Research on Computer Aided Test System for Sealing Characteristics of Hydraulic Support Pure Water Hydraulic Cylinder

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Abstract. The sealing characteristics of the hydraulic cylinder in the hydraulic support will have an momentous implication on the safety and reliability of the whole system. The traditional test methods of the sealing characteristics of hydraulic support pure water hydraulic cylinder have many shortcomings, such as single means, complex process, poor accuracy and low efficiency. Based on this, this paper first analyzes the sealing principle and function of hydraulic support pure water hydraulic cylinder, then studies the CAT system of hydraulic support, and finally gives the design and utilization process of CAT system for sealing characteristics of hydraulic support pure water hydraulic cylinder.

Keywords: Computer Aided Test, Sealing Characteristics, Hydraulic Support, Hydraulic Cylinder

1. Introduction

With the iterative progress of computer tech, especially its significant advantages in computing power, flexibility and control accuracy, it has achieved remarkable utilization results in many fields. Specifically, in the field of mechanical component testing, the utilization of computer-aided tech can quickly and accurately deal with complex testing needs, and meet diversified and personalized testing needs. Pure water hydraulic system has the typical characteristics of being friendly to the environment, so it has been deeply applied in many fields [1]. The sealing characteristics of the hydraulic cylinder in the hydraulic support will have a momentous implication on the safety and reliability of the whole system. It is necessary to carry out a variety of tests on its sealing accomplishment, including durability, reliability, stability and so on.

The traditional test method for the sealing characteristics of hydraulic support pure water hydraulic cylinder has many shortcomings, such as single means, complex process, poor accuracy and low efficiency, which have great room for amelioration and necessity. As the key guarantee for the normal operation of hydraulic support, the sealing accomplishment of hydraulic support includes dynamic seal and static seal. Especially for the test of dynamic seal structure system, the utilization of Computer Aided Test (CAT) system can significantly ensure the rationality, scientificity and feasibility of the whole test design. In addition to the data recording function, the sealing characteristic test system of
hydraulic support pure water hydraulic cylinder should also have the ability of continuous test, regular test and continuous display, which puts forward higher demands for the design and ability of the test system.

As an interdisciplinary and interdisciplinay comprehensive discipline, hydraulic CAT involves many aspects as shown in Figure 1 below. The system effectively collects and analyzes test data with the help of computer tech to realize quantitative processing and output of test parameters. The hydraulic CAT system can also monitor the sealing characteristic test process of hydraulic cylinder in real time, so as to meet the test demands of high efficiency and high precision [2]. The computer aided test system significantly ameliorates the shortcomings of traditional test methods and methods, and provides a comprehensive and intelligent scheme for the test of the sealing characteristics of hydraulic support pure water hydraulic cylinder. The test of the sealing characteristics of hydraulic support pure water hydraulic cylinder can automatically complete the whole test process under the control of computer, which significantly reduces the dependence on manual participation, so as to ensure the objectivity and rationality of the test process.

In short, the sealing accomplishment of hydraulic support pure water hydraulic cylinder will not only implicate the stability of the whole hydraulic system, but also often have an momentous implication on the safe operation of higher-level system [3]. The pure water medium hydraulic support has higher demands for the sealing of the piston rod of the hydraulic cylinder, and it is very necessary to test the sealing accomplishment of the pure-water hydraulic support. The progress of computer tech drives the maturity of pure-water hydraulic CAT system, and realizes the automation and intelligence of parameter test and data acquisition. Therefore, the cat system for studying the sealing characteristics of hydraulic support pure water hydraulic cylinder has momentous practical value.

![Figure 1. Disciplines involved in hydraulic CAT system](image)

2. Sealing principle and function of hydraulic support pure water hydraulic cylinder

2.1. Principle of hydraulic support

Hydraulic support is a support equipment which is powered by high-pressure liquid and composed of hydraulic cylinder, hydraulic control valve and some metal structural parts. It makes the support of the support, top cutting, frame moving and conveyor moving all realize mechanization. Generally speaking, the hydraulic support will form an organic whole with other mechanical systems to realize the comprehensive function of the system. The main actions of the hydraulic support include frame lifting, frame lowering, moving conveyor and frame moving [4]. These actions are completed by using the high-pressure liquid provided by the hydraulic pump station to control the hydraulic cylinders with different functions through the hydraulic control system. The hydraulic pipeline of each support is connected in parallel with the main pipeline of the working face to form their own independent hydraulic system, in which the hydraulic control check valve and safety valve are set in this support, and the control valve can be set in this support or adjacent support.
2.2. Functional structure of hydraulic support pure water hydraulic cylinder

The pure water hydraulic cylinder system of hydraulic support can be divided into bearing structural parts, hydraulic cylinders, control components and auxiliary devices according to the functions and functions of various components. Among them, the bearing structure is responsible for bearing the load of roof and collapsed rock. The main function of the hydraulic cylinder is to realize various actions of the support through hydraulic power. The main function of the control component is to operate and control the action and working characteristics of each hydraulic cylinder of the support [5]. In addition, auxiliary devices, such as pushing devices, are necessary to realize some actions or functions of the support. When the hydraulic support works below the rated working resistance, it has resistance increasing property to ensure the effective support of the support to the roof. The resistance increase of hydraulic support mainly depends on the sealing accomplishment of hydraulic control check valve and column, and the constant resistance and compressibility are mainly realized by safety valve.

3. Computer aided test system for hydraulic support

3.1. Functional concept of computer aided test system

Hydraulic CAT system is usually composed of microprocessor, single chip microcomputer, and computer and so on. By capitalizing on the software, hardware and cyber resources of the computer system, we can expand the function of the test system and ameliorate the performance of the test system [6]. The main functions of hydraulic CAT system include intelligent instrument, automatic measurement and control system, virtual instrument and cyber of measurement and control system. Secondly, the data acquisition process of CAT system converts continuous analog voltage signals into discrete digital signals, which retain the useful info contained in the original analog signals. The data acquisition system of CAT system includes single channel and multi-channel. The multi-channel type can be divided into independent type, general type and synchronous type. The architecture of multi-channel independent data acquisition system is shown in Figure 2 below.

![Figure 2. Architecture of multi-channel independent data acquisition system](image)

3.2. Utilization value of CAT system for hydraulic support

As an momentous development trend of test system under the background of informatization, hydraulic support CAT system is not only convenient to realize closed-loop control, but also can correct the system error, process and analyze the signal through software, and even use software to replace some functions of hardware. The core of hydraulic support CAT system is data acquisition and analog signal conversion output, and their cores are A/D converter and D/A converter respectively [7]. Processing and analyzing the collected digital signals through computer software can greatly
ameliore the ability of the system to obtain info. In addition, in addition to programming by ourselves, the hardware of the test system can be greatly reduced by using the data processing and analysis functions provided by the virtual instrument development platform. It can be seen that the hydraulic support CAT system has the utilization value of easy development, low cost, friendly operation interface and so on.

3.3. Digital signal processing of CAT system for hydraulic support

The main purpose of digital signal processing in cat system is to make the processed digital signal truly reflect the sealing characteristic state of hydraulic cylinder and minimize various measurement conversion errors. The main purpose of digital signal analysis is to reasonably extract the sealing characteristics of hydraulic support pure water hydraulic cylinder from digital signal [8]. Secondly, the digital signal analysis of CAT system includes spectrum analysis, correlation analysis and other different methods. Among them, spectral analysis transforms the time-domain dynamic signal into the frequency domain through Fourier transform, and its mathematical basis is Fourier transform, as shown in Formula 1 below.

\[
\begin{align*}
X(k) &= \sum_{n=0}^{N-1} x(n)e^{-j2\pi nk/N}, \\
x(n) &= \frac{1}{N} \sum_{k=0}^{N-1} X(k)e^{j2\pi nk/N}
\end{align*}
\]  

(1)

The correlation analysis method of CAT system uses the definition of correlation function for calculation and analysis. The cross-correlation function is shown in equation 2 below.

\[
\hat{R}_{xy}(\tau = rT_s) = \frac{1}{N-r} \sum_{n=0}^{N-1-r} x(n)y(n+r)
\]

(2)

4. CAT system for sealing characteristics of hydraulic support pure water hydraulic cylinder

4.1. Sealing technical characteristics of hydraulic support pure water hydraulic cylinder

The structure of the hydraulic support pure water hydraulic cylinder will change with the change of the seal ring structure, the arrangement of the guide ring, and the connection form between the guide sleeve and the cylinder port. The reliability of hydraulic support pure water hydraulic cylinder seal is an momentous premise to ensure the reliability of support system [9]. At present, the seal forms of hydraulic support pure water hydraulic cylinder include drum seal, mountain full seal, and composite seal ring and so on. Among them, the drum seal ring can be sealed in both directions, which simplify the structure of the piston and shorten the length of the piston. However, due to its large size section, it is not suitable for the piston seal of double telescopic columns. The seal failure of hydraulic support pure water hydraulic cylinder is mainly caused by long-term wear and tear, resulting in leakage or material aging and hydrolysis.

4.2. Realization of CAT system for sealing hydraulic support pure water hydraulic cylinder

Firstly, at the realization level of cat hardware system for the sealing characteristics of hydraulic support pure water hydraulic cylinder, the hardware of the test system is mainly composed of industrial computer, data sensor, data acquisition card and conditioning circuit [10]. As the core component of hydraulic CAT system, industrial computer is responsible for the control of the whole test process, analysis and display of collected data, info communication and so on. Cat test bench is composed of hydraulic, electrical, data acquisition and processing system, loading frame and other functional modules. Secondly, the cat software system for the sealing characteristics of hydraulic support pure water hydraulic cylinder is responsible for the pressure data acquisition and processing, and the test data is formed according to the test process and stored in the computer.
In addition, during the operation of the pure-water hydraulic cylinder sealing CAT system of the hydraulic support, the computer control system is controlled. The hydraulic system is responsible for supplying energy to the system, providing the pressure and flow of various valve elements, and data acquisition is carried out by each group of sensors, so as to meet the sealing accomplishment test and contact stress acquisition test of the seals of the pure-water hydraulic cylinder of the hydraulic support. The implementation contents of cat test items include sealing test, no-load sealing test, strength test, loading stroke test, contact pressure curve acquisition test, etc. Finally, the test data are fitted to provide the test data basis for the design optimization of pure-water seals.

5. Conclusion
In summary, the hydraulic CAT system can also monitor the sealing characteristic test process of hydraulic cylinder in real time, so as to meet the test demands of high efficiency and high precision. With the help of computer tech, the test data are collected and analyzed efficiently to realize the quantitative processing and output of test parameters. This paper studies the functional structure of hydraulic support pure-water hydraulic cylinder by analyzing the sealing principle and function of hydraulic support pure-water hydraulic cylinder. Through the research on the CAT system of hydraulic support, the utilization value of CAT system of hydraulic support and the implementation strategy of seal CAT system of hydraulic support pure-water hydraulic cylinder are analyzed.

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Research and Application on sealing characteristics of pure water hydraulic cylinder of hydraulic support.

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