Rsearch and Aplication of Intelligent Fault Diagnosis System Based on RBR for Garbox of Rolling Mills

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Abstract: This paper writes about a intelligent system which is pressing needed for the diagnostic accuracy and efficiency in iron and steel industry. A rule-based reseaning(RBR) intelligent diagnosis system has been developed based on the success diagnosis cases more than sixty times on the site. It has solved the difficulty of knowledge acquisition and it has more precision. This system will be more and more perfect and its application performance is expressed in the paper's example.

Keywords: Rule-based reasoning, Fault diagnosis, Intelligent system, Gear box

0 Foreword

Our laboratory provide fault diagnosis service for dozens of iron and steel enterprises,and the scale and amount of diagnosis has been growing day by day. Due to small amount of technical staff and the data, users have become increasingly demanding - requirements can be accurately diagnosed with parts failures, the conventional manual analysis of the data monitoring system has been unadapted to more and more development. In order to improve diagnostic accuracy and reduce costs, a professional intelligent diagnosis system are urgently needed by enterprises and research institutes.

At present, a number of mature rotating machinery and aerospace structural damage and other aspects of the application of intelligent diagnosis system have been used in domestic and abroad, most of which are the knowledge-based expert system. In this paper, the intelligent diagnosis system is a memory consisted of the expert knowledge, experience, knowledge of books and things of the property itself, but also a variety of cases and the results of the analysis of the rules, and data-processing procedures and methods. According to the diagnostic system data to assess the status of the device type and location of the fault.

1 Design of intelligent diagnosis system for mill gearbox

In this paper, the intelligent system is used in rolling mill gearbox fault diagnosis, the whole system design idea is: used a combination of hybrid reasoning based on collection of raw data and the rules of cases, then the fault diagnosis report will generated automatically. As rule is a general knowledge, and the case is different from their own mechanical characteristics of the development process and results, so the best combination of both methods. Workflow of the intelligent diagnosis system shown in Figure 1. Mill fault diagnosis system based on the case, we hold many on-site results of diagnosis since 1999, in which the success cases are close to 60 copies, summed up the state more than 60 categories, 16 pieces of diagnosis of smart card, 17 pieces of reasoning rules (rules of inference is shown in table 4).

2.1 Workflow of the intelligent diagnosis system

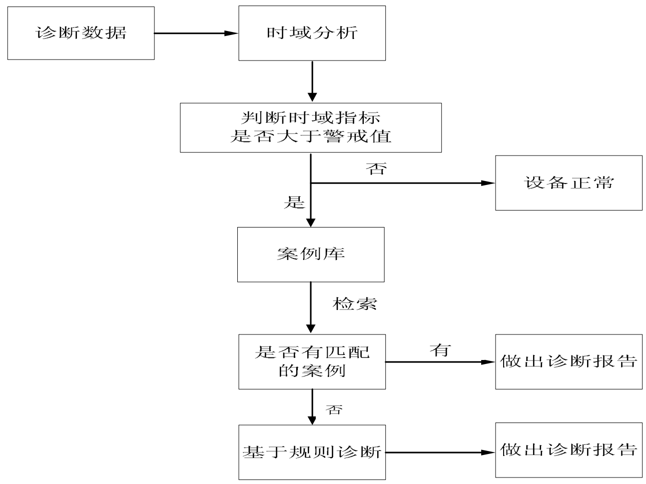
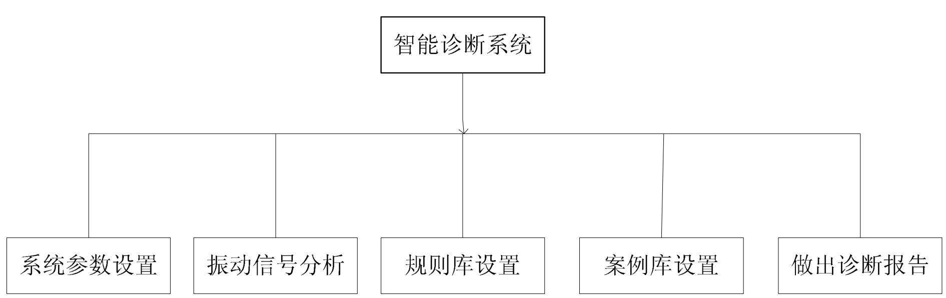


Fig. 1 Workflow of the intelligent diagnosis system

The intelligent diagnosis process is included in the whole process, and intelligent human-computer interaction in the diagnosis of conditions. To make intelligent diagnosis on the premise of the report includes a lot of content, such as the background of equipment, transmission chain plans; would also combine on-line monitoring system shows the trends, the probability density maps, correlation analysis, the frequency spectrum, cepstrum falls map and so on; from artificial Characteristics of the suspected failure choices in the spectrum to see the shaft relation once again. It is only through such human-computer dialogue, intelligent diagnosis system can make more accurate conclusions.

2.2 Intelligent system module

Intelligent diagnosis system consist of five main modules, the system chart shown in Figure 2.



2.3

Fig.2 Intelligent diagnosis system framework

2.2.1 Parameter settings

The main system parameters are set up in both the channel settings and characteristic frequency settings.

（1）Channel settings

The channel settings is main set up for some information of the points, the aim to set up the channel is to demarcation of the relevant points of the vigilance value and risk value, at the same time set the name and serial number of the measured points, the name of the measuring point is the choice of data based on measurements, and the serial number of the point is the retrieve key to channel searching. Channel have set up major operations of the channel change, increase and delete. Channel set up of data tables as shown in table 1.

Table 1 channel set up table

Channel number	Channel name	Measurement unit	Alert value	Risk value

（2）Characteristic frequency settings

The main characteristics of the frequency is the search for knowledge to provide the basis for the search, characteristic frequency is a engagement frequency of the components which is important quantitative indicators to fault diagnosis. The data format of the frequency characteristics are shown in table 2.

Table 2 table of the characteristic frequency

Frequency number	measuring point name	Parts name	frequency description	Code of characteristic frequency	Value of characteristic frequency
			Revolution/mesh	Fr/Fm	

2.2.2 Analysis of vibration signals

The main functions of the modules is through the choice of measuring the vibration data, draw time and frequency domain waveforms and data vibration given commonly used indicator of the value of time-domain, time-domain indexes of the corresponding database table as shown in table 3.

（1）The date and points are the keyword for search.

（2）Rotate speed used to calculate the characteristic frequency.

（3）The time-domain in the table are a part of the rule data for fault diagnosis

Table 3 vibration data sheets

Date	measuring point name	Peak value	Peak-peak value	Virtual value	Aver age	Kurt osis	Pulse index	Margin	Rotate speed

These time-domain indicator for the diagnosis of mechanical failure has helped a lot, so this system software is included with the above-mentioned time-domain indexes of the graphical form.

2.2.3 Case-based reasoning

Reverse search using the case-based method, it based on the library to retrieve the case with the goal of matching the case. However, due to the fault diagnosis case library is not a comprehensive database, the number of the indicators frequency are huge, the frequency value of the goal case are uncertain, the bank intended to be the case in all cases with the goal of seeking similarity case, Search to match the case. The search algorithm is not a traditional European-style that the similarity of the algorithm, but the two cases as opposed to the use of the property as the ratio of search algorithms, adopting a classification search methods, which greatly enhance the efficiency of the fault diagnosis.

2.2.4 Knowledge rules setting

The capture and denotation of rules has the qualitative description, such as a sign of failure, as well as the characteristics of the harmonic, and so on. There are also a number of quantitative description, such as frequency characteristics can be a feature of every frequency, as well as the characteristics of the frequency multiplier, as the diagnosis of the rules. Specific set of rules that we have always used the time-frequency domain analysis of a number of ways. Knowledge is the main achievement of the rules of Knowledge in the operation of the rules, including rules add, delete, modify and save functions. Knowledge can make some adjustments. Table 4 of the rules of reasoning table shows the development of the reasoning for the rules of the mechanical fault diagnosis. Which contains some of the diagnostic system symbols, these symbols are used to their own definition of intelligent diagnosis system, said the rule. In addition to the mechanical device, there are motor, impeller, gear and bearing components such as the rules of symbols.

Table 4 Inference rules table

Inference rules table				
Rule_ID	Rule name	Frequency coding	Auxiliary frequency	Reasoning Rules
1	Fr	Fr		equal
2	XFr	Fr		multiple
3	Ifr	Fr		less than
4	DFr	Fr		fraction
5	Fm	Fm		equal
6	XFm	Fm		multiple
7	FmFr	Fm	Fr	webbing
8	Fi	Fi		equal
9	Fin	Fin		equal
10	Fout	Fout		equal
11	Fbc	Fbc		equal
12	Fc	Fc		equal
13	Fw	Fw		equal
14	Fz	Fz		equal
15	XFz	Fz		multiple

Inference rules table				
Rule_ID	Rule name	Frequency coding	Auxiliary frequency	Reasoning Rules
16	FzFr	Fz	Fr	webbing
17	XFrFz	Fr	Fz	Multiple append

2.2.5 Make a diagnosis report

This part of the intelligent diagnosis system as a whole is the ultimate goal of achieving an automatic fault diagnosis of the report output by the rules and case-based reasoning methods have been diagnosed conclusion to the form of text and images displayed on the screen. The main part of the text is part of the fault, fault diagnosis sign and the diagnosis result, at the same time given the appropriate maintenance treatment. The main part of the image is the vibration data, time-domain waveform and frequency domain waveforms displayed on the screen, but also save and print functions in the form of printouts, if users choose to save diagnostic reports, the diagnosis report can preserve in the form of text on the computer.

3 Application examples of intelligent diagnosis system

This example can better reflect the contribution of intelligent diagnosis system used in the production line. First instance of the use of on-line monitoring system for all types of chart analysis, then use of intelligent diagnosis system for analysis, which compared to a conventional diagnosis and intelligent diagnostic methods for diagnosis of consistency, reflecting the intelligent diagnosis system for efficient and accurate.

3.1 Background introduction

A line of high-rolling mill plants 7 mill gear box had report a alert that there had been failures in the August 2008, this plant put to production on March 21, 2008, the main product is 5.5-14.0mm diameter of round steel and hot-rolled steel under 10mm . Most of the volume through the rolled-ray disc volume supply, also known as a round rod or plate. The main wire used for the reinforcement of reinforced concrete and structural welding or reprocessing (for example, Roberts, nail-making, etc.) of raw materials. Was diagnosed in the rough mill equipment, a total of 18, 1,3,5,7,9,11,13,15,17 for the horizontal mill, as the stand-style 2,4,6,8,10,12,14,16 -Rolling mill. 7 mill does not appear failures from the production to current. There installs a measuring point in the 7 mill gear box input axle.

3. 2 Transmission chain map

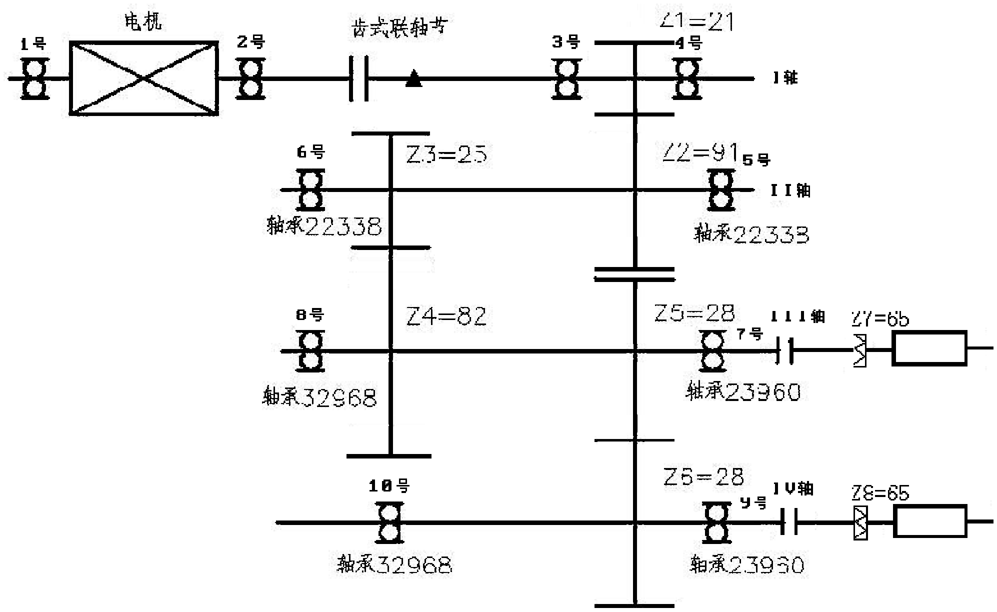


Fig.3 transmission chain map of a high-speed wire mill equipment

(▲ said the measuring point location)

3. 3 Trend Analysis

From the on-line monitoring system of analysis, be able to view the various time-domain indicator of the trend for some time. Beginning and ending time for their own custom. As shown in Figure 4. As can be seen from the chart, the points of the peak on August 12 at the beginning of an upward trend, reaching a maximum value of 90 m / s ², that the trend of deterioration of the state is to develop an initial framework to determine the faulty gear box problems arise.

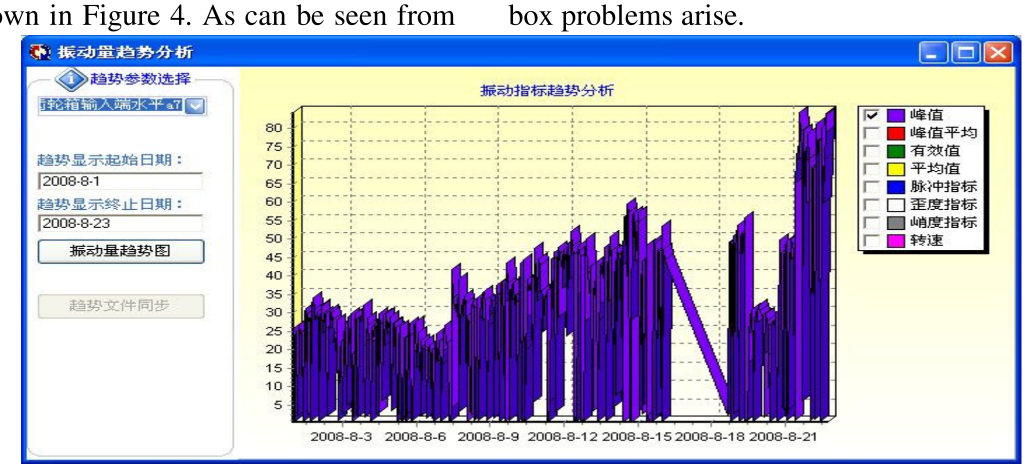


Fig.4 peak trends of a high-speed gear box input points in a rolling mill in August

3. 4 Probability density

It is also a function in the on-line monitoring system, as shown in Figure 5. The 7 gearbox input level measured at the point at 7:00 p.m. on the August 15 the probability density curve, and the standard of probability density distribution varied widely, and graphics are also very steep, and the 7 gear boxes that have hidden faults occur. And other times there are similar characteristics of the probability density, not more elaborate.

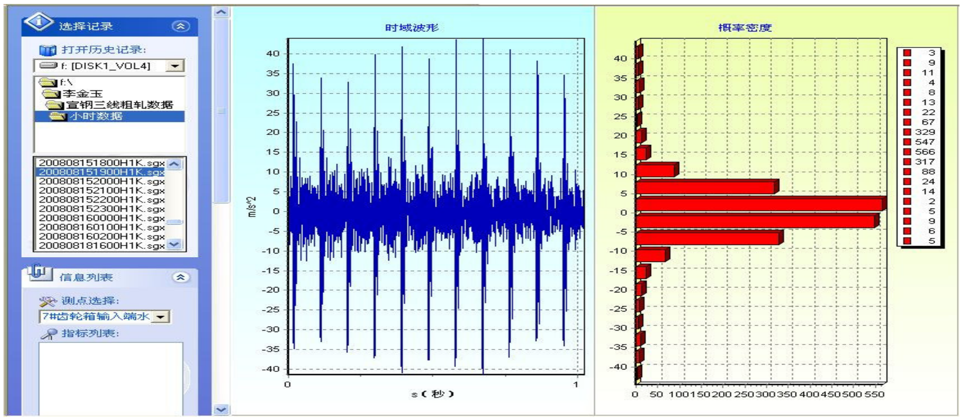


Fig.5 probability density of gear box input level points in a high-speed rolling mill at 19 o'clock on the August 15, 2008

3. 5 Self- relevant analysis

As can be seen from Figure 6 that the plane gearbox input level measured at the point at 7:00 p.m. on the August 15 from the relevant maps, charts, and so there are obvious time: t = 0.093S, corresponding to the frequency of failure: f = 1 / t = 1/0.093 = 10.753Hz, and I axis of the shaft frequency (10.183Hz) are similar, and obviously diamond-shaped graphics to show the plane gear box hidden failure has occurred. Other times have the same self-related features.

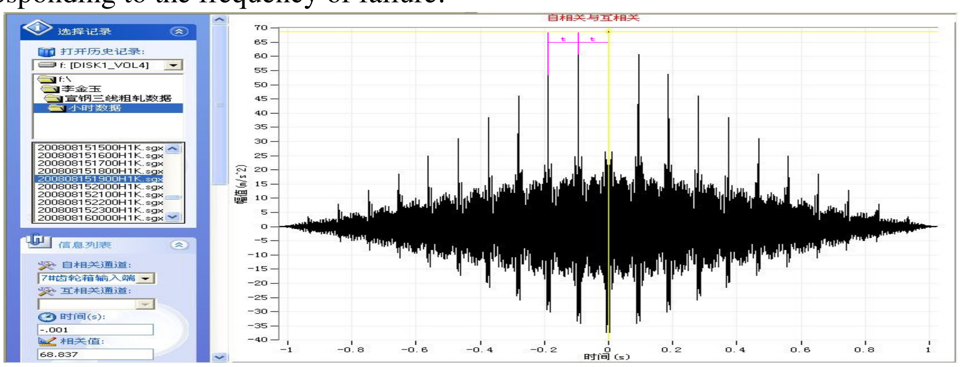


Fig.6 the self-relevant map of gear box input level points in a high-speed rolling mill at 19 o'clock on the August 15, 2008

3. 6 Spectrum analysis

As can be seen from Figure 7, the gear box frame 15 on 8 on 19:00, I shaft rotate frequency (10.742Hz) for the amplitude of 0.083 m / s ², in the I-axis of pinion gear teeth 21, the frequency of engagement is 213.85Hz. Engaging in this frequency no obvious peak, but the 0.5 multiplier, multiplier of 1.5, 2.5 occurring at the peak frequency, and there are intensive modulation side band, while frequent intervals for 10.742Hz, and similar to I shaft frequency (10.183Hz). Multiple times is also similar to the spectrum.

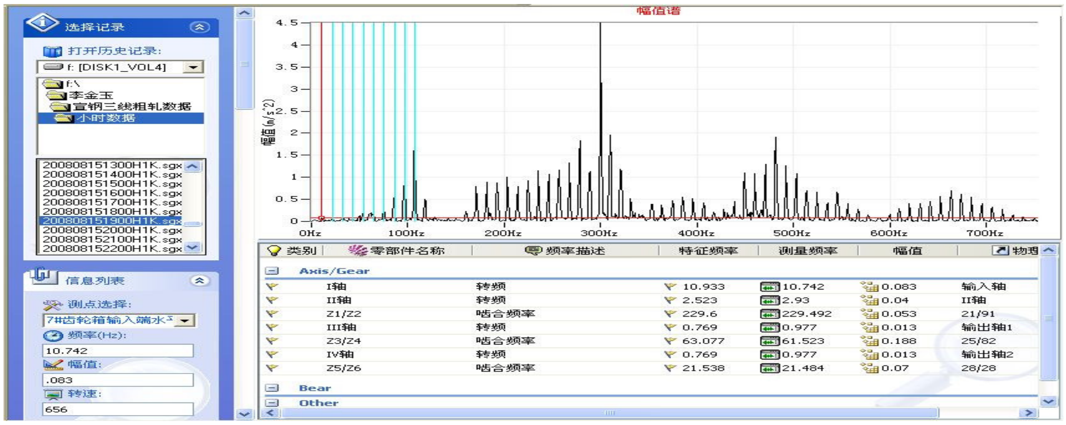


Fig.7 Amplitude spectrum of gear box input level points in a high-speed rolling mill at 19 o'clock on the August 15, 2008

3. 7 Waterfalls Map

Figure 8 can be seen to frame gearbox input ten points at different time points in the map of the waterfall, 299.805Hz frequency noticeable peaks and continuity, and a higher peak, as though I axis to the 28th harmonic frequency Wave, and it is just the 1.5 times of first gear mesh frequency.

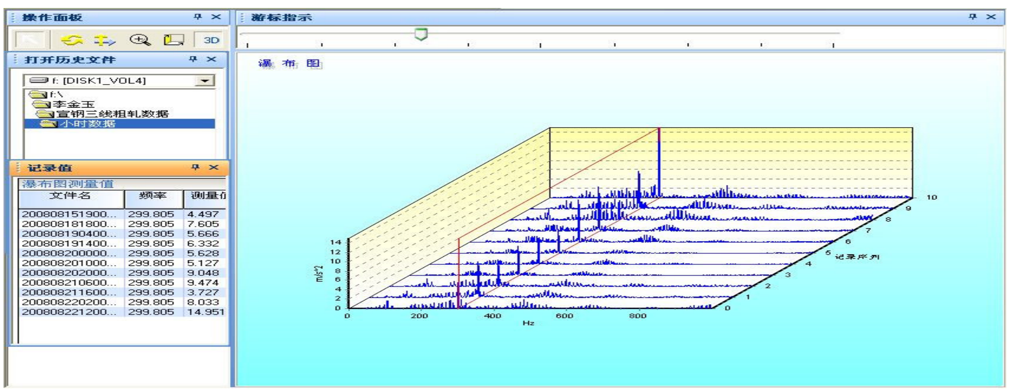


Fig.8 Waterfalls map of gear box input points level in a high-speed rolling mill

3. 8 Intelligent diagnosis

Figure 9 shows the results given by the intelligent diagnosis system, (see red line part). First of all, there is an account of equipment, drive the relationship between speed and points, followed by the most typical time-domain waveform and frequency spectrum. Time-domain waveform diagram to the right of all is the maximum time-domain indexes, the right of the spectrum is the maximum amplitude of the first ten frequency value. Interactive diagnostic information is intelligent diagnostic conclusions, and before the conclusion of the analysis of the artificial line. Intelligence information in the diagnosis of various equipment and be able to see parts of the case diagnosis.

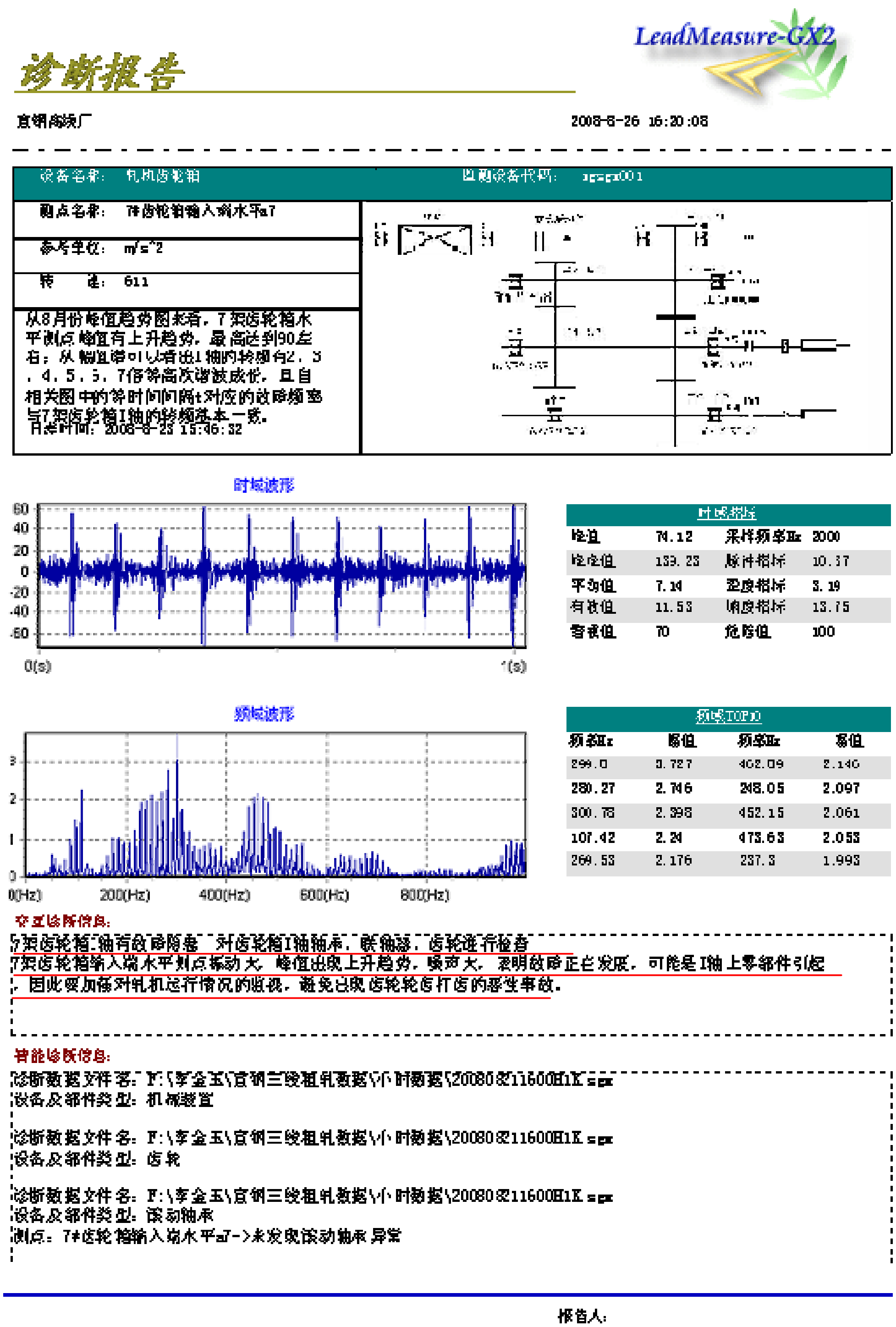


Fig.9 The intelligent diagnosis result for gear box in a high-speed mill

3. 9 The conclusions and the on-site maintenance

From the shape of the graphic spectrum analysis, it is exactly the shape of the characteristics of the mesh frequency fc = 213.85Hz as the center of its 0.5 multiplier, multiplier of 1.5, 2.5 occurring at the peak frequency. Frequency modulation to fz = 10.742Hz interval for the formation of an infinite number of sideband modulation. This shows that the first load of gear on the uneven pitch and failure caused by uneven load fluctuations, which in addition to the dangers of vibration amplitude of an impact, but also the inevitable fluctuations in torque, so that the speed of meshing gears volatility. Such fluctuations in the vibration frequency is Modulators. (Can also be considered to be phase modulation) for the transmission gear, have led to any amplitude modulation factors also lead to frequency modulation. There are always two kinds of modulation. The quality of the smaller pair, especially the phenomenon of frequency modulation. Therefore, the diagnosis can be concluded that: one of the pinion shaft has been more serious bonding. Shutdown examination should deal with this appropriately. Figure 10 shows photos of the fault.

Fig.10 photo in one fault diagnosis of a high-speed wire mill gearbox

4 Conclusion

The system equipment uses the rules of fault diagnosis, carrying out intelligent diagnosis, diagnostic equipment obtained the report, without the need for technicians are familiar with each of the complex rules of diagnosis, greatly increased rate of diagnosis of equipment failures, the technical staff at the same time reduce the labor intensity For the on-site equipment failures to provide expert services; to improve the monitoring unit to deal with the diagnosis and management of professional level, which is increasingly subject to the industrial sector and welcomed the attention, and more and more be widely used.

5 Reference

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