# Research on Processing, Quality Control Technology and Application of Hydraulic Cylinder in Intelligent Agricultural Machinery

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**Abstract:** As a key component in agricultural machinery, the processing technology and quality control of hydraulic cylinders have a significant impact on the performance and lifespan of agricultural machinery. This article aims to explore the processing and quality control technology of hydraulic cylinders in intelligent agricultural machinery, as well as their application research in different agricultural machinery. Firstly, the precision machining technology of hydraulic cylinders is introduced. Secondly, the quality control technology of hydraulic cylinders is elaborated, including the establishment of quality control system, online monitoring and non-destructive testing technology. Finally, the application of hydraulic cylinders in intelligent agricultural machinery is discussed, especially in the hydraulic drive of harvesters and the hydraulic control of planting and fertilization machinery, demonstrating the important role of hydraulic cylinders in improving the intelligence level of agricultural machinery.

***Keywords*:** intelligent agricultural machinery; hydraulic cylinder; processing technology; processing technology; application

## 1. Introduction

With the rapid development of modern agricultural technology, intelligent agricultural machinery has become a key factor in improving agricultural production efficiency and quality. As an important transmission component in agricultural machinery, the stability and reliability of hydraulic cylinders directly affect the efficiency and lifespan of the machinery. This article aims to explore the processing technology and quality control technology of hydraulic cylinders in intelligent agricultural machinery, as well as their applications in different agricultural machinery, in order to provide reference for the research and improvement of intelligent agricultural machinery.

## 2. Precision machining technology for hydraulic cylinders

### 2.1 Processing technology of cylinder barrel

As the main load-bearing component of hydraulic cylinders, the accuracy and surface quality of the cylinder directly affect the performance and service life of the hydraulic system. The cylinder barrel is usually made of high-quality carbon steel or alloy steel through pre-treatment steps such as cutting, forging, and heat treatment to ensure the mechanical properties and processability of the material. In the actual processing, honing or rolling technology is often used for the inner hole of the cylinder to achieve high-precision surface roughness with Ra value below 0.4 μ m, which helps reduce hydraulic resistance and improve work efficiency. In addition, the control of cylinder straightness and cylindricity is also a key point. The straightness of the cylinder barrel is required to be controlled within 0.01mm/m to ensure the smoothness of the piston during reciprocating motion and prevent abnormal wear or hydraulic impact caused by shape errors[1]. After processing, the inner surface of the cylinder is usually subjected to anti-corrosion treatment, such as chrome plating or nitriding, to enhance wear resistance and corrosion resistance, and extend the service life of the hydraulic cylinder.

### 2.2 Manufacturing process of piston rod

Firstly, the piston rod is usually made of high-strength, low-alloy steel, such as 45 # steel or better materials, to ensure stability under high pressure and high load. In the material pretreatment stage, strict heat treatment such as quenching and tempering will be carried out to achieve the desired hardness and toughness. This step may require precise temperature and time control to comply with ASTM A29 or similar industry standards. Next, precision machining of the piston rod is the key step. By precision turning or grinding processes, the diameter accuracy of the piston rod is controlled at the micrometer level to reduce friction with the cylinder and improve the smoothness of motion. For example, it may be necessary to control the roundness error within 0.005mm to ensure that the piston rod maintains minimal resistance during reciprocating motion. In addition, the surface of the piston rod also needs to be hardened, such as nitriding or chrome plating, to improve wear

resistance and corrosion resistance, and extend its service life. The control of surface roughness is also crucial in the manufacturing process of piston rods. According to the ISO3279 standard, the surface roughness of the piston rod should be lower than Ra0.4 μ m to reduce hydraulic oil leakage and the generation of wear particles. At the same time, in order to ensure the dynamic performance of the piston rod during operation, precision measuring equipment such as laser interferometers may be required to strictly detect the straightness and cylindricity of the piston rod, ensuring its stable operation under complex working conditions.

# 3. Quality control technology for hydraulic cylinders

## 3.1 Establishment of Quality Control System

The establishment of a quality control system is a key link in ensuring stable and reliable product performance during the production process of hydraulic cylinders. This system should cover the entire process from raw material entry to finished product exit, including multiple stages such as incoming inspection, process control, final inspection, and continuous improvement. In the incoming inspection stage, strict quality control is carried out on key raw materials such as steel and seals, such as using ultrasonic testing equipment to inspect internal defects in cylinder materials, to ensure that the mechanical properties of the materials meet the design requirements. At the same time, regular evaluations of suppliers are conducted to ensure the stability of the supply chain. In process control, statistical process control (SPC) tools are used to monitor key machining parameters such as cutting speed and feed rate in real-time. Once abnormal fluctuations are detected, corrective measures are taken immediately. In addition, computer simulation analysis such as finite element analysis is used to predict and optimize the stress distribution of hydraulic cylinders, preventing performance degradation caused by small deviations in the manufacturing process. In the final inspection stage, in addition to routine dimensional checks, functional tests such as pressure resistance tests and sealing performance tests are also required to ensure the long-term stable operation of the hydraulic cylinder under actual working conditions. For example, pressure and motion tests higher than standard operating conditions can be set to verify its durability under extreme conditions.

## 3.2 Online monitoring and non-destructive testing technology

### 3.2.1 Surface roughness detection

In the quality control technology of hydraulic cylinders, surface roughness detection is a crucial step. The surface roughness directly affects the working efficiency and service life of hydraulic cylinders. The surface roughness of the cylinder and piston rod is too high, which may lead to premature wear of seals, increase hydraulic system leakage, and thus reduce the working performance of agricultural machinery (such as tractor traction or harvester cutting speed). On the contrary, if the surface is too smooth, it may increase frictional resistance and affect the smoothness of motion. Therefore, strict surface roughness parameters such as Ra value are usually set according to relevant standards (such as ISO4782 or GB/T3327) to ensure that they are between 0.2 and 0.8 micrometers. In actual production, optical interferometers, stylus surface roughness measuring instruments and other tools can be used for precise measurement, and the processing technology can be optimized through data analysis to ensure the high quality standards of hydraulic cylinders[2].

### 3.2.2 Stress and fatigue analysis

Stress and fatigue analysis are crucial steps in the quality control of hydraulic cylinders. Hydraulic cylinders in intelligent agricultural machinery are subjected to repeated mechanical loads, such as the digging action of tractors and the vibration of harvesters, which may lead to fatigue cracks in the cylinder body and accessories. Finite element analysis (FEA) can predict and evaluate the stress distribution of hydraulic cylinders under complex operating conditions to ensure their safe operation within their design life. For example, it is possible to simulate 200000 working cycles and analyze stress concentration areas, such as the connection between the piston rod and the cylinder barrel, to reduce the risk of failure caused by overload.

# 4. The application of hydraulic cylinders in different agricultural machinery

## 4.1 Hydraulic drive of harvester

In intelligent agricultural machinery, hydraulic cylinders play a crucial role, especially in the hydraulic drive system of harvesters. The efficient operation of the harvester relies on precise control of the hydraulic system to achieve fast and smooth adjustment of the harvesting tools. Hydraulic cylinders can provide strong linear thrust, enabling harvesters to maintain stable performance in various complex terrains and crop conditions. For example, an advanced combine harvester may require the hydraulic cylinder to adjust the tool height within seconds to adapt to changes in field height of 0.5 meters,

which places extremely high demands on the response speed and control accuracy of the hydraulic cylinder. In practical applications, the performance of hydraulic cylinders directly affects the operational efficiency and energy consumption of harvesters. By optimizing the design, such as using high-strength lightweight materials to improve the dynamic response of the hydraulic cylinder, the energy consumption of the harvester can be further reduced. At the same time, combined with intelligent sensors and control algorithms, hydraulic cylinders can achieve adaptive adjustment of workloads, ensuring optimal cutting effects under different crop densities, thereby increasing the harvesting area per unit time and reducing agricultural production costs.

### 4.2 Hydraulic Control of Planting and Fertilization Machinery

In intelligent agricultural machinery, hydraulic cylinders play a crucial role, especially in the hydraulic control systems of planting and fertilizing machinery. Hydraulic cylinders can provide precise and adjustable thrust, ensuring consistency in planting depth and precise control of fertilizer application. For example, by designing advanced hydraulic control systems, the error of planting depth can be controlled within ± 5cm, greatly improving the accuracy and efficiency of planting operations[3]. In addition, the dynamic response characteristics of hydraulic cylinders make them equally outstanding in fertilization machinery. By integrating with sensors and control systems, hydraulic cylinders can accurately control the opening and closing of fertilizer nozzles, as well as the speed of fertilization, ensuring that fertilizers are evenly distributed in the field, reducing fertilizer waste, and minimizing potential impact on the environment.

## 5. Conclusion

In summary, with the advancement of technology and the development of intelligence, research on the processing, quality control technology, and application of hydraulic cylinders in intelligent agricultural machinery is gradually deepening. Through continuous technological innovation and optimization, the performance and reliability of hydraulic cylinders have been significantly improved, providing strong guarantees for the efficient and stable operation of intelligent agricultural machinery. In the future, with the further development of intelligent technology, the application of hydraulic cylinders in intelligent agricultural machinery will be more extensive, bringing more convenience and benefits to agricultural production.

## References


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