



用声纹探索世界

Voiceprint Monitoring Technology

Voiceprint monitoring, Health auscultation,
Intelligent Inspection and Safety Escort

Voiceprint Recognition Field Leader

Background



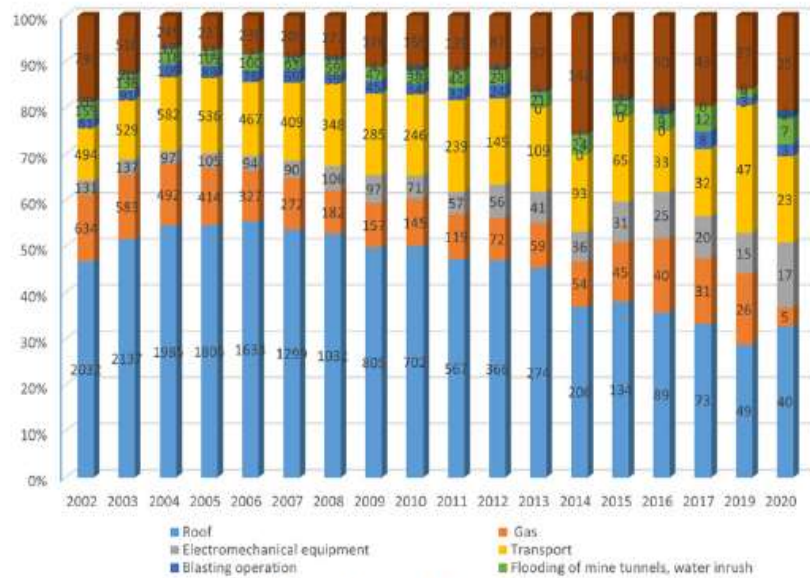
Belt conveyors are used in many important industry that require continuous operation, such as coal transportation in **power plants**, bulk material transportation in **steel and cement plants**, and ship loading and unloading in **ports**.

The operating environment of belt conveyors is usually harsh, and continuous high load operation is the norm. Common faults include **belt tearing, breakage, roller eccentricity**, motor failure, brake failure, and other types of faults.

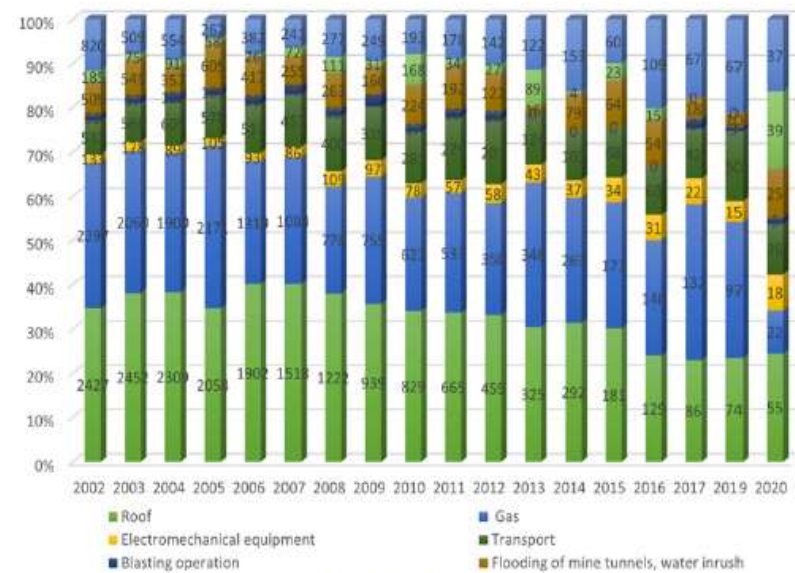
The failure of coal mine machinery belt conveyor equipment can directly lead to an **increase in maintenance costs**, the **suspension of mineral mining**, and **even cause safety accidents**.

Background

Many lives are lost every year at many mines due to conveyor belts catching fire because of friction between the belt and the roller



a) Number of accidents

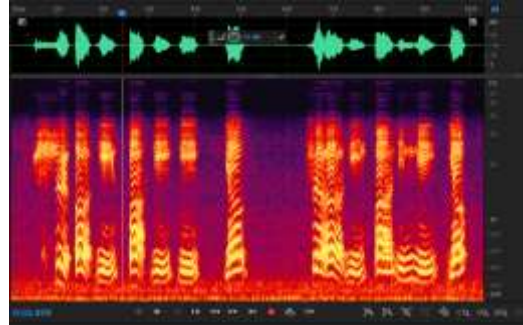


b) Death toll

Fig. 8. Number of different types of coal mine accidents and deaths in China (2002-2020)



Technical principles



By recognizing the 'DNA' of object sounds
Locate faults and discover hidden dangers

During the operation of mechanical equipment, mechanical waves are transmitted through solid/liquid/gas media and captured by sensors. **Acoustic signals contain a large amount of time-domain and frequency-domain characteristic information** (i.e. acoustic fingerprints, abbreviated as "voiceprints"), especially when the equipment is **abnormal, the voiceprint changes accordingly.**

The **CMFMC voiceprint engine** combines core algorithms and artificial intelligence techniques such as **deep neural network learning** to **extract acoustic features** such as frequency spectrum, amplitude, cepstral, waveform, peak, bandwidth, probability density, and kurtosis coefficient from sound signals and process them. These features are not affected by high voltage and strong electromagnetic fields. Therefore, we utilize this unique sound characteristic to compare the voiceprint information of the monitored equipment with normal voiceprint information, which can effectively determine the equipment status, early warn of faults, and diagnose faults, enabling industrial equipment to develop towards a safer and more stable direction.

Sound sensor+sound fiber optic sensor

The acquisition of voiceprint signals only requires attachment to the surface of the device and will not affect its working state. The voiceprint online monitoring system integrates AI, Internet of Things, and 5G. Currently, it can provide **24-hour online detection for major equipment such as rollers, drive devices, tensioning devices, reversing rollers, and braking devices**, mainly for timely warning of various fault states of coal conveyor belts. And it is displayed in real time in the background of the monitoring center and on the mobile APP of the inspection personnel.

Artificial intelligence deep learning is applied to abnormal fault phenomena, providing the operation and inspection personnel with a monitoring curve of the changes throughout the entire life cycle of the equipment, and making auxiliary judgments for correct operation and inspection decisions.



- A complete set of distributed real-time monitoring system consisting of end, edge, and cloud
- Composed of collection end, algorithm end, and platform end

System product hardware

Industrial intelligent analysis terminal (explosion-proof)

DSP noise reduction algorithm designed specifically for industrial scenarios

Local voiceprint analysis engine on the edge, massive data processing on the near end



Industrial diagnostic microphone

Anti-static and flame-retardant properties



Mining optical fiber



Industrial intelligent analysis terminal
(explosion-proof)



Voiceprint collection edge
gateway all-in-one machine



Voiceprint Cloud
Engine Server



Acoustic fiber DAS analysis
all-in-one machine

Bone conduction - Technical principles

Bone conduction technology (solid conduction method):

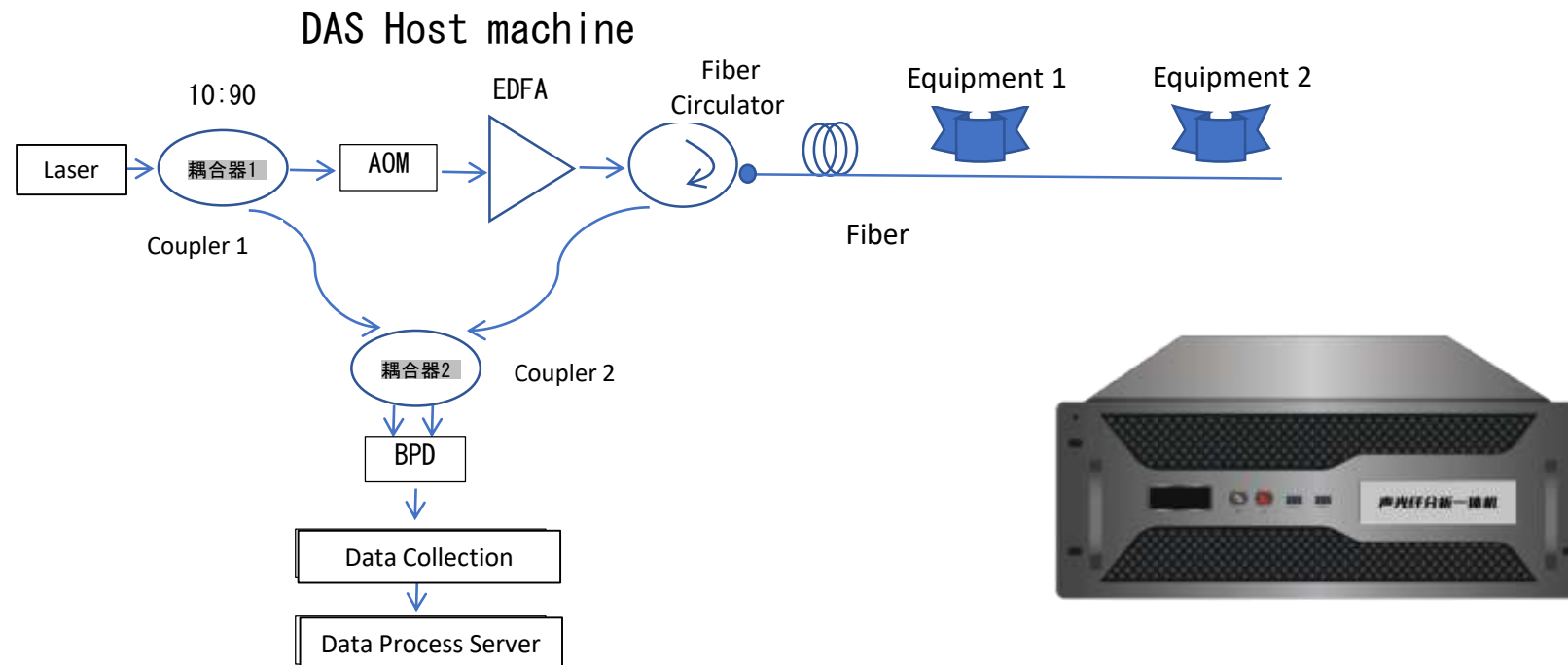
Bone conduction pickups are tightly attached to the casing of industrial equipment, with lower acoustic impedance, shielding external noise, detecting equipment failures, and higher sensitivity.



Acoustic Fiber Optic - Technical Principles

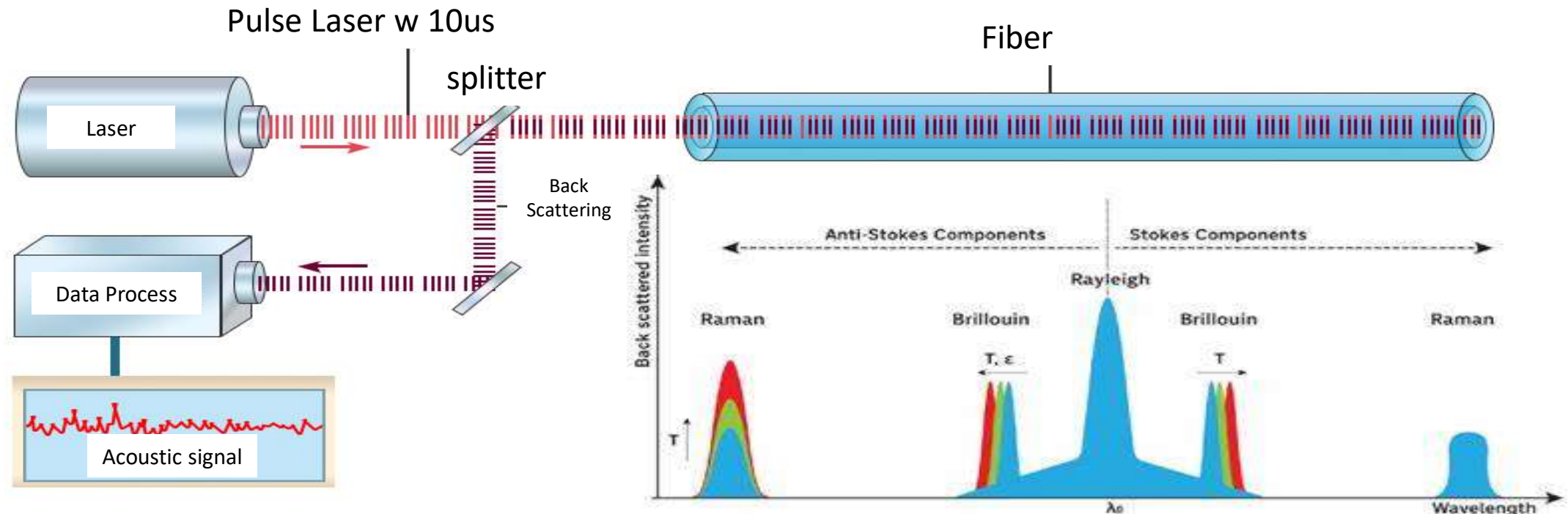
Distributed Acoustic Sensing (DAS) technology:

By using the **phase of coherent Rayleigh scattering light** instead of its intensity to detect sound signals within the audio range, not only can the **amplitude of the phase** be used to provide information on the intensity of sound events, but **linear quantitative measurements** can also be used to obtain phase and frequency information of sound events. **DAS can be regarded as a mobile interferometric acoustic sensor that detects external signals through sensing fibers.** When sound causes a linear change in the phase of the interferometric light at that location, by extracting and demodulating the interferometric signals at different times at that location, quantitative measurement of external physical quantities can be achieved.



Acoustic Fiber Optic - Technical Principles

DAS measurement process: **The laser emits light pulses** along the fiber optic cable, and some of the light interferes with the incident light in the form of backscattering within the pulses. After the interference light is reflected back, the **backscattered interference light returns to the signal processing device**, and at the same time, the acoustic signals along the fiber optic cable are brought to the signal processing device. Due to the constant speed of light, the measurement of sound waves per meter of fiber can be obtained.



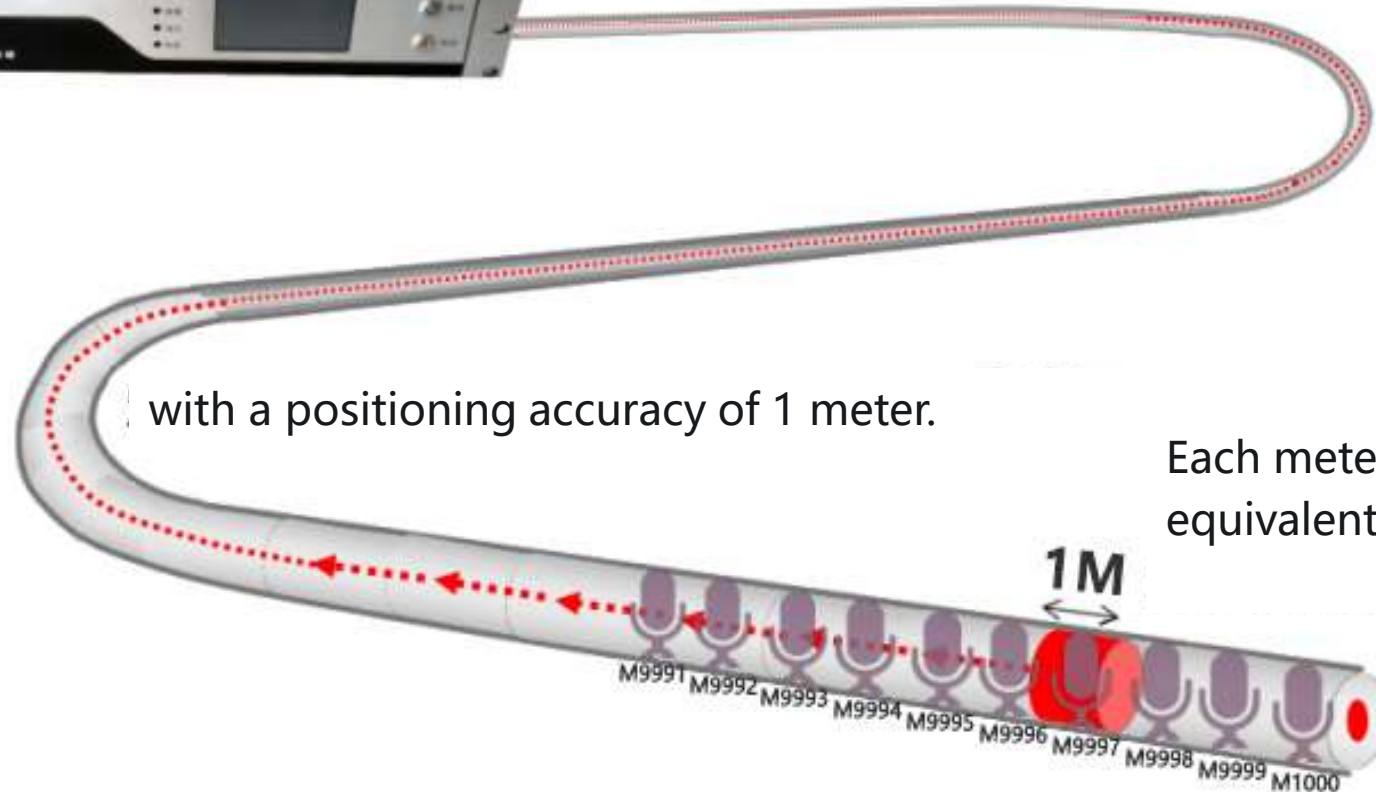
Acoustic Fiber Optic - Technical Principles



Optical fiber serves as a distributed acoustic sensor string

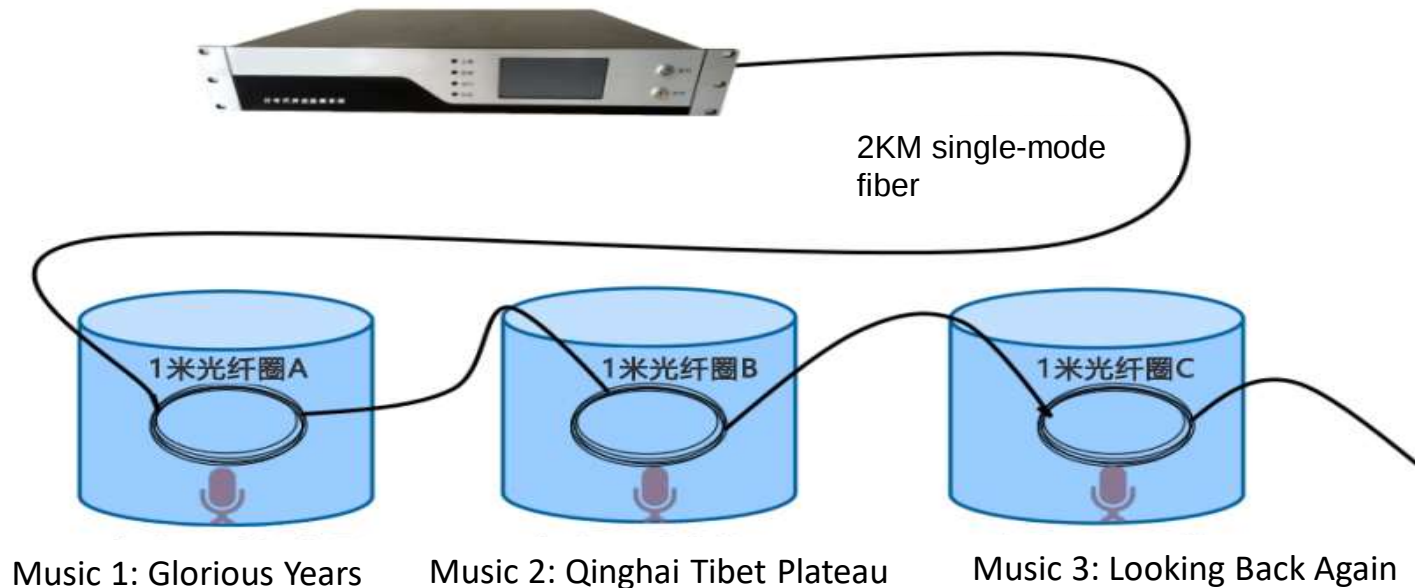
with a positioning accuracy of 1 meter.

Each meter of optical fiber is equivalent to one microphone.



Therefore, 10 kilometers of optical fiber equals 10,000 microphone sensors; 50 kilometers of optical fiber equals 50,000 microphone sensors.

Acoustic Fiber Optic - Technical Principles



Glorious resonance of
metallic texture

Soprano, dolphin voice

Cello overtones, male

Wrap a 2km fiber optic coil at three positions of 500m, 1200m, and 1800m respectively, and place it in a dry isolation box. Simultaneously playing three different types of music, on the device end, three different pieces of music can be demodulated at their respective positions, and can be played completely and clearly through speakers or headphones, accurately locating different music from different positions of the fiber optic cable with a **positioning accuracy of 1m**.

Fault type monitoring

Fault type	fault location	fault description
Belt malfunction	belt deviation	The force points on the left and right sides of the belt are uneven, and long-term use of one side for cargo transportation causes the belt to shift towards the long-term load-bearing side
	Belt tear	The belt tears during operation due to external force or daily wear and tear.
	Belt breakage	The belt breaks during operation due to external force or daily wear and tear.
	Loose belt	The belt may become loose due to heavy loads or prolonged use
Roller malfunction	Wear of roller skin	The middle part of the roller is worn to the point of breakage, and some rollers may also break due to wear at the contact point with the edge of the conveyor belt
	The roller bearing is damaged	The main reason is that the roller bearings do not rotate flexibly, resulting in bearing point wear and severe rust that causes the rollers to not rotate
	Roller bending, deformation, and damage	The bending deformation of the roller shaft is large, and the deflection angle is too large, which causes friction between the shaft and the bearing seat, and also easily leads to damage to the roller seal
Drive device malfunction	Stator winding	Refers to the winding installed on the stator, which is the copper wire wound around the stator
	Rotor body malfunction	Shaft bending, imbalance, shaft cracks, misalignment, and eccentricity, etc The inner and outer rings of the bearing peel off; Rolling element peeling off;
spindle bearing	Supporting bearings at both ends of the spindle	Scratching and breakage of the retaining frame; Bearing dynamic and static friction and collision; Running in circles inside and outside
coupling	coupling	Coupling wear
Brake device malfunction	Oil leakage	There is oil leakage at the connection between the fuel tank and the circuit
	brake pad wear	Braking effect deteriorates due to prolonged use
	leak	There is a gas leak at the connection between the air pump and the circuit

Characteristics of acoustic emission: Detecting fault information ahead of vibration analysis

4.2 Advantages and limitations of acoustic emission

AE offers the following advantages:

- a) it is non-invasive;
- b) it provides real-time process information;
- c) due to its higher sensitivity, it may offer earlier fault detection than vibration analysis;
- d) it offers monitoring of dynamic performance;
- e) it may be applied to a wide range of rotational speeds with significant advantages at slow rotational speeds [of the order of less than 1 Hz (60 r/min)];
- f) it allows for detection of the friction/wear process, for instance, rubbing between loose mating components or deterioration in lubricating condition.

BS ISO 22096:2007

INTERNATIONAL
STANDARD

ISO
22096

First edition
2007-07-15

**Condition monitoring and diagnostics of
machines — Acoustic emission**

Surveillance et diagnostic d'état des machines — Émission acoustique

Main interface

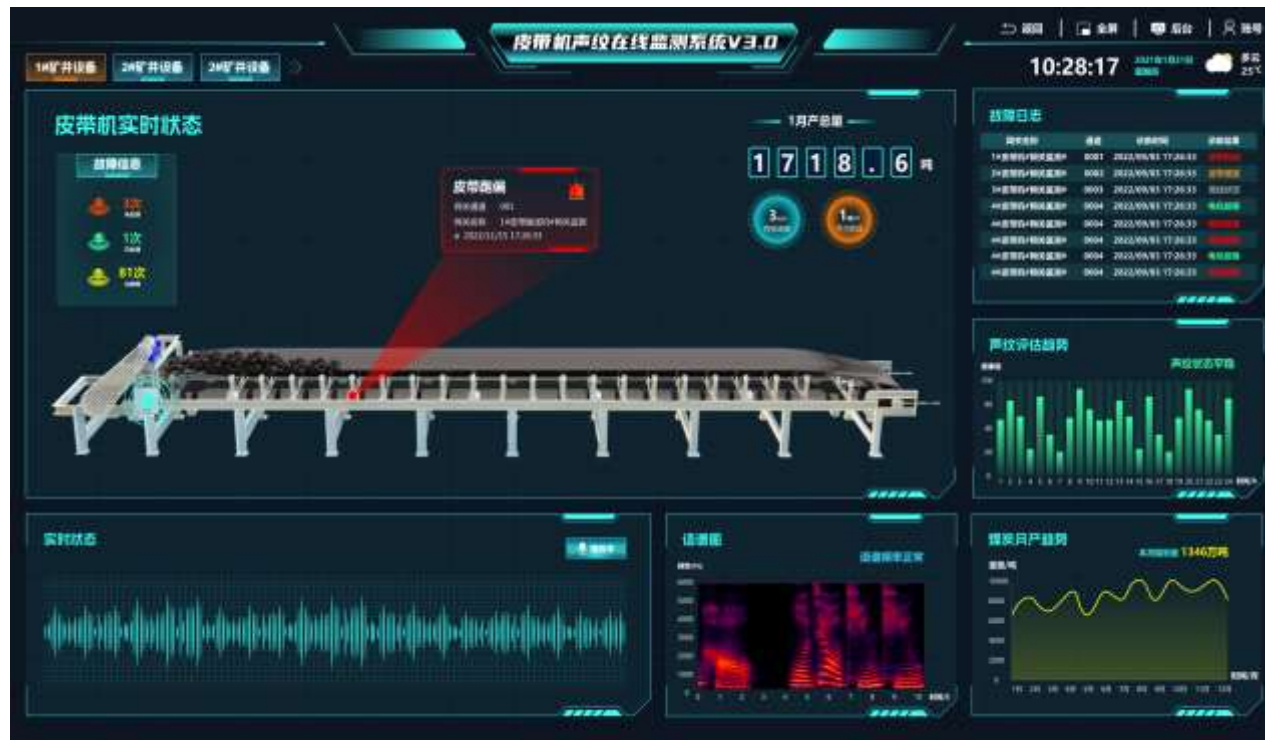


The mine voiceprint monitoring system includes the following modules: organizational structure, permission management, development management, log management, system monitoring, file management, power system, ventilation system, conveying equipment, pipeline system, and scheduled tasks.

Main interface

System Function - Device Voiceprint Monitoring:

Real time display of device operation status, with the ability to switch functions to view voiceprint information from different parts of the device and preview real-time audio, and display the statistical analysis of monitored audio samples in intuitive charts.



Real time audio:

- Display real-time audio spectrograms of each acquisition device;
- Display the voiceprint features of each sound;
- Support audio playback and manual diagnosis/annotation.

Real time operating conditions:

- Display main collection information, sensor information, and gateway information;
- Main transformer operating status;
- Today's abnormal and alarm information.

ification by
the objective

Professional digital analysis of the difference between fault audio and collected audio, and practical verification by professional voiceprint identification experts, the system can provide more accurate data to ensure more objective and reliable identification results.



Automatic graph comparison:

Support the calculation and graphical display of the average power spectrum at the cursor position, between the cursor positions, and over a long period of time, automatically calculating the deviation ratio, which can provide data conditions for comparison work.

Collaboration case



Shendong Coal Belt Conveyor Voiceprint Online Monitoring

17 production mines and washing and selection vehicle systems of Shendong Coal Group are using 348 steel wire rope belt conveyors with a length of over 1.2 meters, with a total transportation length of 357 kilometers. Since 2003, there have been a total of 38 belt tearing accidents (30 belt tearing and 8 belt breakage) within the group, with a downtime of 950 hours. The longitudinal tear belt is 7 kilometers long, causing direct economic losses of approximately 11.72 million yuan.

At present, the Zhongke Haoyin voiceprint online monitoring system has been successfully applied in Shendong Coal to monitor the real-time operation status of the belt conveyor.



Middling coal Technology and Industry Belt Conveyor Voiceprint Online Monitoring

Zhongke Haoyin successfully applied in the middling coal Science and Engineering Project. The patch+acoustic fiber optic system can play a better role in monitoring the belt conveyor system, and was praised by partners.

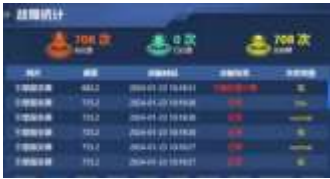


Shanxi Jinyu Group Yuejin Coal Mine

Shanxi Jinyu Group has approved a coal production capacity of 8.4 million tons per year. The Zhongke Haoyin voiceprint online monitoring system has been successfully applied in the Yuejin Coal Mine of Shanxi Jinyu Group. It uses acoustic fiber to monitor the real-time operation status of the belt conveyor, grasp the real-time operation status of the belt conveyor equipment, and timely warn and locate faults.



Shanxi Jinyu Group Yuejin Coal Mine

Fault name	Picture	screen shot	waveform
Normal			
The roller bearing is damaged			
Loose roller bearings			
Idle roller jamming			

Fault case: Shanxi Lubao Group

DAS acoustic fiber optic monitoring is used for coal conveyor belt conveyor, and bone conduction monitoring is used for power equipment.



Typical case: Tianchi Energy South Open pit Coal Mine in Xinjiang

There are many potential fault risks such as belt wear, abnormal rollers, bearing wear, and drive system failure. Real time monitoring of the entire belt conveyor line is seamless and uninterrupted, capturing and analyzing subtle signals, accurately identifying potential fault areas, and warning in advance, effectively avoiding accidents and greatly improving the operational reliability and service life of the conveyor system.



Tianchi Energy South Open pit Coal Mine - Second Mine, Xinjiang

DAS acoustic fiber monitoring of coal conveyor belt conveyor has formed a mature and reliable distributed optical fiber acoustic emission fault warning solution for coal conveyor belt conveyor, and actively promoted its industrialization process, aiming to provide advanced fault warning technology support for domestic and foreign conveying equipment, improve the technical level and safety management capabilities of the entire industry.

