Wireless Tool Wear Monitoring

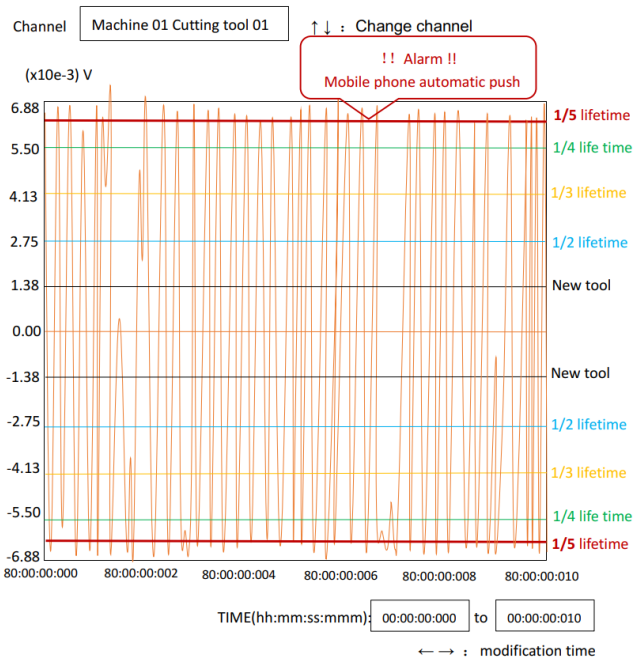
1 Brief introduction

1.1 Theory

The acoustic signal from the machining process reflects the tool wear state, receives the acoustic signal and analyzes the tool wear condition.

1.2 Application Results：

365 days of online monitoring and detection, the whole process of automatic analysis results, Internet of Things remote operation and use, mobile phone alarm push.

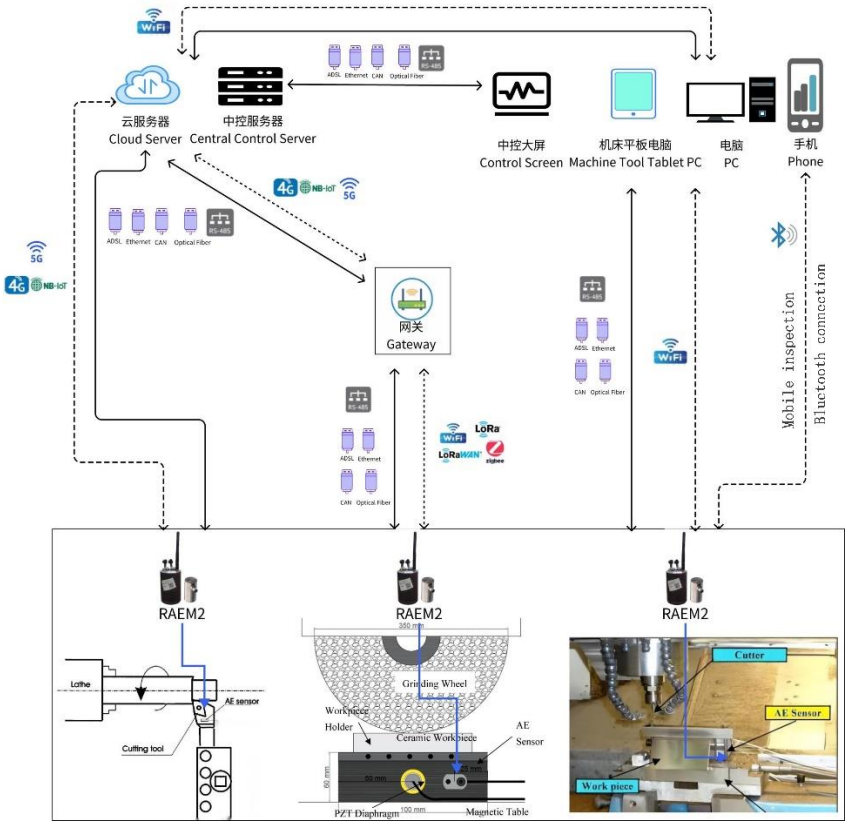


- Online and historical data screen display
- Automatic monitoring and diagnosis results
- Online mobile alarm push

2 Solution - RAEM2 series Remote AE Monitoring System

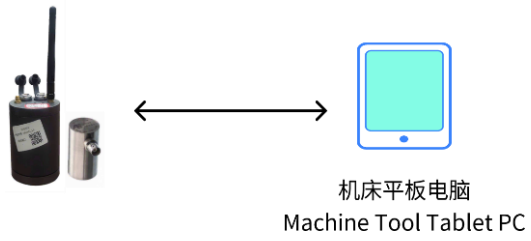
2.1 System diagram

实线(Solid line)：有线连接(wired connection)
虚线(Dotted line)：无线连接(wireless connection)

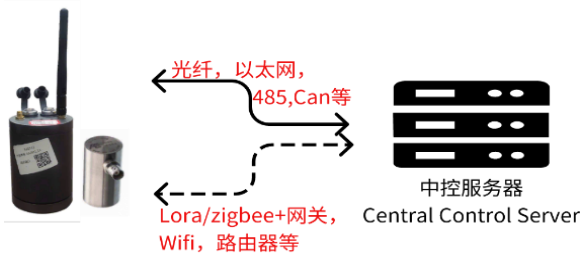


2.2 4 systems communication methods:

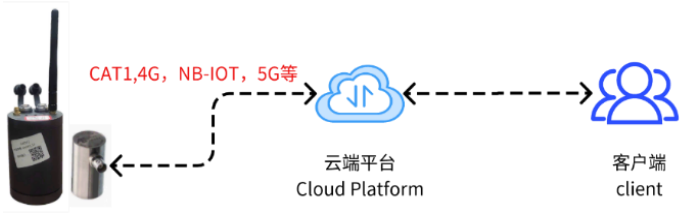
2.2.1 On-site operation and display:



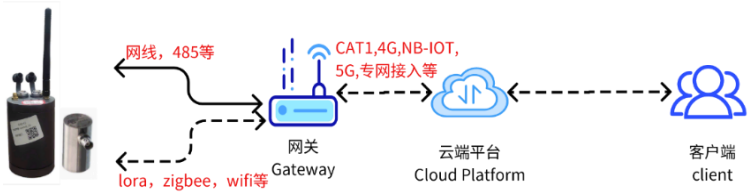
2.2.2 Operation and display in the central control room of the workshop:



2.2.3 Remote network direct communication system:

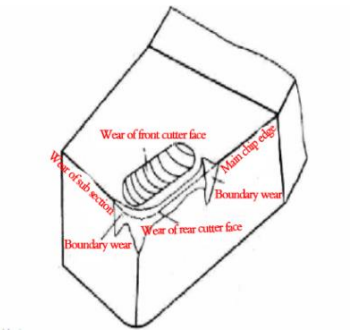


2.2.4 Remote network communication system:



Note: The above systems have the functions of mobile app Bluetooth communication inspection and field debugging setting.

2.3 It is suitable for all kinds of tool state monitoring (wear in the process of turning, milling, grinding, punching, drilling, etc., contact in place of feed amount, punch bit damage and other online state monitoring and automatic alarm).



Tool wear model diagram

3 Main Hardware and Software Introduction

RAEM2 series Remote Acoustic Emission Monitoring System

System composition: RAEM2 monitor, cloud platform, client terminal

(Multiple monitors can form a multi-channel monitoring system for real-time monitoring of large equipment)

3.1 RAEM2 monitor

RAEM2 AE monitor integrates sensor, acquisition board, data communication (Bluetooth, etc.) and battery power supply.

3.2 Sensor

W800, GI40 or GI150 series sensors could be used, and sensor can convert mechanical signals into electrical signals and transmit signals to acoustic emission acquisition and analysis system

W800

GI40

GI150

3.3 Hardware technical parameters

Channel	Single channel AE input	**Sampling accuracy**	16-bit
Acquisition method	Time trigger acquisition	**System noise**	Better than 30dB
Sampling frequency	2M /s	**Dynamic range**	70dB
Protection level	IP65	**Input bandwidth**	10kHz-400kHz
Time Parameter Output	RMS、ASL、energy, amplitude		
Optional Data output port	4G, wifi, network port, RS485, CAN, lora, Bluetooth, etc		
Battery	Battery powered, or external power supply (DC 12V)		
Operating temperature	-20℃~60℃		
Dimensions	Diameter φ62mm, height 50mm-120mm		
Installation	Magnetic base, can be adsorbed on the surface of the measured object		

3.4 Cloud platform

Qingcheng IoT cloud platform, Ali Cloud platform, Amazon cloud platform, etc.

4 方案案例 SOLUTIONS & CASE

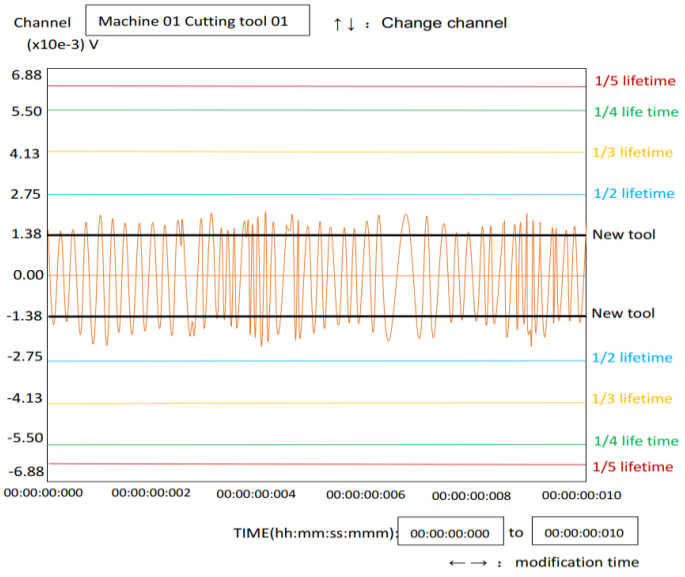
Case: Implement acoustic emission on-line monitoring for a tool of a machine tool

The tool waveform data were examined at 0, 50, 66, 75, and 80 hours during the monitoring period.

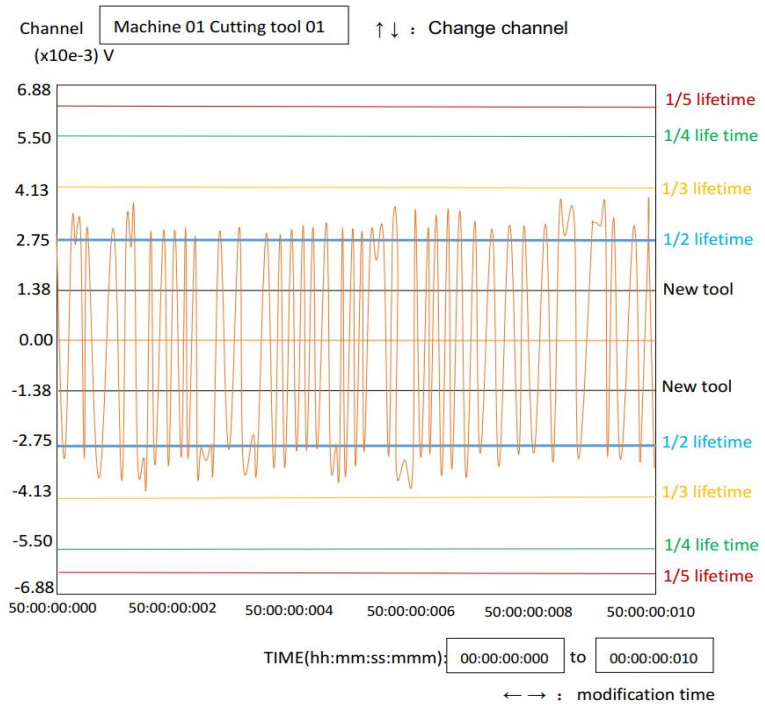
note:

- X-axis: time; Y axis: Voltage value of tool wear waveform signal
- 5 stages: new cutter, 1/2 life remaining, 1/3 life remaining, 1/4 life remaining, 1/5 life remaining

4.1 Tool state at start of measurement: New tool (hour 0).

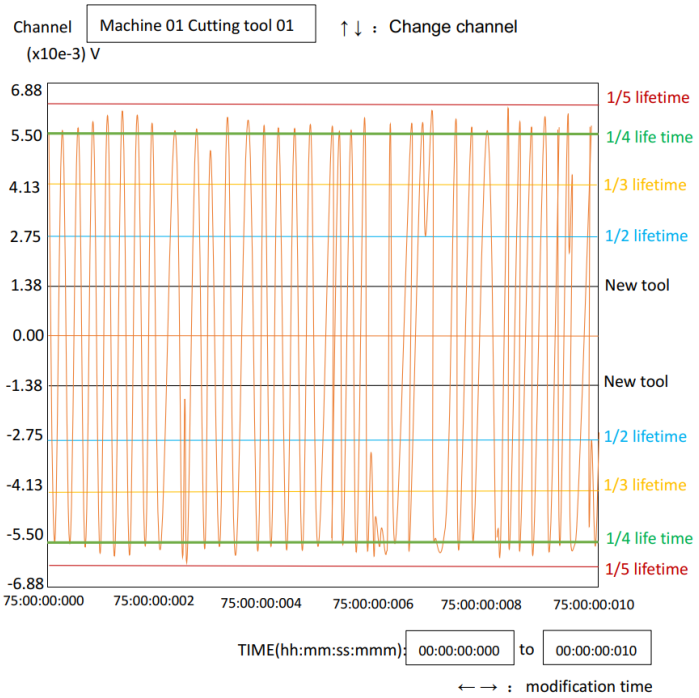


4.2 Tool state after 50 hours: 1/2 life remaining.



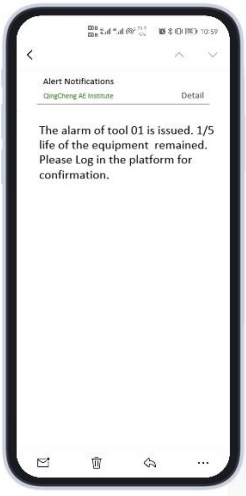
4.3 After 66 hours, tool state: 1/3 remaining life.

4.4 Tool state after 75 hours: 1/4 life remaining.

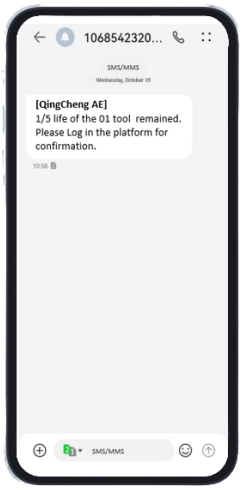


4.5 Tool state after 80 hours: remaining 1/5 life (reach preset push alarm limit).

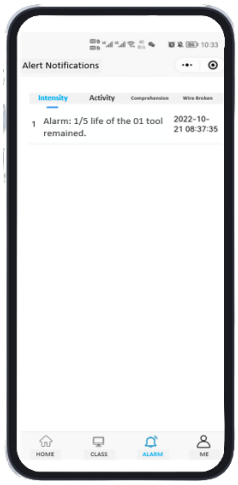
At the same time, as the alarm line is reached, the phone will push alarm information, alarm methods: mini program in WeChat, email, SMS, APP.



Email

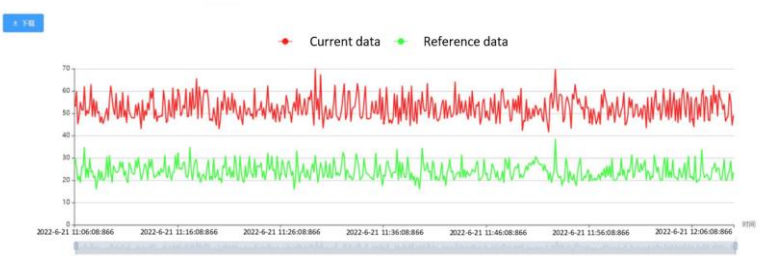


SMS



Mini program in WeChat

In addition, users can perform remote configuration and monitoring through the cloud platform, and upload data to the cloud platform for display and analysis.

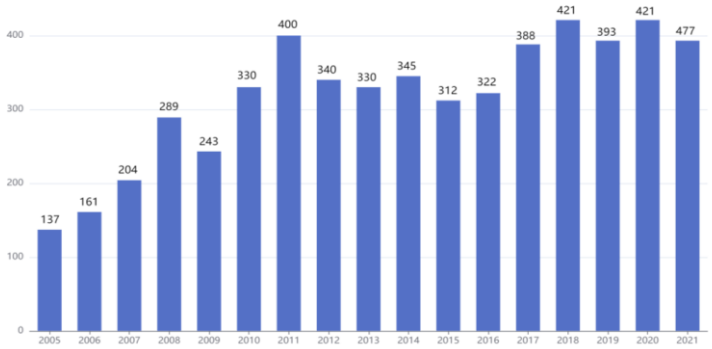


Note: The platform and large screen of the client can be displayed at the same time, and the large screen can display multiple tool results at the same time.

5 Cases

Along with the development and recovery of Chinese manufacturing industry, the scale of Chinese tool market is expected to increase continuously.

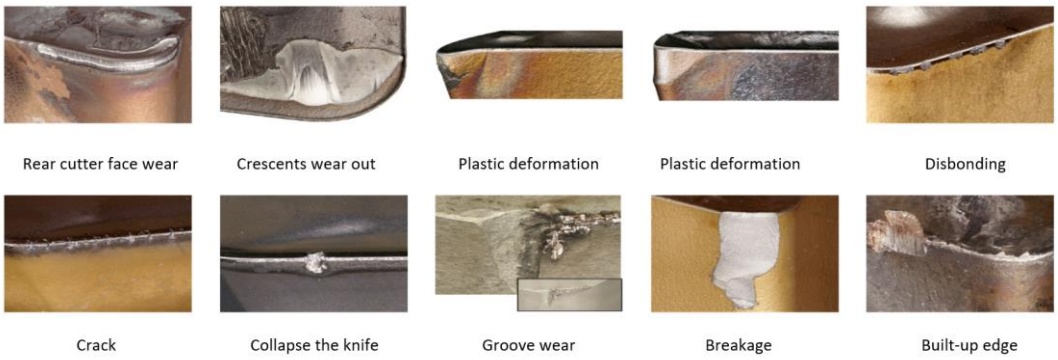
2005-2021 Scale of China's cutting tool market (RMB 100 million)



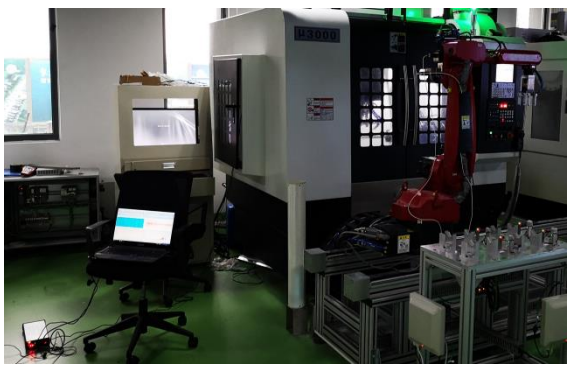
- Deficiency of tool industry pain points:

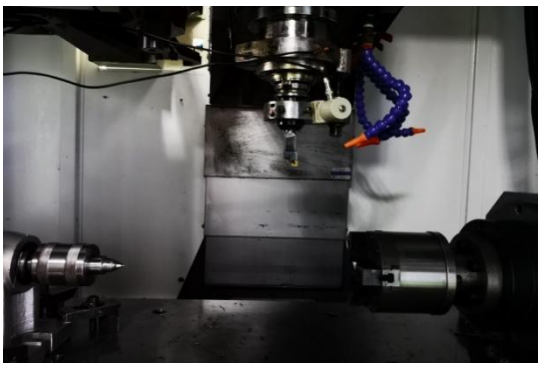
  Wear is the root cause of tool failure, and the maintenance cost caused by tool failure accounts for 15% ~ 40% of the production cost.

- The main mechanism of tool wear is as follows:

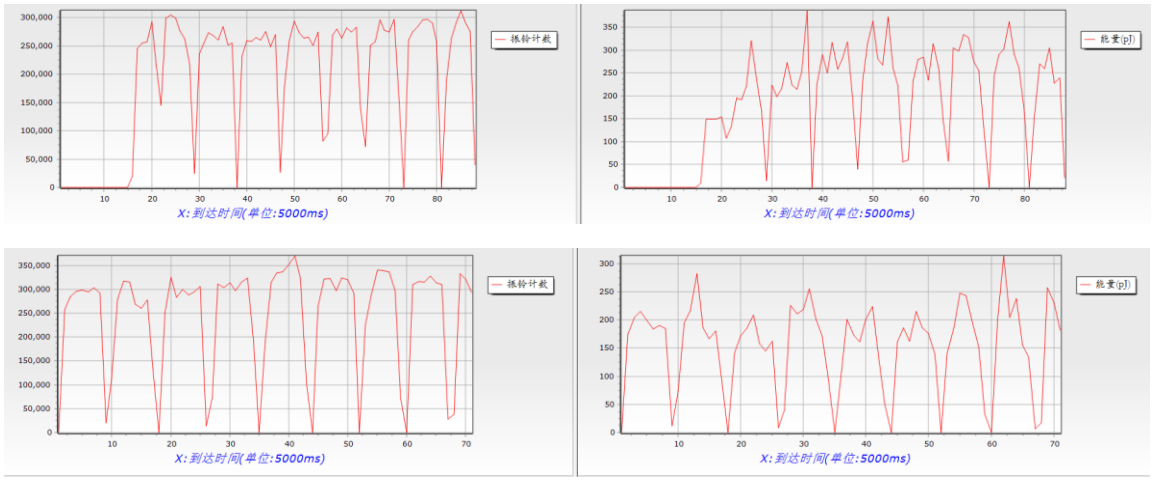


5.1 Wear detection in the process of turning tool





Acoustic emission monitoring site of tool wear during machining



Acoustic emission characteristic parameter curve based on ringing count and energy

5.1.1 The use of appropriate sensors and filters can effectively eliminate the field noise interference. The main AE signals generated in the process of machining are workpiece material cracking and friction signals between the tool and the workpiece.

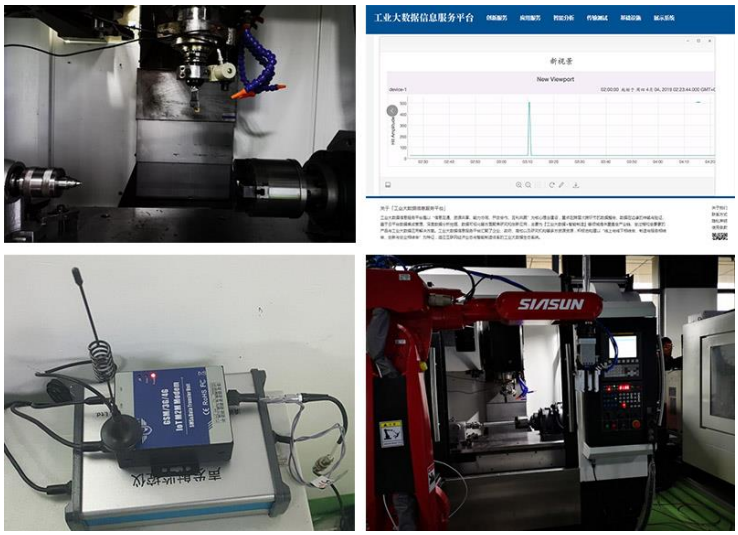
5.1.2 Because the original data cover a variety of AE signals, it is not easy to distinguish the single acoustic emission characteristic parameters before and after comparison.

5.1.3 By comparing the acoustic emission characteristic parameters of various combinations, the early signal of tool wear can be identified effectively in advance by combination identification such as energy and ringing count comprehensive judgment method.

5.2 Acoustic wave (AE) monitoring of machining tool wear

The acquisition module is arranged on the tool, and the collected data is uploaded to the cloud. Through certain algorithms, it can determine whether

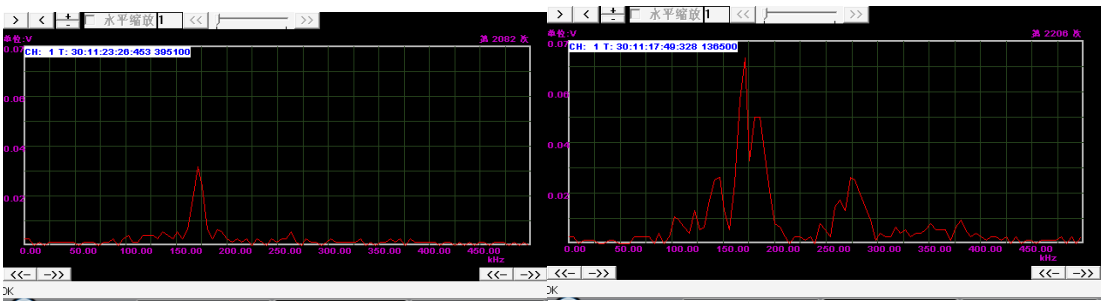
there is failure or wear, and the alarm message is pushed to the client. Avoid tool failure, equipment damage, reduce the shutdown rate, improve production efficiency.

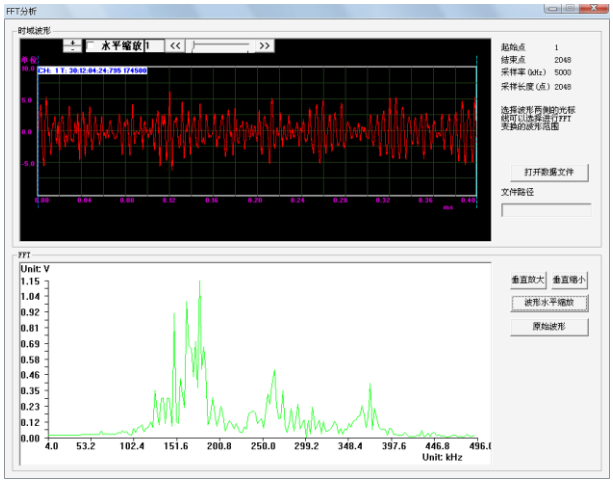


Field operation diagram

5.3 AE monitoring of shaft straightening machine

Acoustic emission monitoring site during shaft alignment





Spectrum of crack signal during axial alignment

Key point:

5.3.1 In the signal spectrum diagram of the sample without crack, the resonance peak is mainly near 150k. This is because in the case of no crack, the shaft deformation is a plastic deformation below the microscopic yield. At this time, there is only a small amount of dislocation line slip and no crack nucleation has been formed, and the AE signals at this time are mainly of low amplitude and low frequency.

5.3.2 When the crack is generated and propagated, the high frequency component of AE signal increases greatly, and there are obvious wave peaks around 250khz and 360khz. The internal dislocation and stress concentration of the material yield and crack to form micro cracks. The speed of releasing elastic energy increases rapidly, which is reflected in the high frequency component of AE signal.

5.3.3 Using the local power spectrum parameters and energy accumulation parameters in the high frequency range, the AE signals of axial cracks can be effectively identified.

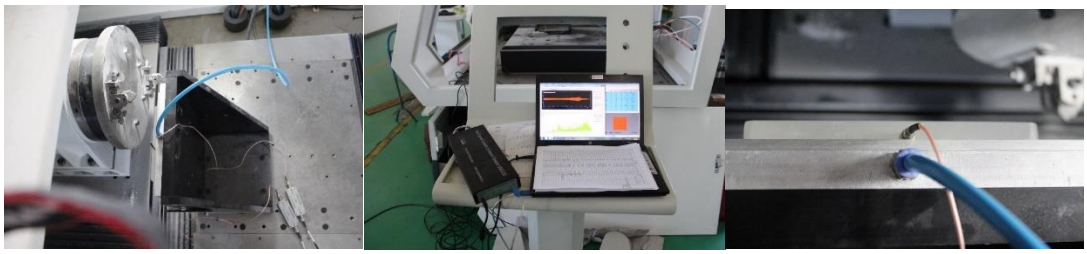
5.4 Acoustic emission monitoring of forging process

Forging and stamping process acoustic emission monitoring site

5.4.1 When the die is pressed and forged, plastic deformation and crack will occur after long-term cyclic force, leading to failure. Acoustic emission technology is used to monitor the time point of crack generation, which provides the basis for failure judgment.

5.4.2 The interference of signal mainly comes from the impact noise of stamping process, workpiece friction, mechanical noise, mainly impact and friction signal to crack signal. Based on the theory of modal acoustic emission, the frequency interval of interest is extracted according to the different distribution of acoustic emission signals of different modes in the frequency domain, and through its distribution changes in the frequency domain, the signal generated by the impact crack can be effectively distinguished from the impact noise and friction.

5.5 Acoustic emission detection of crystal milling process



In the process of precision machining, it is difficult to observe the machining process by conventional methods because of the complex dynamic process and working condition. According to the changes of the AE signals generated by the workpiece and the tool in the process of processing, the state changes in the whole process of processing and the fault diagnosis in the process of processing are evaluated by the introduction of acoustic emission technology.

5.6 AE diagnosis of hammer cracking during diamond synthesis

In the process of synthetic diamond, the cuboid core material is loaded by six hammers.When one of the hammer loading surfaces is cracked, if the machine cannot bestopped in time, the six hammer will collide with each other and all of them will bescrapped. Before, the human ear inspection was carried out by the whole manual, andwhen the abnormal acoustic was heard, the machine would run to shut down, which was of low efficiency and high missed detection rate. Therefore, the acoustic wave (acoustic emission) online monitoring technology was introduced to monitor the synthesis process of the press in real time, and alarm the cracking signal, and trigger the shutdown mechanism of the synthetic press. The dynamic range of detection can be improved effectively by using analog and digital filters to denoise. Using the unique event generation mechanism of acoustic emission and spatial filtering, the location of acoustic source can be accurately identified and the cracking signal of the hammer can be judged.

6 Conclusion

Application：

Acoustic emission technology is used on tool condition monitoring to reduce the user's losses due to tool wear or breakage.

In the process of turning, milling, grinding, punching, drilling and other machines, there may be plastic deformation of the workpiece, wear caused by the friction between the tool and the workpiece or chip, chip fracture and tool fracture.

Advantage

- Online ---- Acoustic wave (acoustic emission) monitor is installed on the monitored and diagnosed object to realize all-weather status monitoring and fault diagnosis in the whole period.
- Intelligent ---- System automatically provides monitoring and diagnosis results without manual data analysis and processing and manual operation. Data acquisition and analysis report shows the whole process of monitoring and diagnosis automatically.
- Remote ---- With the help of the Internet of Things system, users can get the monitoring and diagnosis results of any monitoring and diagnosis points at any distance, including online real-time results and historical process results.