An expert system for the integrated test of a grain depot

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Abstract

The application of an expert system in a grain depot is an entirely new field. It can greatly improve the intelligent and modernized process of storage test, control and management, ensure the quality of stored grain and thus increase labor productivity. This dissertation gives a detailed description of the system structure and its realization method of the parameter-testing expert system for a grain depot in terms of temperature, humidity, moisture content, etc.

Introduction

Grain storage is an important task closely related to the national economy and the people’s livelihood. It directly affects grain quality and its market life-force. To guarantee the storage quality, various automatic temperature-testing systems for grain and automatic ventilation facilities are being devised and developed both at home and abroad. With the help of these devices, the storage quality of the grain can be indirectly judged according to the temperature indication in the storehouse, and the temperature and moisture content in the high-temperature storehouse can be lowered. Such passive test methods reduced to a certain extent, the loss rate of grain in the course of storage. But as the test parameter is not all-inclusive, the test result lags considerably and cannot reflect the storage condition of the grain promptly and accurately or ensure the storage quality thoroughly. According to the figures released by the Ministry of the Chinese Domestic Trade, the total loss of grain due to moldew and rot is well over 5% per year in China. This is an astonishing figure. Therefore, to reinforce the integrated test of grain depot and control the possible loss rate is of active social significance and great market potentiality. In fact, the key factor affecting the grain storage quality is the moisture content, while the moisture content of the grain has something to do with the grain temperature and the humidity of air in the storehouse. The monitor of a depot embraces three parameters: temperature, humidity and moisture content. Then the three parameters are taken into consideration as an organic whole for the intelligent judgment on the basis of the data fusion.

For the above-mentioned reasons, supported by the National Grain Storage Depot of China, we have designed and developed an expert system for the integrated test of grain depots, with our constant efforts of nearly two years. This system has summarized the precious experiences undergone and accumulated over a long period of time by experts on cereal and oil inspection, test and storage. It has also consulted and made reference to many technical indexes and relevant data at home and abroad. The designed test system and knowledge storehouse are of higher accuracy and greater reliability. The system names the information fusion ability of human experts and gives alarm for the abnormal circumstance in the initial stage of a trouble in any individual warehouse, greatly increasing the predictability of an incident and working efficiency and effectively reducing the grain loss in storage.

The system function & the overall structure

The system function

The expert system for the integrated test of a grain depot is mainly used to automatically test the temperature, moisture of the stored grain and the air humidity of a warehouse, to judge the state of grain storage and to suggest methods of treatment.

The functions of the expert system for the integrated test are as follows:

1. the sampling test and the entire test of the grain temperature in every warehouse of a grain depot;
2. the sampling test and the entire test of the air temperature in every warehouse of a grain depot;
3. the sampling test and the entire test of the moisture content of grain in every warehouse of a grain depot;
4. the sampling test and the entire test of the air humidity in every warehouse of a grain depot;
5. the three parameters of temperature, humidity and moisture content, and their data display, analysis and the alarm indicating the grain storage condition;
6. the varying curve of the three parameters regarding temperature, humidity and the moisture content during the present month;
7. the display and printing of the measurement data and

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(8) the automatic formation of the monthly statistical report, form and the statistics of the abnormal measurement points in the warehouse of that very month;
(9) the consultation of knowledge for grain storage, test and trouble removed;
(10) the communication between various expert systems of different grain depots

The structural drawing of the system's hardware

The main processor for the system is PC computer. The extension part is the measurement circuit comprising the 8031 single chip processor system and the signal ethanol of the three parameters about temperature, humidity and moisture content. The main machine is installed in the central test room of the depot and the extension machine is installed at the various sites of the grain warehouses, one extension machine for a warehouse in principle. The main machine can control 200 extensions. Every extension can connect 20 temperature-testing sensors and 8 humidity-testing sensors and 20 moisture-testing sensors. The maximum communication distance between the main machine and an extension may go as far as 10km. A grain storehouseman will easily get to know the parameters about the state of all the warehouses in the whole depot from the main machine screen and the printed sheets in the central inspection room.

Figure 1 is the structural drawing of the hardware of the system.

\[\text{Fig. 1. The structural drawing of hardware of system}\]

The component parts of the software

For the convenience of programming and management, the software is divided into three subsidiary systems:

(1) data testing management subsidiary system;
(2) trouble diagnosis subsidiary system;
(3) technical consultation subsidiary system of a grain depot.

These three subsidiary systems are mutually related and independent. The whole structure is illustrated in Figure 2.

\[\text{Fig. 2. The structural drawing of the software system}\]
Various kinds of information of the screen pictures are stored in the picture bank in the above diagram; the fact base provides the fact foundation for inference; the interpretation base provides some related knowledge on storage technology and management; data testing base provides all the data tested and curves; primitive data base stores the primitive data regarding variety, grade, place of production, date of storage, the moisture content when first put in storage. The defect base stores the data tested of all the abnormal result testing points and the trouble of the system.

**Inferring machine**

The expert system for the integrated test of a grain depot adopts the graded inference patterns and the positive inferring mechanism guided by the rule base. It imitates the mode of thinking of human experts in the process of its inference. When the test result is displayed, the system will begin the information fusion process of the temperature, moisture content, humidity and other measurement parameters. The system will judge the safety coefficient of the stored grain before dealing with it accordingly in a graded way. The possible reasons for the confirmed abnormal circumstances are to be analyzed and the countermeasures are to be worked out.

The reasoning on the basis of the knowledge of the knowledge base enables every operator to give the same reliable judgment and handle it effectively as any experienced warehouseman or technicians. Even a layman completely ignorant of the storage constant can get some wanted information in no time from the interpretation base through the technical consultation function of the system.

Let us look at one example. If the test results of the moisture content gathered from several measurement points in a certain section for the storage of the late rice remain 15.0% - 16.0%, this result has exceeded the safety requirement for the storage of the late rice. The system then automatically enters the temperature-testing state and compares the temperature of the above-mentioned testing points with that of the adjacent testing points. If the numerical value of the temperature is normal, the main machine screen will display: '...In so-and-so warehouse, the moisture content of the measurement point has reached the limit of the dangerous moisture content value, the stored grain is in semi-dangerous state. The moisture content should be immediately reduced.' If the temperature value has gotten a little above normal, the screen of the main machine will display '...In storehouse so-and-so, the moisture content of the grain of the testing points is the dangerous moisture content. The stored grain is in a dangerous state. It should be dealt with without delay!'

**The fact knowledge base**

To establish the knowledge base for the system is a technical key point in realizing the highly intelligent operation of this system. It embraces the fact knowledge base, inferring knowledge base and the problem-solving base, etc. These bases can be conveniently modified and supplemented which lays the foundation for the on-going development and perfection of the knowledge base in its practical use.

**The fact knowledge base**

The fact knowledge base governs all the facts of 32 different items, including the stored grain testing, preservation and the self-trouble-detection

1. the temperature requirement for the grain storage;
2. the moisture content requirement for the grain storage;
3. the requirement of the air temperature in the warehouse;
4. the self-inspecting rules for the temperature signal channel;
5. the self-inspecting rules for the moisture content signal channel;
6. the self-inspecting rules for the humidity signal channel

The above requirements and rules are basically stipulated according to the storage circumstance standard at home and abroad, the moisture content storage standard of various grains, relevant experience data and the technical requirement of the test circuit.

**The rule base**

The rule base is the core of the knowledge base. The entire process of the testing data recognition, the data fusion of the measurement parameters, trouble diagnosis and the method of treatment for the systems all conducted under the guidance of the rule base. It covers 38 items in all.

1. the abrupt change of temperature in the grain;
2. the abrupt change of the moisture content in the grain;
3. the temperature change of the proximate points to the temperature abrupt change point;
4. the moisture content change of the proximate points of moisture content abrupt change point;
5. the moisture content testing channel as the closing signal;
6. the moisture content testing channel as the saturation signal

The structures of these 38 rules bases mime the thread of thought of human experts that enables them to perform the
function of information fusion and trouble detection. So it
does not take long to draw conclusions.

A case in point At a certain testing point when the
moisture content testing signal is the full amount signal, the
system instantly checks the air humidity in the warehouse,
the previous moisture content testing record and the present
moisture content measurement value of the adjacent testing
points. If the last tested result is normal, the air humidity in
the warehouse is normal and the moisture content of the
adjacent testing points is also normal, it shows that the
moisture content testing signal channel of the testing point
has broken down and caused the abnormal output of the
circuit. At this moment, the main machine will indicate on
the screen: '... The moisture content testing signal
channel of so-and-so warehouse has broken down.' If the
cause of the breakdown is further to be found out, select
from the prompting menu 'BREAK-DOWN DIAGNOSIS,'
'the moisture content testing signal channel.' You will soon
find out the relevant cause for the breakdown and the
method of removal.

The security of the system

The computer main machine serves as the core of the expert
system of a grain depot. Its extensions are widely
distributed and the lines are laid over long distances. It is
easy to be interfered by the outside world. Therefore, we
have adopted quite a number of security measures of
software and hardware in the system and achieved good
protective results.

Watchword protection

To protect the internal security of the system, prevent
the illegal users from entering the system, this is designed
with watchword authorization mode in operation.

Cipher code protection

Because the expert system is endowed with the
transplantation in PC machine, it is possible for people to
store and draw unlawfully. We have adopted the software
and hardware cipher code to prevent arbitrary use and
copying in the process of transplantation.

The interference prevention measures

To prevent the interference of thunder and lightning, and
the contamination of the resonant waves of live wire
entanglement, metal screened lines is employed for the long
lines of the signal transmission of the system. Photoelectric
separation is designed in the signal handling channel and the
shielding method is also taken into full consideration in the
power supply.

Conclusion

The expert system of the integrated test of a grain depot is
efficient and practical in characteristics. The system has
been adopted for many depots in such places as Hunan
Province, Heilongjiang Province, Inner Mongolia
Autonomous Region, etc. The result of the actual
application proves that the system is easy to operate,
accurate in measurement, reliable in operation, quick and
accurate in trouble analysis and highly intelligent. Hence,
the exploration work has been done on the application of the
artificial intelligence for the storage trade. The system,
when slightly modified, will find its ready use in the
following trades: tobacco, chemical engineering, medicine,
textile, paper-making, etc.

References

Teng, Z S 1998 Design of the Intelligent Function of LSK-
1 Digital & Erecting Style Grain Storage, 27(1) 29 – 32.
Arpala, P. 1995 Expert system for the optimum design of