

A FAN FAULT DIAGNOSIS SYSTEM BASED ON ROUGH SET

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ABSTRACT

Fan is the key equipment in coal mine production, because of its high cost, and at the high speed without stopping, it is the guarantee of mine safety, the producer must carry on monitoring strictly to avoid the occurrence of major accidents. In this paper, according to the actual situation of a coal mine, combined with the related knowledge of rough set, applying PLC and MCGS for the development of a fan working process, fault diagnosis based on intelligent monitoring and the fault prediction system, it will realize the state monitoring of mine fan, to achieve safe production, prolong the service life of the fan.

Keywords: *Fan, Fault Diagnosis, Monitoring System*

1. INTRODUCTION

In the production process of mine industry, fan is an important equipment. But there are many reasons can cause the fan vibration, affecting the normal operation of the fan turbine, and even fan is damaged by malignant accidents, it seriously affected the daily production plan, which bring the huge economic loss to the enterprise. Because artificial monitoring is limited by the quality and knowledge of workers, observation is much randomness and uncertainty; in addition the timing detection may also miss out on some serious fault feature information, and judging method is too simple, the error probability is large, state parameter display is not intuitive, complicated operation, it prone to misuse. Therefore, in order to ensure the fan system of work safety, prolong the service life, reduce the pellet unplanned down time, we need to develop a fan on-line monitoring system, realize the visual display real-time vibration amplitude, fault alarm, aided failure analysis, so as to effectively guarantee the safety and reliability of fan systems.

Fan is a complex nonlinear electromechanical system in mine, many factors caused the fault, such as rotor unbalance, misalignment, loose and bearing wear, blade crack or breakage [1]. Forms of fault are various, such as the temperature rise, high frequency vibration, the vibration of asthma. These forms exist not only injective relation between fault reasons and performance of each fault symptom,

but also exist between the complex coupling relations. While the rough set theory can effectively deal with the following issues: uncertainty or imprecision knowledge expression, knowledge acquisition, knowledge learning and experience analysis, contradiction analysis, uncertainty reasoning and based on the information retained data simplification from experience. The application of rough set theory in fault diagnosis of fan can simplify the related knowledge table [2, 3].

According to the fault diagnosis of fan [4, 5], we can determine the nature of the fault, level, category and part. Predicts the development trend of fault is the effective measures to prevent accidents and unscheduled downtime, which is the trend of equipment repair. With the development of improved maintenance and fault diagnosis technology repair management level of coal mine and gradually entered the practical, it brings in more revenue than preventive maintenance and traditional active repair, attracted widespread attention in the world [6, 7]. So the fan condition monitoring and fault diagnosis has important theoretical, practical, safe and economic significance

2. OVERVIEW FOR FAN MONITORING SYSTEM

As shown in Figure 1, firstly, through a variety of signal installed in fan by sensor with its operation, these signals include vibration signal, temperature signal, pressure signal and other physical signal. Through the sensor can convert these signals into

electrical signals. Then the data collector to collect the data, it mainly includes denoising, anti aliasing filter to process the signal, monitoring the network will transmit these pretreatment signal, the signal is eventually sent to monitoring signal database, neural network fault diagnosis system and terminal display. At the same time, by predicting and forecasting system in the terminal display of monitoring signal database.

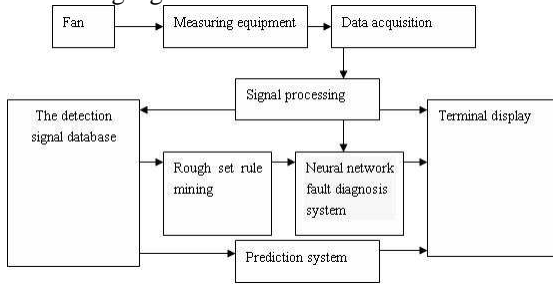


Figure 1 The Fan Chart Monitoring System

The use of historical data in the database of fault mode of fan were analyzed by cluster analysis, as far as possible in the foundation to ensure the accuracy of fault diagnosis on the simplified diagnosis rule table, and then get the most simple rule table, diagnosis based on the radial basis network fault.

The above is to fan monitoring system basic introduction; the following will introduce the key point.

3. KNOWLEDGE REDUCTION

3.1 Reduction and Core

The definition of the R into a set of equivalence relation, $r \in R$ if

$$ind(R) = ind(R - \{r\}) \quad (1)$$

r in R can be omitted, otherwise r in R can not be omitted.

For any $r \in R$, if both in R can not be omitted, R is known as the independent domain knowledge, independent means that each attribute in the attribute set is essential; it independently constituted a set of feature classification knowledge expression system.

The definition, if it exists $Q = P - r, Q \subseteq P, Q$ is independent, meet $ind(Q) = ind(P)$, Q is a reduction of P called (reduction), it represents red (P).

In fact, reduction Q is equivalence relation to minimal expression P is also a set of knowledge, is an important part of P. Although Q is removal of some extra knowledge, it still can obtain

classification results and complete knowledge base of the original P.

The definition of a set of equivalence relations P may have multiple reduction, all reductions of intersection is defined as the core of P, denoted as $core(P)$.

3.2 Attribute Reduction

In the information system $S = (U, A, V, f)$, each object is the use of conditional attribute value C to describe. However, some attributes may be redundant in C, because they can't provide any additional information to S.

The condition attribute $B \subset C$ is of nonempty sets, if there is a subset $P \subset B$, and $ind(P) = ind(B)$, B is called attribute dependency set, otherwise, B is known as the independent set. If the $B \subset C$ is an independent set, and $ind(B) = ind(C)$, then B is called reduction of C, namely C reduction is the condition attributes of maximum independent set.

For any attribute $a \in C$, if

$$IND(C) \neq IND(C - \{a\}) \quad (2)$$

a in C can not be omitted; otherwise, a is called can be omitted

All can not be omitted attribute set in C is called the core, denoted by $(core)(C)$, and

$$Core(C) = \cap RED(C) \quad (3)$$

$(core)(C)$ contains all in reduction C.

The basic algorithm first constructs the data based on distinguish matrix. Then get the identification function based on identifiable matrix on the absorption rate, using the minimization of it, make it become learning paradigm. Each of the main implication is all reduction. The algorithm can used to find all the reduction.

3.3 Software Decision Table Reduction and Reduction of Decision Table in Rough Set

In the intelligent diagnosis system, will use the monitoring data of fan theory on monitoring subsystem obtains the rough set analysis, and decision rules for fault diagnosis fault diagnosis system of fan, so as to simplify the neural network training samples, reduce the complexity of diagnosis system structure.

The following is rough set decision table reduction software development.

The software based on the identifiable matrix heuristic algorithm [8].

Here the selected six original conditions attribute, one decision attribute of the initial decision table as the original decision table. It is shown as figure 2:

2	1	1	2	1	1	1	1
3	2	1	2	1	1	1	2
4	3	2	1	2	2	2	3
5	4	2	1	1	1	1	4
6	0	0	0	0	0	0	0

Figure 2 Original Data

In the picture attribute box initial value is 0 after reduction completion, the final decision table still exists in the properties of the corresponding attribute from the box value is 1. The maximum limit and minimum limit value frame the numerical used to specify the attribute value of maximum and minimum value, to determine the numerical value range. Discrimination parameters used in the discrimination operation, specify the attribute discrimination parameters. Discrete step is to filled with step value.

The bottom two lines were fractional execution button and reflect each step of the display box.

Simplified operation implementation step is as follows:

- (1) Stat software and confirm the original data as shown in Fig.2.
- (2) Press data button, lead the original data into the software, when the textbox indicates the 'complete' means that corresponded with the imported button, and indicates this step finished.
- (3) Press the data filled button, take advance of mean completer algorithm to polish no value in every attribute value. Mean completer algorithm divided the attribute value that in the information list into numerical type and non-numerical type, and the two kinds of processing respectively. It will supplement calcium loss value according to the attribute in other places all examples of the average of the value if the lost for numerical type. And using this property in other places all examples value of the value of the most times to polishing if the lost value is a numerical value. When the textbox that corresponded with the polishing button indicates "complement" and this step finished basically.
- (4) Press the discrimination button, and disperse the decision table with equidistance division method as shown in figure 3. Equidistance division method is using the given users from

discrete step parameter k, and ensure that breakpoint interval as δ , and $\delta = (\chi_{\max} - \chi_{\min}) / k$, therefore, the breakpoint for this attribute is $\chi_{\min} + i\delta, i = 0, \dots, k$. When the textbox corresponded with the Discrimination button indicates 'complement', indicating that it's finished basically.

2	1	2	4	1	2	2	1
3	2	2	4	1	2	2	2
4	3	4	2	4	4	4	3
5	4	4	2	1	2	2	4

Figure.3 Discrete Data

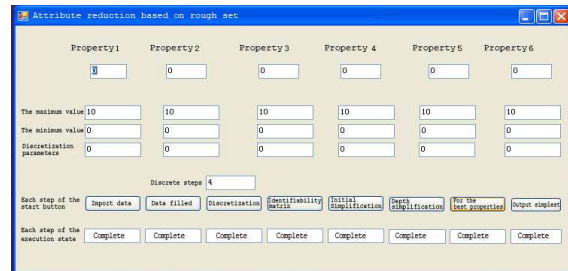


Figure.4 Final Interface

- (5) After pressing identifiable matrix button, and get the identifiable matrix in this decision table. When the textbox corresponded with the identifiable matrix button indicates that 'complement', indicating that it's finished basically.
- (6) Press preliminary simplify button, make the result in the step 5 simplified into upper triangular matrixes. When the textbox corresponded with the preliminary simplify button indicates that 'complement', indicating that it's finished basically.
- (7) Press the minimalist attribute button, now the value attribute box will change, if a certain attribute value of the corresponding value into 1, the attribute reduction for the final attribute is shown as figure 4. Otherwise it is not final attribute. As for the reduction of attribute button corresponding text box display "finish", indicating that it's finished basically.
- (8) Press the output button, the final attributes of decision table will be output to excel document is shown as figure 5. When the textbox corresponded with the output button indicates 'complement', indicating that it's finished basically.



1	1	0	0	0	0	0
2	2	0	0	0	0	0
3	3	0	0	0	0	0
4	4	0	0	0	0	0

Figure.5 Final Data

By using the software, we carried out the minimal decision table reduction test fan monitoring attributes such as table 1

Table 1 : After The Rough Sets Theory Reduction Policy-Making Table

Failure Symptom ID			Fault Name
C4	C5	C6	
24	28	36	F1
24	29	36	F2
26	28	36	F3
27	30	36	F4
24	21	27	F5
24	32	38	F6
24	33	39	F7
26	34	40	F8
24	28	40	F9
24	30	38	F10
26	30	37	F11
24	30	37	F12
24	35	40	F13

The corresponding fault can be regarded as the classification rules by the fault ID in the minimal decision table, from table 1, we only need 3 fault symptom that can distinguish fault types of all, and the 3 fault symptom in on-line monitoring project fan site is 3 signs most easily come out, so when fault diagnosis of fan, we do not need to get the fault symptom of all, which reduces the complexity of the fan monitoring and reduces the response time required for fan fault judgment.

By the minimal decision table shows that the model rules of rough set and clustering reduces the input conditions of fault diagnosis system, simplifies the diagnostic system.

4. APPLICATION OF MCGS SOFTWARE TO DISPLAY JUDGMENT RESULT

Dynamic data exchange (DDE) is a process communication in Windows system; it is an effective method for real-time data exchange between applications. It established message handling mechanism in Windows, two Windows applications to complete a DDE session by passing message to each other. Initiate a session is called client (Client), response session is called server (Server). A separate Windows application at the same time can be both client and server of a program. The client is DDE session initiator, when

sending messages, it not only indicates the type of data required, but also asks a server name (Service) and the topic (Topic) needed. The server name identifies the client wants to establish dialogue object, the server name is the application's executable file name, MCGS name of the DDE server is MCGSRun, while the MATLAB server name is MATLAB. The topic of conversation is defined the theme, general sense for both sides to establish the DDE dialogue is the theme. Most applications of the program to open the file name as a DDE theme of dialogue, for most applications support System theme, and at least one other theme support. Support the theme of the data type called Project (Item), generally a theme support at least one item or more.

In MCGS, supports two kinds of dynamic data exchange ways: one is the output of the DDE, there will be MCGS as DDE server; a DDE input, the MCGS as the DDE client. In the DDE output mode, the theme name for the DataCentre, the project name for the real-time database variables exchange. In the DDE input way, must specify the DDE connection object server name, subject name and the name of the project. If using MATLAB as DDE server, MCGS as client, server name is MATLAB, theme name is System, and the project name is MATLAB workspace variables.

In the MCGS configuration environment "tools" menu select "DDE connection management" menu item, the DDE connection manager window, "fan overall operating state" is set to the DDE input, DDE output and other settings.

Press the "service node configuration" button, the DDE service node configuration window is shown. Press "increase" button, the service node name is set to "MATLAB simulation", the service name is set to "MATLAB", and the theme name should be set as "System".

Configured the server node, the "connection the overall status of fan" is set to "MATLAB simulation", connecting the project were set to y. In this way, the DDE of MCGS connection is set up.

Compared with MCGS, MATLAB provides the DDE function is more powerful. As a client, it supports text format data transfer function, can be provided by using the DDE client in the MATLAB module and server applications to exchange data. The DDE client function MATLAB provides 7 functions; they are ddeinit, ddereq, ddepoke, ddeexec, ddeterm, ddeadv, ddeunadv. In this system, MCGS and MATLAB are connected by heat exchange of data, the MCGS program will

continue to collect the data sent to the MATLAB program, and MATLAB calculated after the completion of returns MCGS.

To establish the connection of MCGS and DDE of MATLAB, we need define variables in the “real-time database” window, in the configuration of the “tools” menu, select “connection management” menu item, in the pop-up window, setting the variable to the DDE output.

In MATLAB, using the ddeinit function establish a dialogue to server, when building successfully, the function returns a number of channels. The request data to the server through the definite function, the function is send data to the server. MCGS and MATLAB connection diagram as shown in figure 6.

The content of the dialogue is through the three names to contract, the client must fill out the service program three names. Service program (sever) program name: MCGS operating environment is “MCGSRun”. Theme (topic): the data domain is discussed, the theme of MCGS provisions for “DataCenter”. Project (item): data object to be discussed, for the MCGS data objects in real-time database. The dialogue is as follows:

(1) The DDE initialization.

```
DDEChannel=ddeinit ('MCGSRun', 'DataCentre');
```

(2) The MATLAB request parameters from MCGS.

```
P1=ddereq ( DDEChannel, 'rolling bearing 1');
```

“The rolling bearing 1” is the MCGS data objects in real-time database, namely project (item); P1 matrix variable MATLAB custom.

(3) MATLAB simulation results will be sent to the MCGS

```
For i=1:n;
```

```
Rc=ddepoke ( DDEChannel, ' Y ', y ( I ) ); end
```

Y is the MCGS data objects in real-time database, namely project (item); y matrix variable MATLAB custom.

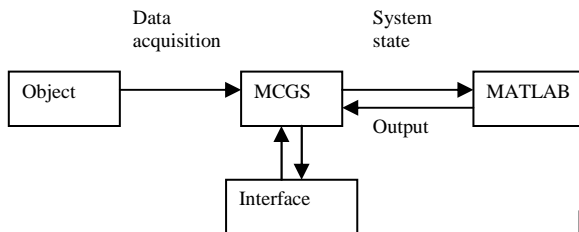


Figure.6 Connection Diagram Of MCGS And MATLAB

Because using MATLAB and MCGS, the software design of the control system is very simple.

First of all, to complete the picture configuration, equipment configuration, real-time database, main menu and operation strategy configuration in MCGS, and the establishment of related variables in the DDE connection; and then in the MATLAB neural network model is established and trained; finally use MATLAB to receive the MCGS data as the network input, the network simulation training well, network the output is the simulation results returned by DDE MCGS.

When entering the MCGS runtime environment, MCGS receives the real-time changes of fan of PLC data, MATLAB neural network’s input change, and along with the simulation results of MATLAB, MCGS “the overall status of fan” is also changed.

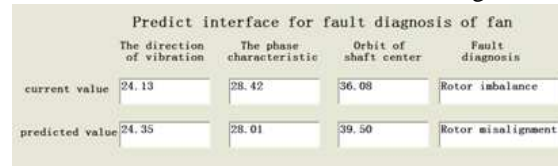


Figure.7 Fault Diagnose And Forecast Interface Of Fan

The monitoring system is designed in this paper to the fan data archiving, extracting characteristic signals according to a certain algorithm, neural network is applied to fault diagnosis of fan, and according to the current characteristics of the signal and the historical data to predict the characteristic signal and the diagnosis of some time in the future as shown in Figure 7.

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