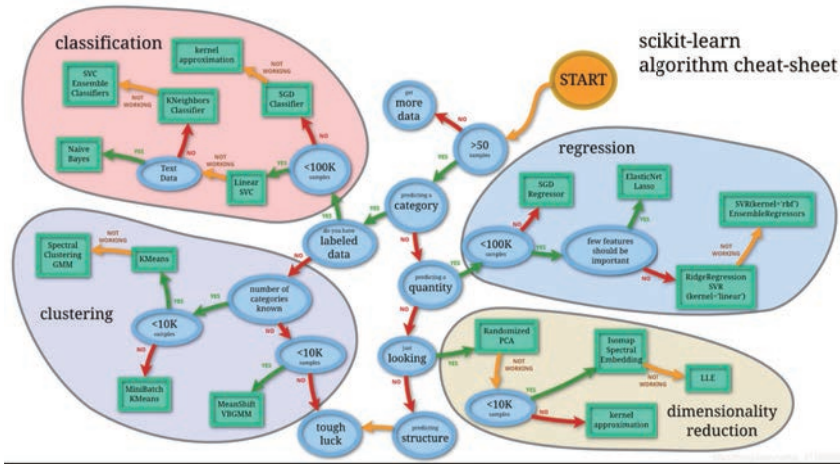
Machine learning can be used to solve a wide range of problems. However, there are many different algorithms, and knowing which algorithm is suitable for a particular application scenario can be complicated. This article focuses on choosing the most suitable machine learning algorithm when applying artificial intelligence to the mining industry.

1. Determine the problem you want to solve

The first step is determining the problem you want to solve: is it a dimensionality reduction, prediction, classification, or clustering problem? This can narrow the selection range and determine which type of algorithm to choose.

What type of problem do you want to solve?

Classification Problems: logistic regression, decision tree classifier, random forest classifier, support vector machine (SVM), naive Bayes, or neural network

Main Applications: mineral pre-sorting (e.g., XRT), mineral grade and element detection (XRF-X-Ray fluorescence slurry grade detection, X-Ray ash analyzer), intelligent flotation, predictive maintenance

Clustering Problem: k-means clustering, hierarchical clustering, or DBSCAN

Main applications: before building supervised machine learning algorithms for classification and prediction applications, unsupervised machine learning is needed to analyze a large amount of raw data, achieve clustering analysis of data, and find relationships and hidden features between different categories of data.

For example, before building a model for the dynamic density control system in a coal preparation plant, it is necessary to find the relationships between various data (such as the relationship between valve opening and separation density, the relationship between valve openings, etc.). The three most essential variables in the dense medium coal preparation process are the density of the dense medium suspension, the coal slurry content, and the qualified medium bucket liquid level. HOT has researched data feedback, parameter setting, and dense medium density control in the dense medium coal preparation process and established a model for predicting the density of the dense medium suspension. In this process, HOT used the least squares support vector machine (LS-SVM) algorithm to train sample data, establish a calibration model, and accurately calibrate data detected in the online gray measurement instrument.

2. Consider the size and nature of the dataset

a) Size of the dataset

If the dataset is small, choose a less complex model, such as linear regression (for data analysis with less than 100 samples, Excel can perform good linear regression analysis of multiple variables, including binary variables). More complex models, such as random forests or deep learning, may be appropriate for larger datasets.

How to judge the size of the dataset:

Large datasets (thousands to millions of rows): gradient boosting, support vector machine, neural network, or deep learning algorithms.

Small datasets (less than 1000 rows): logistic regression, random forest, decision tree, or naive Bayes.

For mining and coal preparation plants, the data is usually extensive. For example, the dynamic density control system may have thousands of data lines for just a few teams, such as ash content, density, valve opening, etc., which is only one production link in the entire coal preparation process. Especially for large and medium-sized mining group companies with multiple mining and coal preparation plants, cleaning, analyzing, and applying massive data is very challenging. For example, Shendong Coal Group's Shanwan Intelligent Coal Preparation Plant has established a customized, precise production development and application model (as shown in the figure below), which is connected to Shendong's ERP and business execution system data to obtain production plans, loading plans, coal quality data, etc. Hand-entered data, receive real-time data from the automation system, analyze and store data in real-time, and display

statistical data from the production site to the management in an accurate and timely. This model can predict the product quality under different production methods based on the raw coal quality information, combined with the cost accounting method, and perform statistical analysis on the product cost and benefits under other production methods in related systems, to analyze the optimal production method combination based on the principle of maximizing benefits and provide support for management and decision-making.
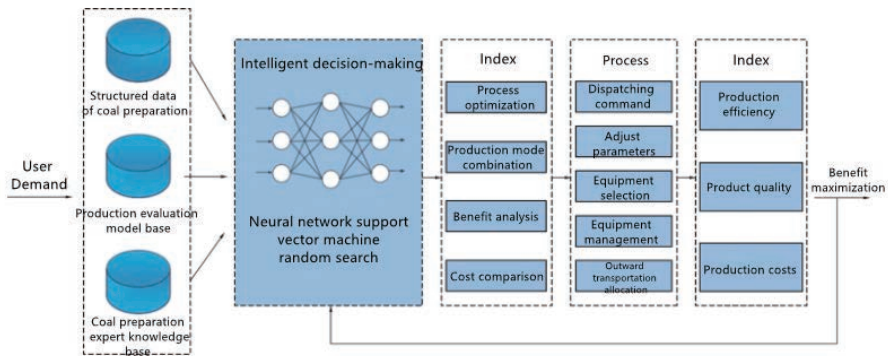
b) Data labeling

Data can be labeled or unlabeled. Labeled data can be used in supervised machine-learning models like random forest, logistic regression, or naive Bayes. Unlabeled data requires unsupervised machine learning models, such as k-means or principal component analysis (PCA).

c) Feature properties

For categorical features, decision trees or naive Bayes may be used, while for numerical features, linear regression or support vector machines may be more appropriate.

Categorical features: decision trees, random forest, naive Bayes.

Numerical features: linear regression, logistic regression, support vector machines, neural networks, k-means clustering.

Mixed features: decision trees, random forest, support vector machines, neural networks.

d) Missing values

Decision trees, random forest, or k-means clustering may be used for datasets with many missing values, and for datasets with missing values that do not fit these models, linear regression, logistic regression, support vector machines, or neural networks may be considered.

3.Interpretability vs. Accuracy

Some machine learning models are more accessible to interpret than others. If interpretability is important, models such as decision trees or logistic regression can be selected. If accuracy is the key concern, more complex models such as random forest or deep learning may be more suitable.

4.Data complexity

If there may be non-linear relationships between variables, more complex models such as neural networks or support vector machines may be needed.

Low complexity: linear regression, logistic regression.

Medium complexity: decision trees, random forest, naive Bayes.

High complexity: neural networks, support vector machines.

In the mining industry, most data falls into the medium to low complexity range, with only a few intelligent mining processes using more complex algorithms. For example, in a coal preparation plant's dynamic density control system, a data mining model was established using neural network, logistic regression, and decision tree algorithms to predict the circulating medium density, with input matrices including belt weighing, ash analyzer, and circulating medium density. After comprehensive comparison and evaluation using ROC curves and confusion matrices, the neural network algorithm was more suitable for predicting the circulating medium density. In addition, BP neural networks are also used in flotation and mineral processing plant reagent addition systems.

5. Balancing Speed and Accuracy

When considering the trade-off between speed and accuracy, more complex models may be slower but could also offer higher precision.

Speed is more critical: decision tree, naive Bayes, logistic regression, and k-means clustering.

Accuracy is critical: neural networks, random forests, and support vector machines.

6. High-dimensional Data and Noise

If dealing with high-dimensional or noisy data, dimensionality reduction techniques (such as PCA) or models that can handle noise (such as KNN or decision trees) may be needed.

Low noise: linear regression, logistic regression.

Moderate noise: decision tree, random forests, k-means clustering.

High noise: neural networks, support vector machines.

7. Real-time Prediction

If the real-time prediction is needed, models such as decision trees or support vector machines should be selected.

For example, XRT Ore Sorting, XRF slurry grade detection, and predictive analytics;

8. Handling Outliers

If the data has many outliers, robust models like support vector machines or random forests can be chosen.

Models sensitive to outliers: linear regression, logistic regression, power regression.

Models with high robustness: decision tree, random forests, support vector machines.

9. Deployment Difficulty

The ultimate goal of a model is to be deployed, so deployment difficulty is the last factor to consider:

Some simple models like linear regression, support vector machines and decision trees can be relatively easily deployed in production environments because they have small model sizes, low complexity, and low computational costs. However, on complex datasets such as large scale, high dimensionality, and nonlinearity, the performance of these models may be limited, and more advanced models, such as neural networks, are needed.

For example, the XRT Ore Sorting technology algorithm mainly uses basic algorithms such as random forests and support vector machines for mineral and gangue (coal and waste rock) identification and analysis rather than convolutional neural networks. This is because, in XRT's actual production application, precise separation of minerals at the sub-millisecond level is required. **Therefore, more advanced algorithms cannot meet the practical needs of production.**

In conclusion, choosing the correct machine learning algorithm is challenging and requires balancing specific problems, data, speed, interpretability, deployment, and selecting the most suitable algorithm according to requirements. However, following these guiding principles ensures that your machine learning algorithm is highly suited to your specific use case and provides the necessary insights and predictions.

From Mars to Earth, LIBS Is Rejuvenating the Mineral Processing by Accurate Element Analysis!

Laser-Induced Breakdown Spectroscopy (LIBS) or Laser-Induced Plasma Spectroscopy (LIPS) is a rapid chemical analysis technology that uses a short laser pulse to create microplasma on a sample surface. This analytical technique offers many compelling advantages compared to other elemental analysis techniques.
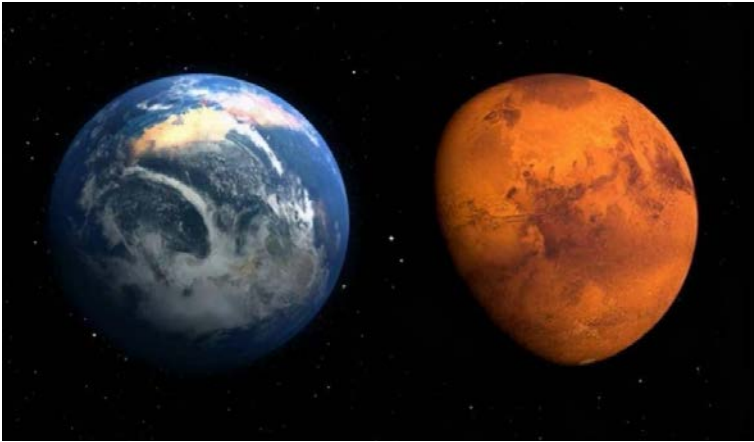
The surface composition detector of the Zhurong rover includes Laser-Induced Breakdown Spectroscopy (LIBS) and Short-Wave Infrared Spectroscopy.

Let's start with the latter. "Spectroscopic" detection is a commonly used remote sensing method. Different materials have different characteristics in reflecting light, and the result is that the reflection spectrum image containing a particular substance will show prominent absorption bands in certain specific bands. This is the "fingerprint" that scientists search for when looking for a particular sense in outer space that they cannot physically reach.
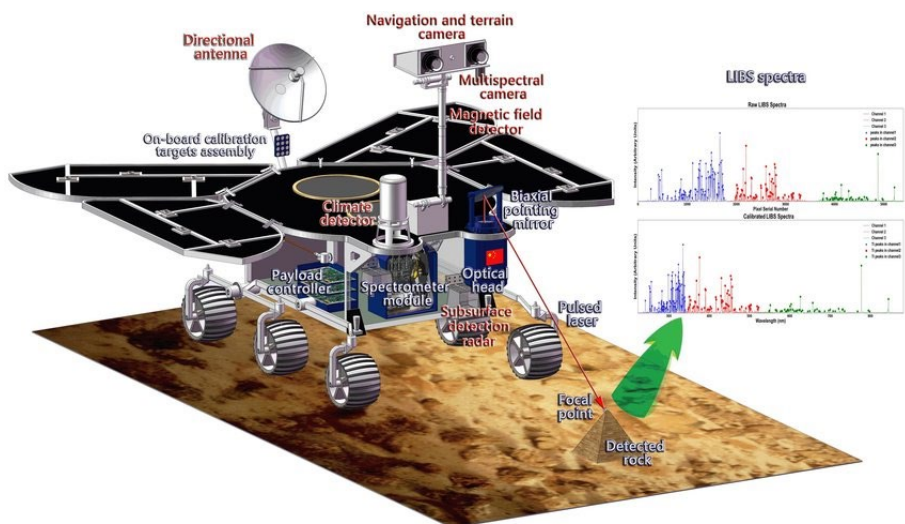
Whether it is a spectrometer carried by an orbiter or a spectrometer taken by a rover, essentially, they both detect which minerals are contained on the planet's surface and what their distribution is by observing the features of the reflected spectrum of the target area— the difference is only in the detection frequency band and resolution of different spectrometers, and the corresponding detected material composition may also differ.

The Short-Wave Infrared Spectroscopy is a detection band of this spectrometer in the short-wave infrared band (0.85-2.4 μm).

The LIBS is even more impressive: by emitting high-energy laser pulses to the target object, it detects the characteristic emission spectrum during the cooling process of the ablation-excited plasma. It then remotely detects the basic composition information of the target object. Simply put, this is a "laser cannon."

Atoms, Ions, Molecules
Clusters, Particles

Pulsed Laser Beam

TARGET

Laser Ablation
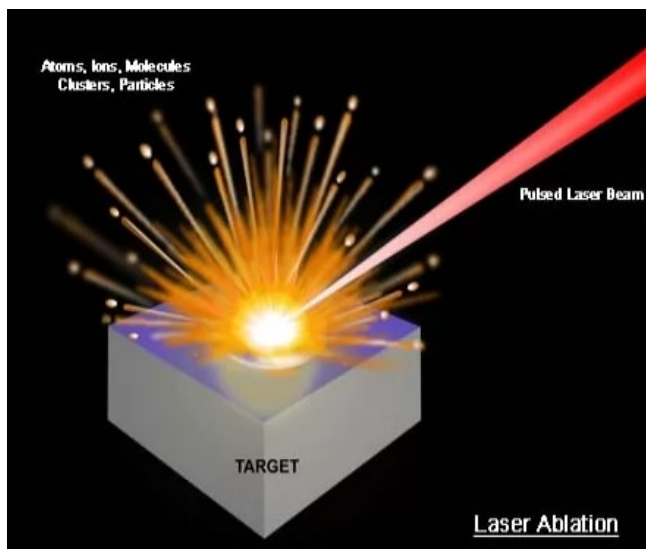
The LIBS of the Zhurong rover can detect more than ten elements in the target object, including silicon, aluminum, iron, magnesium, calcium, sodium, oxygen, carbon, hydrogen, manganese, titanium, and sulfur. This is also China's first time using this technology for deep space exploration. Before this, NASA's ChemCam and SuperCam carried by the Mars rover verified the scientific value of this "high-energy" technology on Mars.

How does the LIBS laser-induced breakdown work? Spectral analysis can reveal the chemical composition of planets and stars tens of thousands of light-years away. Essentially, this is based on the unique characteristic that each element has a distinctive absorption spectrum. This principle can also be applied in reverse. When electrons return from the "higher" energy level to the "lower" energy level, they release the energy they previously absorbed, which means the previously absorbed specific wavelength of light will be rereleased, changing from an "absorption" spectrum to an "emission" spectrum. The most common example in life is the different colored flames produced when metals burn:

copper produces a blue flame, lithium produces a red flame, calcium produces an orange flame, sodium produces a yellow flame, and barium produces a green flame. Each element has its unique emission spectrum.
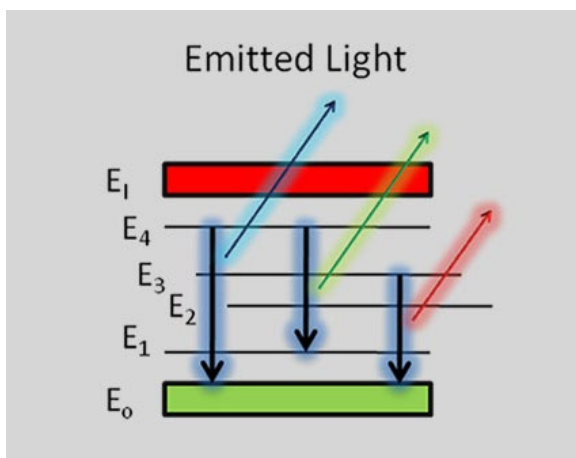
Therefore, in theory, to analyze the chemical composition of a compound, one only needs to ignite the combination and explore the spectrum of its flame. But, of course, without even considering that some compounds' ignition points and even melting points can be very high, in most cases, people want to complete the analysis without destroying the sample itself. This is where the laser comes in. Compared with the "violent" behavior of collecting the spectrum of the flame of the plasma by igniting the compound as a whole, the laser, which also originated from quantum mechanics, has the unique advantage of being able to release enormous energy in a short time and small range, allowing a small part of the compound to become plasma without damaging the overall sample. If the shutter of the spectrometer is fast enough, it can capture the light emitted by the plasma after the trace sample is ionized in a short time. On the premise of not damaging the sample, it can construct an emission spectrum and analyze the specific composition of the compound sample.
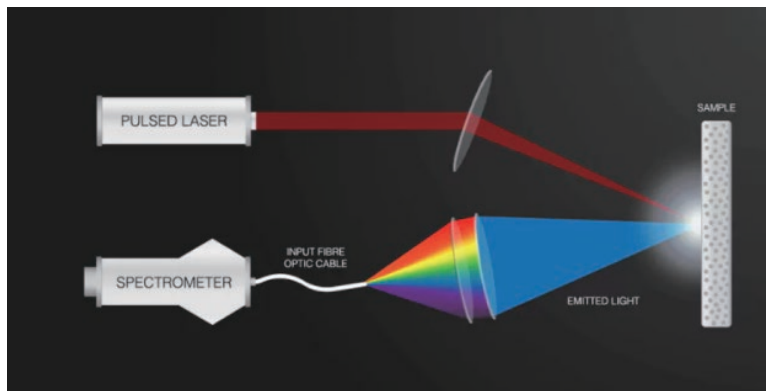
Specifically, LIBS focuses on a tiny area on the sample's surface and rapidly emits a pulsed laser with a temperature exceeding 30,000 degrees Celsius, causing the sample to ionize to about one picogram (10^{-12} grams) to 1 nanogram (10^{-9} grams). As a result, chemical bonds quickly break down, and electrons within the elements are instantly excited to higher orbits. The plasma then expands supersonically and rapidly cools after 10 microseconds (10^{-6} seconds), and the excited electrons return to lower orbits to release the light of specific wavelengths. The spectrometer then scatters the light at different wavelengths to analyze the chemical composition. Taking water, the most commonly used substance in nature, as an example, the water spectrum of LIBS is as follows:
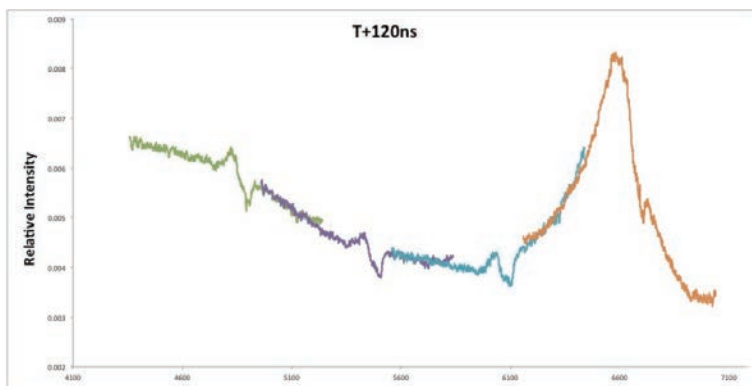
There is a prominent peak at a wavelength of about 660 nanometers, called the Balmer series alpha line, which corresponds to the light released by the electron of a hydrogen atom returning from n=3 to n=2. The accurate wavelength is 656.3 nanometers, corresponding to visible red light. The peak is much broader than almost a single line for pure hydrogen gas. The peak position is also shifted because the plasma generated has a concise duration and is easily affected by external factors such as refraction in water. Therefore, for samples with complex components, LIBS often requires hundreds or even thousands of laser pulses to obtain a large amount of spectral data for comprehensive analysis to reduce the impact of external factors on single sampling. Fortunately, even with 1000 laser pulses, only about one microgram of mass is lost, and the sampling time is short, which will not harm the sample or actual collection.
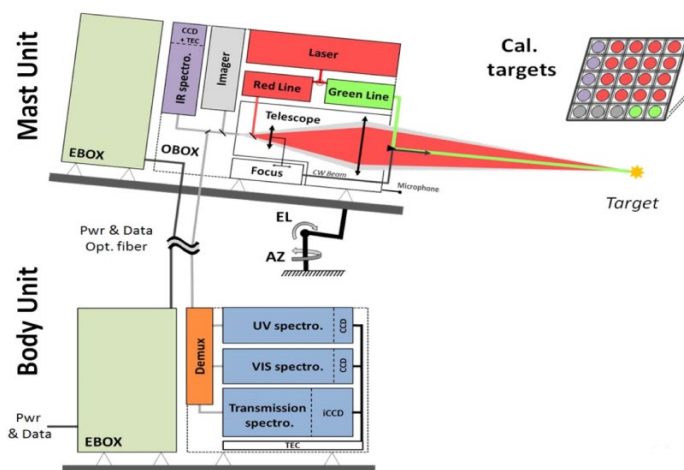
Because of its non-contact sample composition analysis feature, LIBS is particularly suitable for use in outer space explorers. For example, ChemCam, which uses LIBS technology, followed the Curiosity Mars rover and landed on the surface of Mars in 2012. The "eye" on the "head" of the Curiosity rover is the ChemCam laser emitter, which emits a 5-nanosecond pulsed infrared laser to ionize the Martian soil within a range of 7 meters. The 110-millimeter lens

camera under the laser emitter then transmits the light emitted by the plasma state of the Martian soil to the spectrometer inside the vehicle through optical fibers, and the spectrometer scatters the light onto the spectrum from 240 nanometers to 820 nanometers.

Now, let's turn to the application to mineral processing.

In response to the need for fast and real-time quantitative detection of multiple elements, exceptionally light factors (Z<11), involved in different products in different industries, this cutting-edge technology relies on the green technology of laser-induced breakdown spectroscopy to solve the technical problem of rapid detection of all elements, and develop intelligent spectroscopy technology for quick and quantitative detection of all elements, thus meeting the product requirements of key sensor links in the field of intelligent manufacturing. As a result, it will be widely used in coal, soil, metallurgy, and other areas, filling the technical gap of missing sensors.

Based on the theory and technology of micro-area enhanced spectroscopy, HOT has developed an online coal quality analyzer. Using the approach of large dielectric constant and the technology of discharge-enhanced spectroscopy to partially suppress the matrix effect, the spectral intensity has increased by

nearly ten times. The spectral stability has increased by 57%, achieving high-precision spectral measurement, solving the problems of low accuracy and poor stability in coal quality testing, and then completing the industrial application of a high-stability all-element rapid detection spectroscopy system establishing an industrial base. This system can conduct a high-precision and quick quantitative analysis of more than 50 elements, including C, H, N, and S, and provide four significant indicators of coal calorific value, ash content, volatile content, and moisture content.

Application areas:

√ Online quality management of industrial enterprises;
√ Energy-saving and consumption reduction of coal-fired power enterprises!
√ Combustion control;
√ Quality identification;
√ Rapid monitoring of elements in the soil industry;
√ Rapid screening of beneficial and harmful elements of bulk commodities by customs.

HOT LIPS Element Analyzer has provided a green online coal quality detection solution for coal enterprises, which has been applied in several coal preparation plants in Guizhou and several power plants in Shandong. In the application scenario of power plants, the last technical link of combustion control of coal-fired power enterprises is opened up. As a result, each unit can save millions of money annually on average. The total energy saving of several installed units is more than tens of millions of cost, significantly reducing the boiler accident rate caused by improper element detection and changing the rough operation mode of the coal-fired power industry.

Application Prospects:

The market potential for rapid detection of all elements in the mining industry is enormous, covering coal quality testing, mineral elements, and other sectors, with a market capacity of nearly 100 billion yuan. However, traditional element detection technology has a low sampling rate, and the sample preparation and processing process could be more convenient. For example, coal quality analysis in coal preparation plants and coal-fired power plants takes 4-6 hours, which cannot meet the real-time coal blending, fine coal combustion control, energy-saving, efficiency-enhancing, and other large-scale environmental needs.

Furthermore, existing real-time analysis technology is based on radioactive methods such as neutron activation technology, which the industry opposes due to its radioactive nature, and requires strict safety and environmental impact assessments. On the other hand, the all-element rapid detection instrument combines LIPS technology's real-time and green advantages. On this basis, innovatively introduces the spectral enhancement method, significantly improving the detection accuracy and breaking through the industrialization problem of LIPS technology, truly achieving fast and accurate detection. Therefore, our product has unique technical advantages, solves the detection industry's pain points, meets the detection market's needs, and has broad development prospects.

After the equipment is put into operation, the accuracy of all element detection has reached the industry standard. The Yueliangtian Coal Preparation Plant in Guizhou, combined with the Dynamic Dense Medium Controlling System, produces about 8,000 tons of clean coal annually, with an economic benefit of up to CNY 15 million annually.

Conveyor Belt Tearing Monitoring System

Specific Safe Stable Solid

The system can find the tearing fault of conveyor belt within 0.1s, accurately judge the fault location, and offer alarm prompt. It has the features of easily installation, high detection sensitivity, high resolution, strong real-time performance and accurate positioning.

Conveyor belt tearing image identification accuracy : ≥99.5%

Tearing location accuracy : ≤±1m

Self cleaning + Warning prompt

Automatically store pictures/images of abnormal conditions

Features

- The non-working surface is double monitored by thermal imaging and visible light.

- With automatic calibration and self cleaning function.

- Using a variety of parameters and algorithms to monitor, with feature analysis function .

- Automatic monitoring, identification, alarm, support access to the main control, linkage shutdown can be realized.

- Automatically save tear images and videos, which can be viewed at any time.

Patents & Software copyright

Software platform

Visible image

Infrared image

Main Technical Parameters

Tearing image determine delay	≤ 0.1 s		Atmospheric pressure	80 — 106 Kpa
Applicable conveyor speed	0 — 8 m/s		Tearing location accuracy	≤ ±1 m
Applicable conveyor belt width	650 — 2400 mm		Storage temperature	−40 — 80 ℃
Storage temperature	−30 — 60 ℃		Protection level	IP66
Relative humidity	≤ 95 %RH (No condensation)		Continuous working time	7 × 24 h
Conveyor belt tearing image identification accuracy	≥ 99.5 %		Working power ①	85 — 264 VAC

① Can be customized according to customer requirements

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Cover Rubber Wear Monitoring System

Specific Safe Stable Solid

It is used for real-time monitoring of the change of conveyor belt surface thickness, accurately predict the service life of conveyor belt. Realize belt thickness data collection, analysis and recording in the positioning area, achieve double-latitude data association, data more in line with the site. Belt abnormal point real-time alarm, realize linkage to reduce losses. According to the historical data to analyze the conveyor belt running state, adjust the belt in real time, so that the belt will run more healthy.

Features

- Monitor the wear of the conveyor belt and find abnormalities in time.

- The service life of belts can be predicted by combining the information of belt operating load, temperature, speed and wear data curve.

- According to the analysis of wear anomaly, the equipment can be adjusted according to the abnormal wear characteristics and prolong the service life of the conveyor belt.

- Equipped with automatic monitoring, identification, alarm and other functions, combined with other intelligent products of BOTON, the conveyor belt health status is comprehensively analyzed to generate conveyor Belt Health Diagnosis Report.

Prediction of belt life

Measuring thickness accuracy : ±0.5mm

Positioning accuracy : ≤ ±1m

Automatic monitoring + Early warning push

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Software platform

Main Technical Parameters			
Effective measurement bandwidth	800 – 2400mm	Operating temperature	–30 — 60 ℃
Maximum measurement thickness	≤40mm	Storage temperature	–40 — 80 ℃
Measuring accuracy	±0.5mm	Atmospheric pressure	80 — 106 Kpa
Conveyor belt operating speed range	0 — 8 m/s	Protection grade	IP66
Continuous working time	7 × 24h	Power supply ①	85 — 264 VAC
Relative humidity	≤95% RH (No condensation)		

① Can be customized according to customer requirements

BOTON 宝通智能

Conveyor Belt Non-destructive Monitoring System ST Series

Specific Safe Stable Solid

The system is used to detect wire rope core conveyor belt joint twitch, wire broken, rust, edge glue off, surface glue drop and other defects and damage, with good safety, sensitive detection, high resolution, real-time system, accurate positioning characteristics.

Features

- All-weather monitoring and identification of wire rope core conveyor belt joints twitch, wire broken, rust, edge glue off, surface glue drop and other defects and damage .

- Check the health status of the joint.

- Accurately mark the location of defects and realize fixed-point shutdown.

- Automatically generate and directionally push detection and analysis reports.

High resolution recognition : ≥1X1mm

Radiation meet the national standard : ≤5µSv/h [1]

Accurate positioning : ≤1m

Automatic monitoring + Early warning push [2]

[1] The maximum radiation value at 1m away from the equipment
[2] Automatic storage of abnormal pictures/images

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Software platform

Physical conveyor image

Abnormal warning image
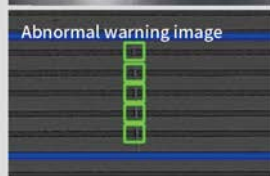
Main Technical Parameters

Radiation leakage	≤ 5 µSv/h	Atmospheric pressure	80 — 106 Kpa
Minimum identifiable fracture	1 × 1　(mm)	Operating temperature	−20 — 60 ℃
Abnormal wire rope arrangement can be identified	1 × 1　(mm)	Storage temperature	−40 — 80 ℃
Conveyor belt operating speed range	0 – 8 m/s	Relative humidity	≤ 95%RH　(No condensation)
Suitable for conveyor belt bandwidth	650 – 2400 mm	Power supply [1]	85 — 264 VAC
Detectable conveyor belt thickness	80 mm	Continuous working time	7 × 24h

[1] Can be customized according to customer requirements

Conveyor Belt Joint Status Monitoring System

Specific Safe Stable Solid

The system is used to detect the slight changes in the joints of the conveyor belt. It has the characteristics of convenient installation, high detection sensitivity and strong practicability of the system. The system determines whether the joints are loose through the analysis of data and reflects the quality of the joints of the conveyor belt.

Features

- Continuously measure the change of joint status.

- Self-identify the joints and corresponding positions of the conveyor belt at any time.

- Automatic monitoring, identification, alarm, support access to the main control, linkage shutdown can be realized.

High monitoring accuracy, up to millimeter level

Applicable bandwidth: 800-2400mm

Trend analysis + Early warning

Automatic monitoring + Early [1] warning push

① Automatic storage of abnormal pictures/images

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Software platform

Main Technical Parameters

Applicable conveyor belt speed	0 – 8 m/s	Relative humidity	≤ 95%RH (No condensation)
Applicable conveyor belt bandwidth	800 – 2400 mm	Protection grade	IP65
Measurement accuracy	≤ ±5 mm	System communication interface	RJ45 Ethernet
Operating temperature	–30 — 60 ℃	Continuous working time	7 × 24h
Storage temperature	–40 — 80 ℃	Working power supply ①	85 — 264 VAC
Atmospheric pressure	80 — 106 Kpa		

① Can be customized according to customer requirements

BOTON 宝通智能

Intelligent Deviation Correction System

Specific Safe Stable Solid

The system has the characteristics of convenient installation, high detection sensitivity and strong real-time performance . It can monitor the deviation of conveyor belt running in real time and carry out dynamic deviation correction in time, and display the operation condition after deviation correction.

Features

- All-weather monitoring, deviation exceeds the set range, deviation correction device will automatically correct.

- When the deviation is very serious, the automatic alarm, and trace the curve of abnormal deviation point.

- Feature analysis function (such as deviation direction, deviation, etc.) to determine whether deviation really occurs.

- Offset data automatically generates curves and stores them.

Real-time monitoring, self-adaptive deviation correction

High precision of offset : 5mm

Automatic save abnormal data and Complete trend analysis

Intelligent deviation correction + Warning prompt

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Software platform

Main Technical Parameters

The monitoring accuracy of offset	5mm	Applicable conveyor width	650 — 2400 mm
Atmospheric pressure	80 — 106 Kpa	Working temperature	–30 — 60 ℃
Protection level	IP65	Storage temperature	–40 — 80 ℃
Continuous working time	7 × 24h	Relative humidity	≤ 95%RH（No condensation）
Power supply [1]	85 — 264 VAC	Conveyor belt operating speed range	0 — 8 m/s

① Can be customized according to customer requirements

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BOTON 宝通智能

Intelligent Roller System

Specific Safe Stable Solid

The system can find roller faults in time, accurately judge the position of the fault roller, monitor the working state of the roller in real time, collect and record data, and evaluate the health condition of the roller according to the historical data. It has the feature of easily installation, high detection sensitivity, high monitoring accuracy and strong real-time performance.

Features

- Real-time monitoring of rollers' temperature, vibration and speed, storage and analysis data.

- Evaluate the health condition of rollers and predict remaining service life.

- Accurate positioning, identify rollers' identity.

- Multiple parameters and algorithms to monitor rollers' temperature, vibration and speed, with feature analysis function, determine whether the roller is abnormal or not.

- With automatic monitoring, identification, alarm and other functions.

Real-time monitor + Accurate prediction

Accurate positioning

Self-power technology + Long service life

Automatically monitor + Warming prompt

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Software platform

Main Technical Parameters

Temperature measure range	−40 — 125 ℃	Applicable belt width	650 — 2400 mm
Temperature error range	≤ 1℃	Working temperature	−40 — 60 ℃
Rotate speed error	≤ 1% FS	Storage temperature	−40 — 80 ℃
Vibration error	≤ 1% FS	Relative humidity	≤ 95%RH (No condensation)
Protection level	IP65	Atmospheric pressure	80 — 106 Kpa
Wireless communication distance	≤ 500m no obstructions	Conveyor belt operating speed range	0 — 8 m/s
Continuous working time	7 × 24h		

BOTON 宝通智能

Equipment Vibration Measurement System

Specific Safe Stable Solid

The system is used to monitor the vibration information of the equipment in real time, judge the health status of the equipment, find the equipment problems in time, reduce the downtime time, ensure the continuous and stable production, and ensure the normal operation of the equipment.

Features

- The network - use standard ethernet and TCP/IP protocols, and the hardware selection is flexible and diverse, which can be applied to monitoring systems with different scales and various requirements .

- Alarm information - have the function of historical record, and have the database of historical record of vibration data.

- Vibration overlimit alarm function: the overlimit value can be set and adjusted according to relevant regulations.

- Automatic monitoring, identification, alarm, support access to the main control, linkage shutdown can be realized.

- The data collected by each sensor can draw a real-time curve for easy data viewing.

Easy installation

High precision

Send early warning information in time

Self-learning to build data model

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Software platform

Main Technical Parameters

Vibration monitoring range	± 16g	Atmospheric pressure	80 — 106 Kpa
Measurement resolution	vibration: 0.1 g	System communication interface	RS485
Operating temperature	–5 — 40 ℃	Protection level	IP65
Storage temperature	–40 — 80 ℃	Continuous working time	7 × 24h
Relative humidity	≤ 95% RH (No condensation)	Power supply[①]	85 — 264 VAC

① Can be customized according to customer requirements

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Wireless Temperature Measurement System

Specific Safe Stable Solid
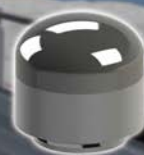
The system is used to monitor the temperature information of equipment in real time, judge the health status of equipment, find equipment problems in time, reduce the downtime, ensure the continuous and stable production, and ensure the normal operation of equipment.

Features

- Dual sensors (contact + non-contact measurement), monitoring the temperature of the equipment to automatically judge the status of the equipment all the time.

- With ultra-long communication distance, high confidentiality, high concealment. Avoid potential wireless signal interference, communication distance of 500 meters.

- Automatic fast networking between sensing fulcrum without separate configuration.

- Convenient installation, strong adaptability to environment.

Convenient installation,Magnetic fixation can be installed or screw fixation

High precision

Long communication distance + Strong anti-interference

Automatic rapid networking without configuration

MA

Patents & Software copyright

Software platform

Main Technical Parameters

Wireless temperature sensor				Wireless gateway		
	Communication frequency	433MHz			Communication methods	4G、Ethernet、RS485
	Temperature measurement range	−50 — 200 ℃@PT100			Wireless communication distance	≤500m no obstructions
	Temperature error range	±0.5℃ @PT100			Number of connected nodes	128
	Temperature measurement range	−40 — 120 ℃@IR			Working temperature	−20 — 60 ℃
	Temperature error range	±1℃ @IR			Storage temperature	−40 — 80 ℃
	Wireless communication distance	≤500m no obstructions			Relative humidity	≤95%RH（No condensation)
	Working temperature	−20 — 60 ℃			Atmospheric pressure	80 — 106 Kpa
	Storage temperature	−40 — 80 ℃			Continuous working time	7 × 24h
	Relative humidity	≤95%RH（No condensation)			Power supply	12 − 24 VDC
	Atmospheric pressure	80 — 106 Kpa				
	Protection level	IP65				
	Power supply	built−in battery				
	Battery life	2 years @25℃				

HOT (Chengdu) Industries Co., Ltd

Chengdu is the park city under the snowy mountains and the hometown of pandas.
Welcome to visit!

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