Construction of monitoring system for pump, pressure vessel and pressure pipeline based on big data analysis

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ABSTRACT

The main goal of nondestructive testing (NDT) is to regularly test the pressure vessels in order to reduce the probability of failure accidents. On the basis of NDT, it can effectively avoid container breakage and ensure the safe use of containers. In the actual use process, we will face complex conditions, so we must attach great importance to the safety of container use. At present, there are still many problems in the inspection of pressure vessels and pipelines. Only by objectively understanding these problems can we better carry out the inspection of pressure vessels and pipelines and ensure the application safety of pressure vessels. This article takes NDT technology as the main research content, analyzes the combination of NDT and pressure vessel and pressure vessel management, and puts forward a fault detection algorithm for pumps, pressure vessels and pressure pipelines based on big data analysis. The simulation results show that the pressure equipment fault detection algorithm based on this algorithm is better than support vector machine (SVM) in time measurement accuracy and efficiency, and can accurately detect the equipment state and fault. Non-destructive testing technology has incomparable advantages over other technologies, but it also needs to constantly improve the application level to improve the work efficiency.

Keywords:Nondestructive testing; pressure vessel; pressure pipeline; big data

1. INTRODUCTION

Pressure pipeline is a kind of dangerous special equipment widely used in petrochemical enterprises. In the application of pressure pipelines and pressure vessels, their equipment is usually in a state of high pressure, high temperature and high load. Therefore, the quality of their equipment has an important impact on the safety and stability of applications, the life safety of relevant operators and the effective implementation of process technology [1]. Non-destructive testing technology can find defects in the interior and surface of materials or workpieces, measure the geometric features and dimensions of workpieces, and determine the internal composition, structure, physical properties and state of materials or workpieces [2]. In order to avoid the failure of pressure vessels and pressure pipes, it is need to inspect the equipment regularly. Non-destructive testing plays an important role in the use of pressure vessels and equipment. Non-destructive testing technology has effectively improved the automation degree of pressure vessels and pressure vessel management, and accelerated the growth of intelligent industry [3]. If you want to provide better service for modern society, you can't meet the current production and operation mode. Using NDT technology is an important symbol of pressure vessels and pressure vessel management and protection keeping pace with the times. It can effectively find the defects on the surface and inside of the specimen, and at the same time, it can effectively measure the size and other geometric characteristics of the specimen, so as to determine the physical properties and structural composition of the specimen [4].

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In the actual use process, we will face complex conditions, so we must attach great importance to the safety of container use. Therefore, it is of practical significance to deeply study and analyze the application of NDT technology in pressure vessels and pressure pipelines [5]. As the wall bearing of pressure vessel is under great pressure at any time, once an emergency such as leakage occurs, the pressure difference between the two sides of the wall will lead to the rapid flow of fluid to the low pressure, which will not only bring huge economic losses and energy waste, but also very likely lead to vicious accidents such as explosion [6]. The application of pressure pipes and pressure vessels in industry plays an important role in improving the quality of industrial production and ensuring the actual income of production enterprises [7]. For pressure vessels and pipelines, safety is the first priority. Its safety involves design, materials, manufacture, installation and use, etc. Among them, the inspection of pressure vessels and pipelines is also an important measure to ensure safety. At present, the better inspection method is ultrasonic inspection [8]. The existing positioning and detection technology usually needs manual intervention, with small detection range, long detection time and low detection accuracy, which can't meet the real-time requirements of large containers for positioning systems. This article takes NDT technology as the main research content, and puts forward the construction strategy of monitoring system for pumps, pressure vessels and pressure pipelines based on big data analysis.

2. METHODOLOGY

2.1 Application of NDT technology in pressure vessel and pipeline monitoring

Taking the crack detection of the inner wall of boiler and pressure vessel as an example, it is need to combine the conditions of existing detection equipment with the specifications, crack morphology, structure and shape of the workpiece to detect the stress cracks in the vessel. At the same time of NDT, the time of NDT should be selected correctly, according to the purpose of NDT, as well as the characteristics of equipment working conditions, materials and manufacturing processes. Therefore, it is very important to select the time of NDT correctly [9]. In the process of testing the pressure pipeline, the scientific and reasonable introduction of NDT technology can find out the defects of the pipeline raw materials, especially the cracks and inclusions in the pipeline materials, and also the defects in the pipeline manufacturing process. On this basis, the defects in actual use of pipelines can be detected, and the concrete conditions and cracks of pipeline corrosion can be mastered. When conducting NDT, the NDT method should not be blindly selected, but the most appropriate NDT method should be selected for NDT of pressure equipment.

All kinds of testing methods have their own characteristics, and they are not universally used in all workpiece testing and defect testing. The most appropriate NDT method should be selected according to the actual situation. When the pipeline is in a loaded state, cracks or openings will occur, so it can be detected in time by means of penetrant NDT technology, which provides necessary guarantee for the safety of pipeline operation. In all NDT, any NDT method can not replace other NDT methods, and any NDT method is not universal. Therefore, when conducting NDT, we should adopt as many testing methods as possible, and learn from each other's strong points to get more comprehensive defect information, so as to know more about the actual point [10]. The improvement and growth of technology is two-way. First, we should pay attention to the application of advanced technology in the process of pressure vessel and pressure vessel maintenance. In modern society, there are more and more demands for automation, so it also puts forward higher requirements for the growth of NDT technology. Only by continuously developing programming programs can NDT technology be applied more widely.

In the production application of pressure pipelines and pressure vessels, ultrasonic NDT technology is used in the quality inspection, which is a common NDT technology. In the implementation of NDT technology for pressure pipelines and pressure vessels, the quality testing of pressure pipelines and pressure vessels is mainly carried out by erecting ultrasonic transmitter, installing ultrasonic signal receiver, debugging testing software and installing some sensors. Ultrasonic NDT technology has the advantages of large thickness, high sensitivity, high speed and low cost, and can locate and quantify defects [11]. It has the advantages of strong applicability, high detection efficiency and safety, and is widely used in the quality detection of various pressure devices. Based on the analysis of the current application and development status of pressure pipelines and pressure vessels, magnetic particle NDT technology is a kind of commonly used NDT technology. According to the difference of magnetic powder media, NDT technology is usually divided into dry testing and wet testing. In the implementation of NDT technology, magnetic powder covers the testing component to magnetize it, and then the workpiece defects are detected according to the magnetic marks, and the defects are judged and evaluated.

2.2 Nondestructive monitoring algorithm for pumps, pressure vessels and pressure pipelines

It is of great significance to analyze the operation flow of NDT technology in pressure pipelines and pressure vessels and implement the planning and design of the operation flow for the improvement of testing quality and the accuracy of testing data. In the specific implementation, regarding the planning and design of the operation process, the testing operators should conduct research based on the structural status of the pressure device, the applied pressure of the pressure device and other parameters, as well as the application process technical parameters of related devices, and then formulate relevant operation processes and testing procedures based on the production parameters, process parameters and structural status of the device, and form standardized operation files [12]. In the implementation of testing technology, the security of testing media, the security of testing operation mode and the security of testing program are tested. In the specific detection operation, the adverse phenomena such as casualties and component damage caused by insufficient technical safety are avoided, and the safe and stable detection of the pressure device is ensured. The process of deep learning algorithm for nondestructive monitoring of pressure vessels and pipelines is shown in Figure 1.

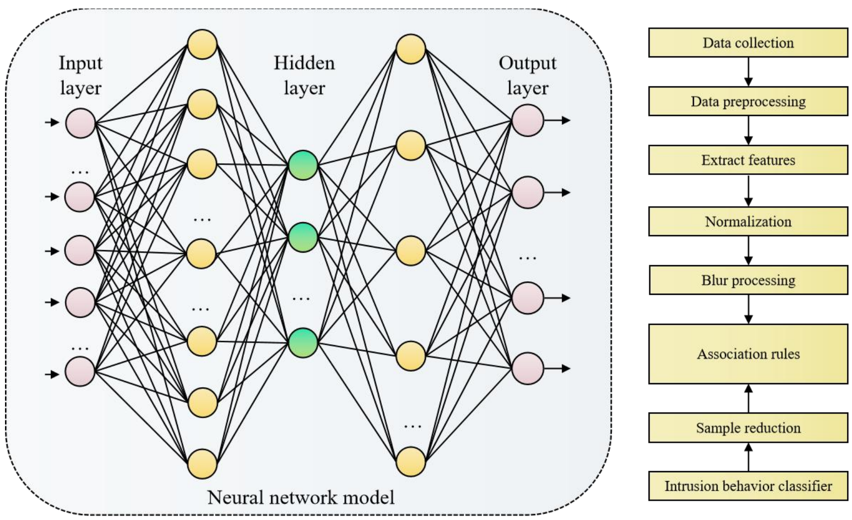

Figure 1. Flow of deep learning algorithm

From the perspective of safety control and inspection quality improvement, the application of NDT technology in pressure pipelines and pressure vessels should improve the professional skills of inspection workers. With regard to the improvement of professional skills of testing operators, the testing unit can carry out staff skills training in the form of team work, strengthen the introduction of talents, and improve the professional skills of personnel, so as to ensure the qualification of professional skills of testing operators. Let the eigenvector of sample x_i be expressed as $(a_{i1}, a_{i2}, a_{i3}, \ldots, a_{im})$. Then, the expectation and variance of each attribute in all sample points X are calculated respectively:

$$avg(X(a_i)) = \frac{1}{g_i}\sum_{j=1}^{g_i} a_{ji} \quad i = 1,2,\ldots,m \tag{1}$$

$$std(X(a_i)) = \sqrt{\frac{1}{g_i - 1}\sum_{j=1}^{g_i}(x_i(a_i) - avg(X(a_i)))^2} \quad i = 1,2,\ldots,m \tag{2}$$

Where $x_i(a_i)$ is the value of sample j on the a_i attribute. The formula will be dimensionless:

$$x_j(a_i) = \frac{x_i(a_i) - avg(X(a_i))}{std(X(a_i))} \tag{3}$$

The data obeys the normal distribution of $N(0,1)$, and the dimensions between attributes are removed.

When the pressure vessel and pipeline equipment fail, the signal energy near the fault location is relatively large, and the signal energy far away from the fault location is relatively small. Therefore, the fault feature can be extracted by changing the signal energy in the relevant frequency band:

$$E_{3\phi} = \int \left| S_{3j}(t) \right|^2 dt = \sum_{k=1}^{n} \left| x_{jk} \right|^2 \tag{4}$$

Where x_{jk} is the amplitude obtained after the signal S_{3j} of pressure vessel and pipeline equipment is reconstructed. As the failure of pressure vessel and pipeline equipment will change the signal energy in each frequency band, the signal energy change is used as the feature vector for reconstruction:

$$R = \left[E_0^{'}, E_1^{'}, \ldots, E_7^{'} \right] \tag{5}$$

When the fault is large, the signal energy in the relevant frequency band will also increase, which increases the amount of computation. Therefore, normalization is required:

$$I_j \frac{E_j^{'}}{\sqrt{\sum_{j=0}^{7} \left| E_j^{'} \right|^2}} \tag{6}$$

The normalized feature vectors of pressure vessel and pipeline equipment faults are described as follows:

$$I = \left[I_0, I_1, \ldots, I_7 \right] \tag{7}$$

From the perspective of operating efficiency and economic benefits of production enterprises, the application of NDT technology plays an important role in the improvement of production quality and the safe and stable application of pressure devices. In the implementation of NDT of pressure pipelines and pressure vessels, the quality of software and hardware of testing devices has great influence on the accuracy and perfection of testing data [13]. Therefore, in the actual operation, the debugging and maintenance of the software and hardware before the implementation of the testing operation is also the main points for attention in the operation implementation.

3. RESULT ANALYSIS AND DISCUSSION

In the field of electrical automation, the stability of technology is the most critical, which requires that the matching technical form should also pay attention to the development direction of stability. As a programmable automation program, NDT can avoid improper human operation. Therefore, the development prospect of NDT is to improve its anti-interference ability, so as to further promote the overall level of pressure vessels and pressure vessel management automation industry [14]. The principle of computer operation is to integrate and analyze a large amount of testing data, and pass the processed data model to the processor or provide it to engineers. Computer information processing technology can effectively improve the basic work of data, free people from heavy repetitive work, and effectively reduce the error rate, which plays an important role in improving work efficiency. The comparison results between the pressure equipment fault detection algorithm and SVM algorithm in this article are shown in Figure 2.

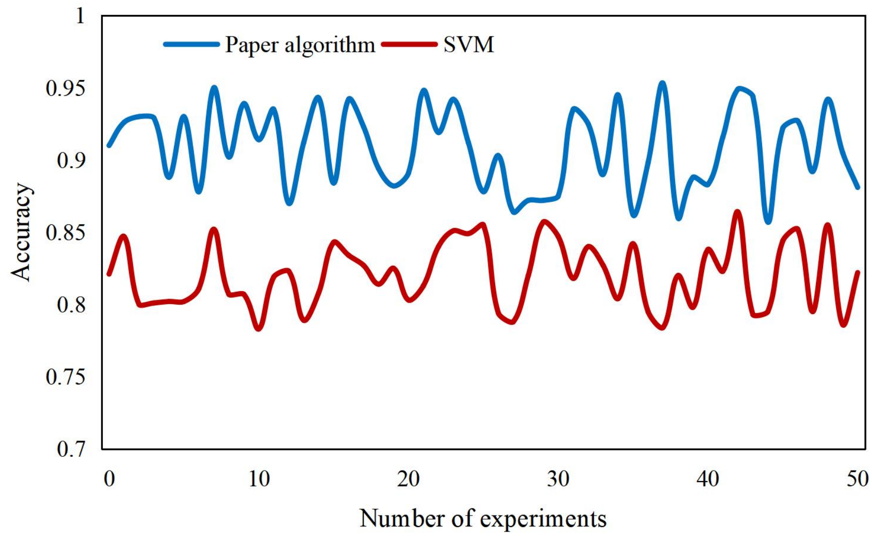

Figure 2. Accuracy comparison results

The results show that this method is more reasonable, feasible and scientific than the traditional SVM algorithm. Among many data signals, it is the task of signal processing technology to extract useful information. The comparison of the average absolute errors of the algorithms is shown in Figure 3.

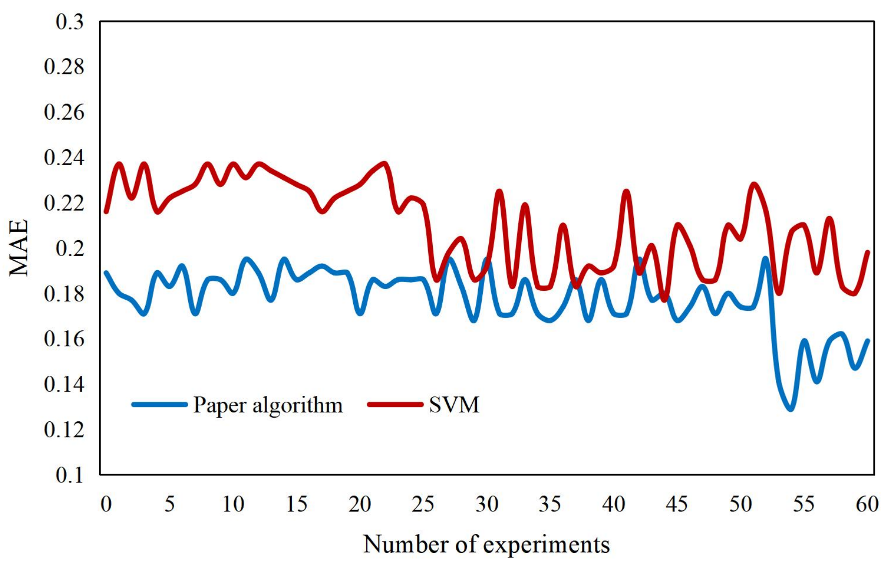

Figure 3. Comparison of average absolute error of algorithms

It can be seen that, compared with SVM algorithm, this method has obvious advantages in the later stage of operation, and the error is reduced by 28.77%. The fault diagnosis result of pressure equipment is determined by the threshold of fault residual, which can be used to describe the fault characteristics. The results of sample test using SVM algorithm are shown in Figure 4. The test results of the test samples using the algorithm in this article are shown in Figure 5.

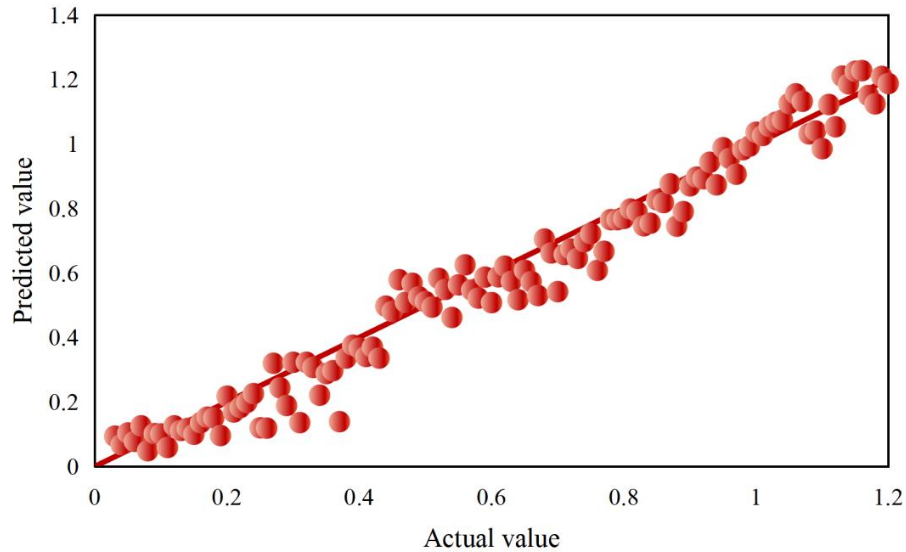

Figure 4. Scatter diagram of actual value and predicted value of SVM algorithm

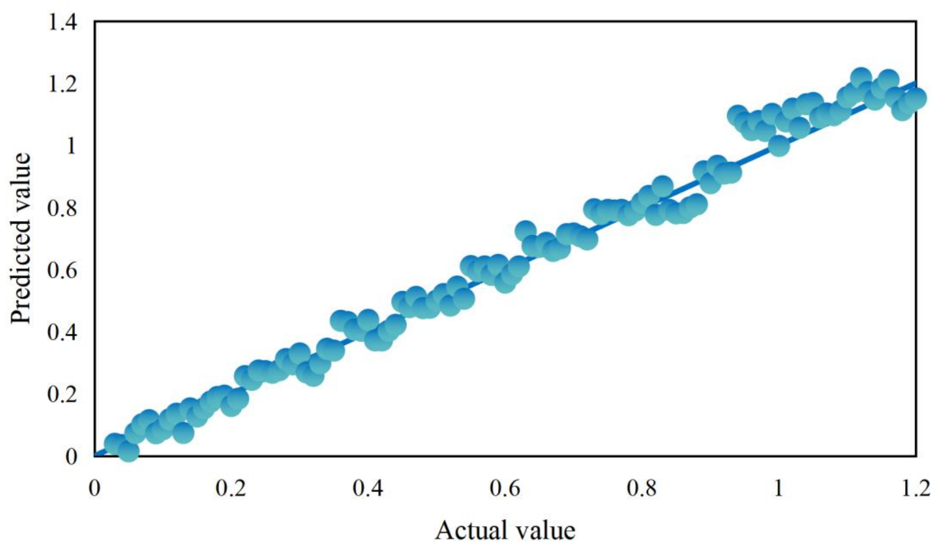

Figure 5. Scatter diagram of actual value and predicted value of the algorithm in this article

It can be analyzed that the pressure equipment fault detection algorithm based on the algorithm in this article is better than the SVM in time measurement accuracy and efficiency, and can accurately detect the equipment state and fault. The biggest advantage of on-line pressure monitoring and fault diagnosis technology is that it can judge the health degree of pressure equipment and diagnose the faults existing in the operation of pressure vessels and pipelines according to the monitored data. In different use time, carry out different inspection work contents, and judge the service life of pressure equipment by relying on a large amount of monitoring data, and make a reasonable replacement and maintenance plan. The implementation of software debugging is mainly from the aspects of software response speed and accuracy of software settings.

In the aspect of hardware debugging and maintenance, we mainly debug and maintain the electrical performance, operating sensitivity, running performance, processor performance and memory upgrade of the device, so as to ensure the rationality and effectiveness of NDT technology in the application of pressure pipeline and pressure vessel testing. It is need to continuously strengthen the deep integration of NDT technology and big data, and make it the focus of NDT technology development in the future, and make use of artificial intelligence and other related technical advantages to make up for the deficiency of NDT technology, so as to enhance the intelligence degree of NDT technology and make the pressure vessel and pressure vessel management and protection industry constantly improve and progress.

4. CONCLUSION

In the actual use process, we will face complex conditions, so we must attach great importance to the safety of container use. Therefore, it is of practical significance to deeply study and analyze the application of NDT technology in pressure vessels and pressure pipelines. The existing positioning and detection technology usually needs manual intervention, with small detection range, long detection time and low detection accuracy, which can't meet the real-time requirements of large containers for positioning systems. This article takes NDT technology as the main research content, analyzes the combination of NDT and pressure vessel and pressure vessel management, and puts forward a fault detection algorithm for pumps, pressure vessels and pressure pipelines based on big data analysis. The pressure equipment fault detection algorithm based on the algorithm in this article is better than SVM in time measurement accuracy and efficiency, and can accurately detect the equipment state and fault. Compared with SVM algorithm, this method has obvious advantages in the later stage of operation, and the error is reduced by 28.77%. In order to meet people's demand for high-rise buildings, the construction unit needs to start with the design and construction of Bear Building, closely combine the design and construction together, constantly improve the construction technology, and adopt advanced construction equipment to ensure the smooth progress of construction projects, so as to achieve the expected design goals.

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