Research and Development of Storage Environment Monitoring Based on Internet of Things

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Abstract

With the rapid development of the economy and society, we have entered the era of great wealth, but we also face a huge challenge of the storage and management of materials. Storage is one of the most important working process of logistics. With the development of commodity economy, it gradually presents the development trend of specialization and scale. Meanwhile, it also puts forward a new problem to be solved. Warehousing on a large scale and the variety of goods, not only to establish an efficient operating process, but also to be equipped with a specific storage environment monitoring system to ensure the safety of storage personnel and goods. Different types of storage the environmental monitoring parameters are different. Analysis of the storage environment not only need to use the environmental monitoring professional knowledge, but also related to the theory of goods, such as understanding the characteristics of the goods.[1]How to create a better storage environment is an eternal topic which is worthy to study. Storage environment monitoring is one of the main problems in the warehouse management and the whole logistics system. How to create more safe and appropriate storage environment, prevent supplies moldy, damp, ignition and detonation and deterioration, which is the main storage safety management. However, the implementation of information technology in warehouse environment monitoring is an important guarantee of the safety management of storage environment. As a big agricultural country, Chinese agricultural products warehousing cost is much higher than the developed countries. In our country, fruits, vegetables and other agricultural products in the harvesting, transport, storage and other logistics loss rate as high as 25% - 30%, and the developed countries control in less than 5%. Backward storage management is the main reason for the loss. The traditional management mode in manual or semi mechanized operation, which is low efficiency, appear frequent errors, causing goods mildew, theft and other series of losses. To be obviously, in the face of increasingly complex storage needs, the traditional way of management has been difficult to do. With the recent emergence of a series of storage problems, storage environmental monitoring in a information way is imperative, and the rapid development of Internet of Things, to provide the new technology, new methods and new ideas for the storage environment detection. Based on the Internet of Things to study the storage environment monitoring, can effectively improve the environmental monitoring of real-time, effective, to achieve information sharing and decision making, to provide the basis for environmental monitoring management. Storage environment monitoring is the fundamental of the logistics management system. This paper presents a storage environment monitoring system based on Internet of Things and wireless sensor.

Key words: Internet of Things; Storage environment; Wireless sensor

1. Research Background

With the development of modern economy and society, material circulation acceleration, logistics industry, supply chain management is no longer a strange concept to us, the importance of storage management in logistics industry is increasing. However, the current situation is that the level of automation of warehouse management is too

low, dependent on human, serious lag and other series of problems. Every year, the number of accidents and losses appearing because of the poor storage management. Warehouse fire, explosion and a series of accidents are caused by poor storage management. Faced with the urgent problem we have to worry for the current warehouse management , The core issue of warehouse management is the warehousing environmental monitoring, only to create a safe, appropriate storage environment to avoid the storage of dangerous incidents occurred.

The traditional storage environment monitoring and management is mainly rely on human to realize, through the thermometer, humidity and other equipment to realize the storage environment monitoring, through the artificial record, feedback, control management to achieve storage management. However, human resources are limited, can not achieve real-time monitoring of the storage environment. With the development of information technology, through the wired way to build a warehouse environment monitoring system, arrangement of the fixed monitoring points in the monitoring region, through a wired communication mode the monitoring data will be fed back to the monitoring center, so as to realize the real-time monitoring of the storage environment. However, there are many problems, such as complicated wiring, poor mobility and so on with wired way. At present, with the promotion of wireless sensor technology, RFID technology and theirs application, domestic and international warehousing environmental monitoring technology has been a great progress. Through arrange mobile wireless sensor in the warehouse, collect various environmental parameters of storehouse and transfer these parameters to the control center, for this way , it can save manpower and avoid the wiring complexity and other problems.

2. Significance of Research

In recent years, with the acceleration of material circulation, the expansion scale of storage, storage management issues become increasingly prominent, especially in the storage environment monitoring, real-time monitoring of the storage environment is the fundamental of storage management. Recently, storage accidents occurrence frequently due to poor storage management, the root cause is that warehousing environmental monitoring is not in place. The warehousing environmental monitoring system based on internet of things can monitor storage conditions on a real-time and effective way, for reduce storage accidents and unnecessary economic loss has important significance.

3. Key Technologies
3.1 Wireless sensor network technology

The wireless sensor network can be seen as three parts, which are data acquisition network, data issue network and control management center.[2]It's mainly contains integrated sensors, processing unit and communication module of the nodes, each node with others formation a distributed network through network protocol, then transmission the collected data to the information processing center via radio waves.[3]

3.2 Internet of Things overview

The Internet of Things, make various information sensing device, such as a radio frequency identification device (RFID), infrared sensors, global positioning system (GPS, laser scanners and other various device, combined with the internet and formation a huge network. Networking is the interdisciplinary emerging hotspot of research field, which combines sensor technology, embedded computing technology, modern network and wireless communication technology, distributed information processing technology, can through various integrated micro sensor collaboration to real-time monitoring, sensing, collecting the information of objects, processing information through the embedded system, and transmit the perceptual information to the user terminal in a multiple hops relaying mode through the random self-organized wireless communication network .

3.3 Internet of Things technology application status

Internet of Things set information automatic extraction, integration, local networking, intelligent service and

management as a whole, and realized information technology applied in the circulation of goods.[4]It is estimated that China's Internet of Things market size to 2015 will reach 750 billion yuan, the annual compound growth rate will more than 30%, it is a hot spot for future economic growth. The development of warehousing logistics is more significantly, such as intelligent warehouse construction of Jiangsu province Wuxi grain science and technology logistics center emergency materials reserve, Shandong province Jining Jiaxiang networking storage integrated monitoring system, all of these are Internet of Things technology in the successful applications case of the warehousing areas. Internet of Things technology inject new vitality to China's warehousing logistics industry, and expanding the development space.

4. Analysis of Storage Environment Parameters

Storage environment parameter is a basic index of the storage environment monitoring. Storage environmental parameters mainly include temperature, humidity, oxygen, carbon dioxide and other types of gas concentration, light intensity, dust, soot, pH value, etc..[5]These are the most common storage environment parameters. Storage environment monitoring system is mainly to collect the real time and effective values of parameters, then feedback to the monitoring platform, to ensure the parameter in the safety range through the control center.

4.1 Temperature

Temperature is one of the most common storage environment parameters, ordinary goods are generally stored in room temperature environment, the temperature of the room temperature is usually controlled at 0℃-30℃. However, there are also a number of items can not be long-term stored at room temperature environment, like the fruit, vegetables, seafood, dairy products and other goods, which arranged in normal temperature environment for a long term are easy moldy, metamorphism. Their requirement of temperature relatively high, so in the storage and transportation of each link to ensure that they are in a suitable temperature, for this kind of goods storage environment should pay particular attention to the storage temperature control.

4.2 Humidity

Humidity includes absolute humidity, saturated humidity, relative humidity and dew point. Absolute humidity is refers to the content of steam in the air, usually measures of absolute humidity form the amount of steam in the air. Saturated humidity is refers to the unit of space to accommodate the upper limit of steam. In general, the applications of relative humidity is more widely. Relative humidity a percentage between absolute humidity and saturated humidity in the certain temperature, that is the difference of steam between actual contents and saturated content. Dew point: the humidity of air when steam in air on a status of saturated humidity. The most commonly used is the relative humidity of the air, the bigger relative humidity is, the closer with saturation state , the more humid of air, moisture is not easy evaporation; on the contrary, the lower relative humidity is , the further with saturation state, the more drier of air and water is more easily evaporate.[6]Air humidity is easily affected by the temperature of the air, the higher temperature, the air will become drier, the air humidity is getting smaller and smaller. Different items on the requirements of air humidity are different, in the storage of fruits air humidity determines the maturity of fruit; and humidity is too high to cause corrosion in the warehouse where the metal is stored. Many other goods such as chemicals, tobacco, alcohol, sausage, wood, artwork, integrated circuits, and others must also be stored in a certain degree of humidity or in the condition of zero humidity. Therefore, the storage of different items to pay extra attention to the control of air humidity.

4.3 Gas concentration

Gas concentration on the storage environment has an important influence, the concentration of various gases are important parameters of warehousing environmental monitoring, the gases concentration monitoring including

oxygen, carbon dioxide, methanol, sulfur dioxide, ethylene and various harmful gases. The oxygen and carbon dioxide concentration effect the metabolic processes of organic matter maintain their own life activity, they are the focus of storage gas concentration monitoring; in addition, with the ripening effect of ethylene, sulphur dioxide and other toxic gases which also are important parameters to monitor for storage safety.

For example, grain in the warehouse, with the time increasing, some grain will be fermented and appears problems of methanol evaporation. Methanol is a kind of combustible gas, in the process of grain storage, its concentration is strictly controlled. If the concentration of flammable gas exceeds the threshold value, it is very likely to cause the explosion of combustible gas or grain warehouse. In warehouse storage of fruits, ripe fruit will release ethylene, and ethylene have ripening effect, so in fruit storage warehouse to pay attention in particularly of ethylene.

4.4 Light intensity

Light intensity is a physical term that refers to the luminous flux of visible light by unit area. In the storage environment, the light intensity has a positive impact on the storage of goods, but also has a negative impact. Some unstable substances, which are easy to decompose under light conditions and lead to deterioration, the heat produced in the reaction process and flammable gases can cause safety accidents. Such as alcohol, a number of chemical reagents, and some drugs which are easy decomposed and deteriorated when see the light. At the same time, the sunlight can   impact the growth of many microbial. Such as, deteriorative microorganism can cause foods, industrial products mildew and rot, which lead a serious influence of storage safety. Such microorganisms in direct sunlight 1-4 hours to die, so the goods prone to mildew and rot should be stored in a better light illumination environment. For different light sensitive items to pay attention to the storage environment in light intensity control.

4.5 Dust

Dust like other substances have a certain energy. Because of the small particle size and large surface area, the surface energy of the dust can also increase. A 1 g heavy coal and its surface area is only $5 \sim 6 C m^2$, and 1 g of coal dust, the surface area of $2 m^2$. Dust mixed with air can form flammable mixture gas, in case of fire or high temperature object, catch fire easily, complete combustion process at a moment, release a lot of heat, the combustion gas is suddenly increased, the volume expand violently,and format very larger expansion pressure. After the combustion of dust, oxidation reaction is very rapid, it produces heat can be quickly passed to the adjacent dust, resulting in a series of chain reactions.

The existence of dust in the atmosphere is inevitable, however, the dust will have a negative impact on the goods, in a certain space, the fire is very easy to explode. Energy that is stored on the surface of crushed material particles is called surface energy. The size of surface energy is proportional to the degree of crushing of the material, the greater the degree of grinding, the greater the surface energy. Dust particles are very small, with a very high surface energy, easy to physical or chemical changes. After the dust and the air fully mixed, meet the appropriate conditions, will be in an instant explosion, release a huge energy.

However, the dust explosion is also required to meet a series of conditions, dust explosion must have a certain condition, summarized as follows:[7]

(1) particle size: This is an important factor affecting the reaction speed and sensitivity. The smaller the particle is, the more easily it burns, the stronger the explosion. Particle diameter of 200μm, and a larger degree of dispersion, easy to float in the air, heat fast, easy to catch fire. Particle diameter of more than 500μm, which contains a certain amount of large particles are not easy to burst.

(2) chemical composition: If COOH, OH,, NH2, NO, C=N,, C=N, and N=N groups in organic dust, the risk of explosion is relatively large; Dust containing halogen, potassium and sodium, the explosion trend is weakened.

(3) Explosive concentration: In a given volume, the minimum weight of a suspended dust that is capable of propagating flame is called an explosion concentration. Usually, dust will explode when dust concentration reached

explosion concentration. The explosive concentration of flour is about 15～20 g/m&sup3, and the explosive concentration of bulk grain is about30～40g/m&sup3.

(4) air humidity: when the air humidity is large, hydrophilic dust will absorb moisture, so that dust is difficult to diffuse and fire, the speed of the propagate of flame will be reduced. Even if the dust is on fire, the heat is first consumed in the evaporation of the water in the dust, and then used in the combustion process. Dust humidity more than 30% is not easy to burst.

(5) there is sufficient ignition temperature: dust explosion originated in the external flame, such as mechanical impact, welding and cutting, electrostatic spark or electric spark, friction sparks, matches and heat transfer, etc.. The minimum ignition temperature of this kind of ignition source is 300 ~ 500℃.

(6) enough oxygen:combustion of dust in a suspended environment should contain enough oxygen.

(7) Dust turbulence degree:Dust suspended in the air, turbulence intensity bigger, more easy to absorb oxygen in the air and accelerate the reaction rate, and easy to explode.

Therefore, to monitor the dust and sooty in the storage environment, and to increase the environmental warning function, can effectively control the occurrence of the disaster. Storage environment in the different storage of goods, should be development different environmental parameters for monitoring requirements, monitoring the key parameters of the storage environment and collect the data for storage and analysis. In the presence of abnormal parameter information alarm, timely take the necessary measures.

4.6 PH value

The index of hydrogen ion concentration is the ratio of the total number of hydrogen ions in the solution and the amount of the total substance. Goods are generally stored in the indoor environment, from the general sense, it is a small threat of acid rain, and the relationship with the pH value of the air is also smaller. However, storage environment is a dynamic system, Environment directly affects the physical and chemical properties of the goods, due to the influence of the external factors, the nature of the goods has been changed to produce volatile, sublimation and other phenomena, feedback to the environment, interact and restrict each other. For example, in chemical library, all kinds of chemical powder, liquid, through   sublimation and evaporation combined with water vapor in the air , air pH was alkaline or acidic, encounter cold air to form droplets and attached to the surface of the goods, the packing of goods damaged if the situation is not serious, the goods occurred chemical reaction and produce risk if the situation is serious.

5. Development Trend of Storage Environment Monitoring Based on Internet of Things

With the continuous expansion of the storage scale, the level of automation is increasing, the scope of the application of storage environmental monitoring gradually expanded. Therefore, equipped with advanced environmental monitoring system is the inevitable requirement of the large-scale and automation process of warehousing , and it is also the fundamental guarantee for the realization of storage safety management.The distributed storage environment monitoring system based on intelligent sensor network can reduce a lot of manual operation, improve the accuracy of monitoring results, and greatly improve the efficiency of the work. Wireless sensor network technology can accurately collect and transfer the relevant environmental parameters in real time, which can effectively make up the deficiency of the existing monitoring system, and has high application value. The storage environment monitoring system based on Internet of Things technology can realize the real-time and automatic monitoring of the large-scale storage system. It will gradually replace the traditional monitoring system.[8]

The sensitivity of different goods to environmental parameters is different, and the environmental conditions of safety storage is also different. Based on existing storage level of environmental monitoring and networking applications of wireless sensor network technology, research and development with multi parameter sensing and transmitting power of wireless sensor network node equipment, is the key to have a lot of space multi parameter

monitoring capacity of the storage environment monitoring system design and implementation.[9]In addition, the reasonable deployment of sensor nodes can effectively improve the accuracy, integrity and effectiveness of monitoring information. Reasonable layout of sensor nodes, efficient use of limited resources, to maximize the reduction of energy consumption, and it is the first problem to be solved in practical application.[10]In the large storage system, the finite element division can be used for a certain space,and adopt appropriate optimization algorithm, determined the most suitable number and distribution of nodes.

6. Summary

At first, this paper analyzes the research background , purpose and significance, introduces the design of networking technology, wireless sensor technology, then studied the application of these technologies in the storage environment monitoring system, and make a comparison with the traditional warehousing environmental monitoring system, summed up the characteristics and advantages of networking storage environment monitoring system based on Internet of Things. Then analysis several major parameters which can impact storage environment, and their impact on the storage environment and the storage environment monitoring system for their monitoring and control based on the Internet of Things. Finally, prospect the development trend of the storage environment monitoring technology based on Internet of Things. From the traditional manual way of monitoring, storage environment monitoring system based on the wired way , to the change of storage environment monitoring system based on the wireless sensor network , from the status and development trend of research can be seen, wireless sensor network is in the initial stage, as a new research focus in the field of information, which is used in warehousing environmental monitoring potential is very large, the application range of warehousing environmental monitoring also will be used more widely.

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