DISASSEMBLING PROCESS AND TECHNOLOGY OF AXIAL PISTON PUMP FOR REMANUFACTURING

Kelun Yan, Tong Liu, Huixian Han*
Hunan Mechanical and Electrical Polytechnic, Changsha, 410151, China.
*[1]*Corresponding author: Kelun Yan*
Email: yankelunmpcs@163.com

Abstract - In response to the "circular economy" policy of the green environmental protection industry, the remanufacturing of axial piston pumps has been studied in depth. Firstly, the structure and working principle of each component of the axial piston pump are deeply studied, and then each component of the piston pump is regarded as an independent part, the contact and spatial relationship between the components are analysed. The disassembling specifications of remanufacturing must be strictly observed, and the principles of stability, safety and independence must be adhered to. Secondly, the spatial position of each component and the constraint relationship between adjacent components are studied in turn. The constraint matrix is established from the two aspects of space and contact, and the model of the disassembling device is designed according to the principle of priority and stability in the disassembling process. Then a complete disassembling process and the system are built, and the internal cycle procedure of the disassembling device is designed. Finally, through the simulation experiment and analysis of the virtual model of the disassembling device, the feasibility of the design scheme is verified by taking the former pump as an example. The results show that the disassembling effect of the disassembling device is all qualified and all parts are not damaged. It meets the requirements of stability, safety and independence, and the disassembly of various models and parts, which has the advantage of batch operation and can improve the disassembling efficiency and quality. It is ensured that the produced products meet the standard quality and can reduce the manufacturing cost and time, and save natural resources. Therefore, the disassembling device of the axial piston pump will be of great significance.

Keywords: Remanufacturing, Axial piston pump, Design of the disassembling device, Disassembling process.

1. Introduction

Currently, the world is in a period of rapid development of urbanization and industrialization. The level of manufacturing represents the economic growth of a country, and the advanced degree of manufacturing is also an important judgment of national assets. Reasonable and scientific remanufacturing is a manufacturing method of recycling, disassembling and reprocessing waste machinery under the concept of environmental protection and adhering to the principle of harmonious coexistence between man and nature. It can ensure the quality of the products produced meet the standards and can reduce the manufacturing cost [1], while reducing the manufacturing time, and saving natural resources. So the world is currently vigorously advocating waste recycling and reuse.

Nowadays, the manufacturing level of piston pumps in various countries has reached the level of high-volume production. In the ranking of machinery manufacturing in the global companies, Caterpillar of the United States and Komatsu of Japan are still firmly in the first and second places, except for these two giants, the Asian market share has reached 52.4%. Some researchers have found that the concept of "remanufacturing" has been evolving in recent years. According to the historical situation in the past five years (2016-2020), the overall scale of the global high-pressure piston pump in the past few years, the scale of major regions, the scale and share of major enterprises, the scale of major product categories, and the scale of major downstream applications, etc. are studied. The scale analysis includes sales, price, revenue, market share, and others.

According to reports, the revenue of the global high-pressure piston pump in 2020 is about 2789.5 million dollars, and it is expected to reach 3206.1 million dollars in 2026 [2], with a compound annual growth rate of 3.5% from 2021 to 2026. However, the working conditions of various types of construction machinery are different, and they are

generally poor. The number of damages and failures during service is large, and their parts are prone to corrosion, wear, and breakage. Therefore, the remanufacturing and recycling of the piston pump has a certain social and economic benefit. So the research and design of the disassembling device of the axial piston pump will be of great significance.

2. Disassembling Process and Technology of Axial Piston Pump under the Principle of Environmental Protection

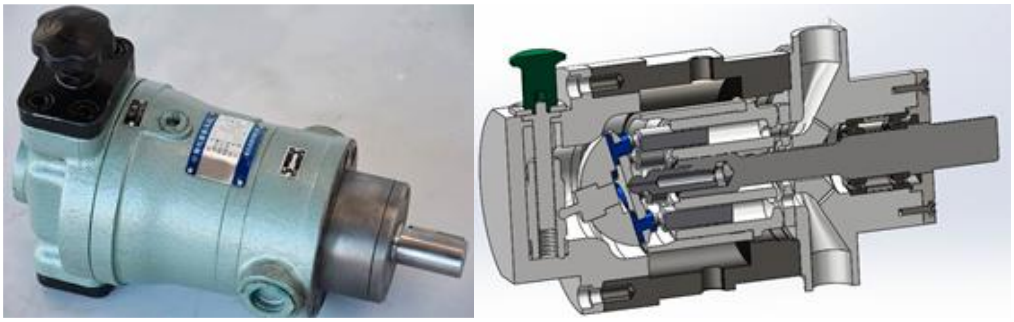
2.1 The structure and Working Principle of each Component of Axial Piston Pump

The piston pump is a mechanical device powered by hydraulic pressure.

Because the structure of power is hydraulic, the piston pump is in a state of high pressure, large displacement and strong sealing when it is working. Its operating power is low-load and relatively energy-saving, and its weight is light and easy to handle. Simultaneously, it is not easy to be damaged and has a relatively long service life, so it can be used in many large-scale projects. A piston pump is a complex machine, the internal mechanism is very sophisticated and complex, and the parts are many and expensive.

The axial piston pump is one of the most commonly used types of piston pumps in the industry. Its components are very sensitive to oil pollution in the use environment, so it needs frequent cleaning and maintenance in daily use, which requires high maintenance technology.

The appearance and partial section of the swash plate axial piston pump are shown in Figure 1.



(a) (b)

Figure 1: The appearance and partial section of the swash plate axial piston pump (a: appearance; b: part sectional)

Figure 1 shows that the swash plate axial piston pump is composed of parts such as a drive shaft, a flange plate, a cylinder block, a pump casing, a return plate, a variable head, a constant pressure valve, a spring, a dial, a variable piston, a variable subject, piston, swash plate, slipper, distribution device, etc. Its drive shaft and the cylinder block are on the same center line. The swash plate and the distribution device of the axial piston pump are fixed. There is a certain angle between the cylinder block and the axis of the swash plate. The internal structure of the swash plate axial piston pump is shown in Figure 2.

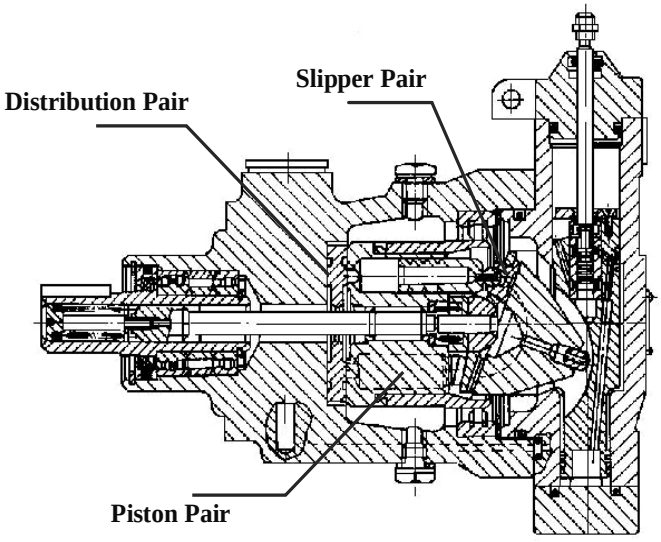


Figure 2: The internal structure of the swash plate axial piston pump

When the axial piston pump is working, the motor drives the drive shaft and the cylinder to start to rotate, and the piston starts to operate. The piston of the swash plate piston pump has four pairs of friction pairs, which reciprocate at the same time, and the volume of the cavity of the sealed part between each piston and the cylinder block will change. When the angle between the axis of the cylinder block and the swash plate is between 1°~20° [3], there is displacement, but when the angle between the axis of the cylinder block and the swash plate is zero, the piston does not move, not absorb oil, and the displacement is zero.

Since the piston pump has three pairs of pistons for friction during operation, a certain high temperature will be generated, which will reduce the working efficiency of the piston pump and generate a large amount of liquid oil that is blocked in the piston hole. When working for a long time, the liquid oil condensed dust and waste chips will form solid oil particles, which will adhere to the surface and cause friction and eventually cause parts to be scratched. It will make the piston pump work less smoothly and generate more waste [4], which will eventually cause more serious overall performance degradation.

In addition, if the center return plate is severely worn or cracked, it will cause the piston to be pulled or burned, stuck or broken, and even the piston and the cylinder block will not work. The technical requirements for the mechanical manufacturing of the piston pump are very high, and the materials are very expensive, so the disassembly and inspection of the waste machinery and the reuse and remanufacturing are of great significance.

2.2 Disassembling Process and Disassembling Principle of Axial Piston Pump

The machinery used in the project is currently the priority for the reuse of old machinery, because it is more environmentally friendly and can meet the needs of sustainable development. Reasonable and scientific remanufacturing adheres to the principle of harmonious coexistence between man and nature, and is a manufacturing method of recycling, disassembling and reprocessing waste machinery. It can ensure that the produced products meet the standard quality and can reduce manufacturing costs and manufacturing time, so it is currently vigorously advocating waste recycling, mechanical remanufacturing and other processes.

The core process of mechanical remanufacturing is shown in Figure 3.

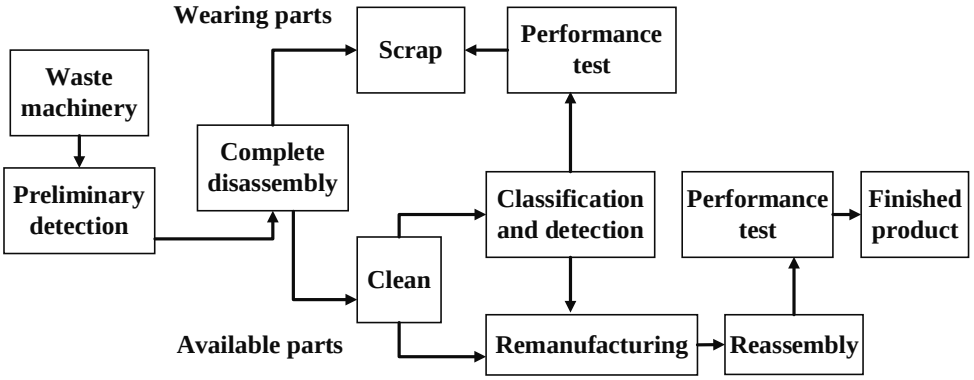


Figure 3: The core process of mechanical remanufacturing

The figure involves the key processes and steps of the remanufacturing process of mechanical products. All remanufacturing is based on the disassembly of old machinery, so the disassembling method, the disassembling technology and the disassembling process are very important [5]. Remanufacturing disassembly refers to the disassembly of used and scrapped mechanical products into individual parts and components according to certain rules and sequences. In the process of disassembly, it is ensured that there is no secondary damage to the components as much as possible, so that the subsequent re-manufacturing can be carried out.

Firstly, the original machinery can be disassembled before entering into the secondary utilization manufacturing process, so the disassembling steps of the axial piston pump have become the key research content. The disassembling process and standards also have certain requirements [6]. During the disassembling process, it is necessary to dismantle in the original loading direction, and establish a constraint equation according to the standard direction, which can ensure that the disassembled parts are unobstructed and unconstrained in space. The basic requirement of disassembly is to avoid secondary damage to the parts as much as possible, and the parts to be disassembled and other parts are not damaged [7]. Combined with the disassembling principle of the piston pump, the relationship between the parts will be analysed, and a constraint matrix will be

established to judge the impact of each disassembling step on this part and other parts. The stability and safety of each disassembling step are calculated. After designing the program, expand the program to a mode that can be operated in batches, and can meet the disassembly of various models and components, to improve the efficiency and quality of disassembling.

2.3 Model Design of the Disassembling Device for Axial Piston Pump

The components of the axial piston pump are classified and the direction in which each part is disassembled is pre-set [8].

The specific classification and disassembling direction of the parts are shown in Table 1.

Table 1: The specific classification of the parts and the setting of disassembling direction

	Classification	x	y
Front adjuster	/	/	+y
Screw 1	Connectors	-x	/
Front drive shaft and Bearing components	Bushing type	-x	/
Front sealing cover	Bushing type	-x	/
Front pump cover	Bushing type	-x	/
Long hexagon bolt 1	Connectors	-x	/
Front pump body	Bushing type	-x	/
Front swash plate	Bushing type	-x	/
Front cylinder block and piston components	Bushing type	+x	/
Front oil pan	Bushing type	-x	/
Intermediate pump body	Basic components	/	/
Rear oil pan	Bushing type	-x	/
Rear cylinder block and piston components	Bushing type	-x	/
Rear pump body	Bushing type	+x	/
Rear swash plate	Bushing type	+x	/
Long hexagon bolt 2	Connectors	+x	/
Rear pump cover	Bushing type	+x	/
Rear sealing cover	Bushing type	+x	/
Rear drive shaft and bearing components	Bushing type	-x	/
Screw 2	Connectors	+x	/
Rear adjuster	/	/	+y

According to Table 1, the space constraint matrix Q about the components of the piston pump can be established, as shown in equation (1).

The constraint matrix M for judging whether to contact is shown in equation (2).

$$Q = \begin{bmatrix}
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&1&1&1&0&1&1&1&1&0&0&0&0&0&0&0&0&0&0\\
0&1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&1&1&1&0&1&1&1&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&1&1&0&1&1&0&1&0&0&0&0&0&0&0&0&0&0\\
0&0&1&0&1&1&1&0&0&0&1&0&0&0&0&0&0&0&0&0&0\\
0&0&1&0&1&1&1&0&0&0&1&0&0&0&0&0&0&0&0&0&0\\
0&0&1&0&0&1&1&0&0&0&1&0&0&0&0&0&1&0&0&0&0\\
0&0&1&0&0&1&1&0&0&0&0&0&0&0&0&0&1&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&1&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&1&1&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&1&1&0&0&0&1&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&1&1&0&1&1&1&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&1&1&0&0&0&1&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&1&0&0&1&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&1&1&1&1&1&1&1&0&1&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0
\end{bmatrix} \quad (1)$$

$$M=\begin{bmatrix}
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&1&1&1&0&1&1&1&1&0&0&0&0&0&0&0&0&0&0\\
0&1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&1&1&1&0&1&1&1&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&1&1&0&1&1&0&1&0&0&0&0&0&0&0&0&0&0\\
0&0&1&0&1&1&1&0&0&0&1&0&0&0&0&0&0&0&0&0&0\\
0&0&1&0&1&1&1&0&0&0&1&0&0&0&0&0&0&0&0&0&0\\
0&0&1&0&0&1&1&0&0&0&1&0&0&0&0&0&1&0&0&0&0\\
0&0&1&0&0&1&1&0&0&0&0&0&0&0&0&0&1&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&1&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&1&1&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&1&1&0&0&0&1&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&1&1&0&1&1&1&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&1&1&0&0&0&1&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&1&0&0&1&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&1&1&1&1&1&1&1&0&1&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0
\end{bmatrix} \quad (2)$$

Equation (3) can be obtained by analyzing equations (1) and (2).

$$|QR_1|=|QR_2|=|QR_6|=|QR_{16}|=|QR_{20}|=|QR_{21}|=0 \quad (3)$$

After matrix and equation calculation, it can be obtained that the components that can be disassembled in the first step are the front adjuster, screws 1 and 2, long hexagon bolts 1 and 2, and the rear adjuster, while the front and rear adjusters are not the body parts of the piston pump [9], so be the first to disassemble.

Besides, since screws 1 and 2 are slightly higher than the rest of the parts, they should be removed next [10]. The simulation diagram of the specific disassembly situation of the first step is shown in Figure 4.

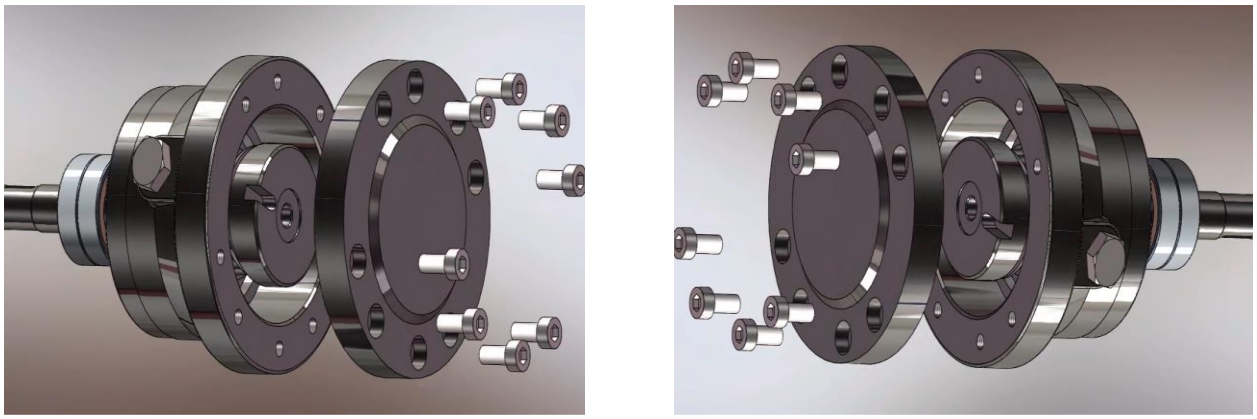
(a) (b)

Figure 4: The simulation diagram of the specific disassembly situation of the first step (a: disassemble the long hexagon screw 1; b: disassemble the long hexagon screw 2)

Since the front and rear adjusters are not the body parts of the piston pump, they are not shown in the figure, and the screws are small connecting parts, so they are not shown.

Therefore, the disassembly sequence of the first step is: front adjuster - screw 1 - long hexagon bolt 1 - long hexagon screw 2 - screw 2 - rear adjuster.

After the first disassembly step is completed, the previous constraint matrix Q and constraint matrix M are updated and recalculated, and the calculation result obtained is that the components disassembled in the second step are the front sealing cover and the rear sealing cover. The simulation diagram of the specific disassembly situation of the second step is shown in Figure 5.



(a) (b)

Figure 5: The simulation diagram of the specific disassembly situation of the second step (a: disassemble the front sealing cover; b: disassemble the rear sealing cover)

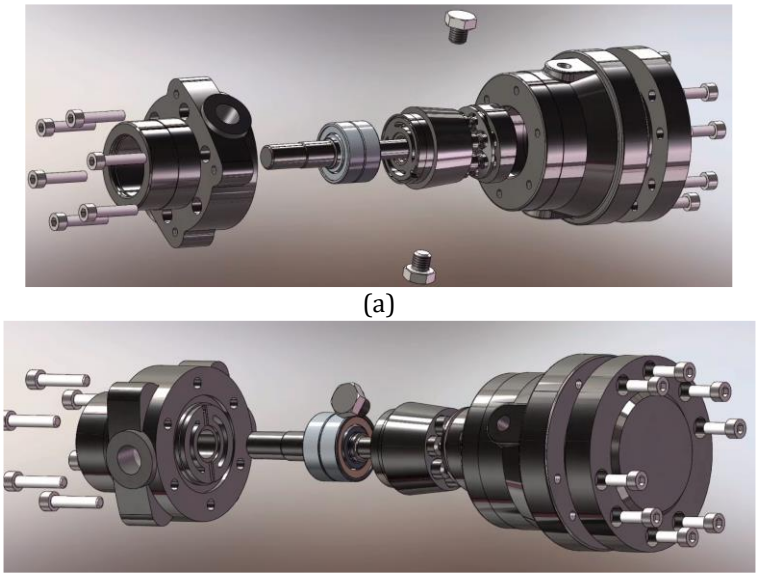
After the second disassembly step is completed, the previous constraint matrix Q and constraint matrix M are updated and recalculated. It can be obtained that the components to be disassembled in the third step are the front and rear oil distribution plates, the middle pump body, the front and rear cylinder blocks, and the front and rear pistons components. The disassembly sequence of the third step is: front oil distribution plate - rear oil distribution plate - middle pump body - front cylinder block and piston components - rear cylinder block and piston components, the simulation diagram of the specific disassembly situation of the third step, as shown in Figure 6.

(a) (b)

Figure 6: The simulation diagram of the disassembly of components in the third step (a: disassemble the front and rear oil distribution plate; b: disassemble the middle pump body, front and rear cylinder block and piston components)

According to the third step, when disassembling the front and rear oil distribution pans, it has no effect on its components, so it should be disassembled first, and the remaining independent intermediate pump body should be disassembled [11], and finally the front and rear cylinder blocks and the corresponding piston components should be disassembled. After completed the third step, update the previous constraint matrix Q and constraint matrix M and then recalculate [12].

The components that need to be disassembled in the last step and the disassembly sequence are: front pump cover—rear pump cover—forward oblique plate - rear swash plate - front rotating shaft and bearing components - rear rotating shaft and bearing components, the simulation diagram of the specific disassembly situation of the last step is shown in Figure 7.



(a)

(b)

Figure 7: The simulation diagram of disassembly of components in the last step (a: disassemble the front and rear pump covers, front and rear swash plates; b: disassemble the front rotating shaft and bearing components)

When disassembling according to the last steps, it should be noted that the front and rear swash plates will affect other components, so the unconstrained front and rear pump covers should be disassembled first. After the disassembly is completed, dismantle the independent front and rear swash plates [13], and finally dismantle the front and rear drive shafts and bearing components.

The entire disassembling process should be: front adjuster - screw 1 - long hexagon bolt 1 - long hexagon screw 2 - screw 2 - rear adjuster - front sealing cover - rear sealing cover - front oil distribution plate - rear oil distribution plate - middle Pump body - front cylinder block and piston components - rear cylinder block and piston components - front pump cover - rear pump cover - front swash plate - rear swash plate - front drive shaft and bearing components - rear drive shaft and bearing components.

Disassembled in this step, neither the parts disassembled in this step nor the other adjacent parts are damaged [14], which meets the requirements of stability and safety.

Finally, the process needs to be designed into a program and extended to a mode that can be operated in batches, and can meet the disassembly of various models and components, to improve the efficiency and quality of disassembling. The program design of the disassembling process and batch operation is shown in Figure 8.

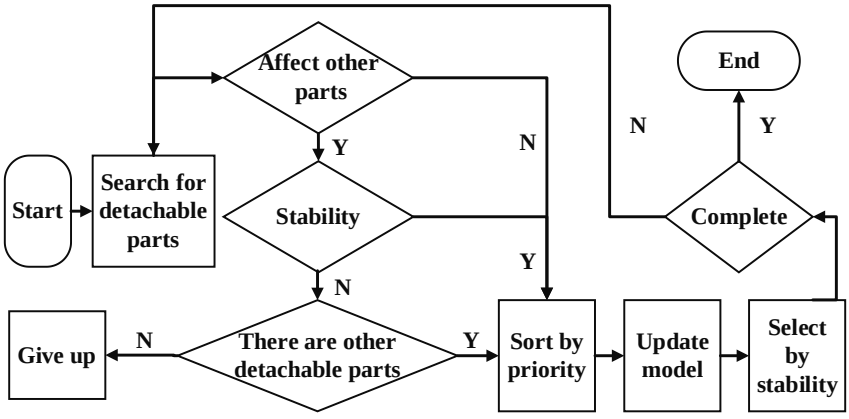


Figure 8: The flow chart of disassembling process

Disassembling in such a disassembling sequence is very in line with the disassembling principle of remanufacturing [15], which does not cause secondary damage to the components, and meets the requirements of stability and safety.

This disassembling process will become the disassembling sequence of the disassembling device designed later, and the process technology of the disassembling device must be based on this premise to ensure the smooth, safe and stable disassembly of each component of the piston pump.

2.4 Simulation Parameter Setting of Virtual Model of Disassembling Device

The disassembly is different from the assembly, and the disassembly has the characteristics of independence, versatility and robustness [16]. To put it simply, the disassembling device is a special machine that will be used in mass production, and there are uncertainties in the object to be disassembled, so the disassembling device needs to be able to independently judge and complete the disassembling operation. It has a certain accommodating capacity, that is, it can dismantle mechanical products of different models and specifications within a certain range. it needs to maintain its stable operation when the disassembling device is working, and the disassembling action should be as simple as possible without procrastination, and it needs to comply with each principles and sequence of mechanical disassembly.

The running time and parameters of each step of the disassembling device of the axial piston pump need to be set according to the disassembling process and time sequence mentioned above [17]. In general, the disassembling device should have the function of automatically positioning the center, the function of clamping the machine to be disassembled, the function of providing power for the axial force, etc. After positioning through the centering function, the machine is clamped, and then the screw rod is driven to rotate by the hydraulic motor.

The structure of the core components of the disassembling device is shown in Figure 9.

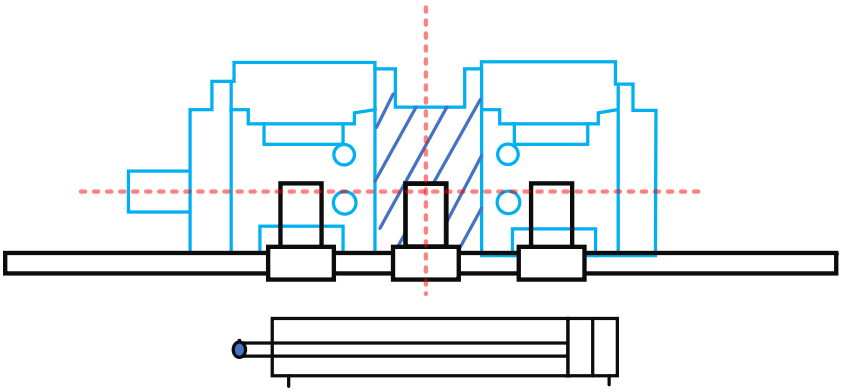


Figure 9: The structure of the core components of the disassembling device

In Figure 9, the disassembling device includes floating claw, swing arm, rotating shaft, forward and reverse T-shaped screw rod, clamp and power system, T-shaped nut, center positioning nut and other parts [18]. Taking the pump body before disassembling as an example, the main parameters of the disassembling device are set, as shown in equations:

$$DAI(F)_{7max}<1960N \tag{4}$$

$$Assml(F)_7 \approx 600N \tag{5}$$

$$Dassml(F)_7 \approx 840N \tag{6}$$

$DAI(F)_{7max}$ is the maximum pre-set clamping force of the front pump body. $Assml(F)_7$ is the pre-set force when assembling the front pump body. $Dassml(F)_7$ is the pre-set force when disassembling the front pump body. However, due to different working environments and conditions of the piston pump, the pump body will be damaged and corroded to different degrees [19], so it is difficult to dismantle and the force should not be too large.

Therefore, the pre-set clamping force is generally controlled within 0N~1200N, and the contact area is generally set between 550mm and 600mm. the calculation of the actual contact stress is shown in equation (7):

$$F=\sqrt{\frac{F_{contact}}{L_{contact}}\left(\frac{1}{\rho_1}+\frac{1}{\rho_2}\right)\Big/\pi\left(\frac{1-\mu_1^2}{E_1}+\frac{1-\mu_2^2}{E_2}\right)} \tag{7}$$

Meanwhile, it is necessary to measure the self-locking parameters. Besides, to make the torque of the screw rod not easily deformed, it is also necessary to measure the strength of its thread teeth. The calculation for the self-locking parameters and the strength of the thread are shown in equations (8) to (11):

Equivalent friction angle: $\varphi_v=\arctan\frac{f}{\cos\beta}$ (8)

Lead angle: $\varphi=\arctan\frac{S}{\pi d_2}=\arctan\frac{np}{\pi d_2}$ (9)

Shear strength of threaded hazardous section:

$$T=\frac{F}{\pi bdu} \tag{10}$$

Bending strength of threaded hazardous section:

$$T=\frac{6Fl}{\pi db^2u} \tag{11}$$

d and d_2 are the diameter of the thread. P is the pitch. F is the axial force of the screw rob. b is the thickness of the root of the thread teeth, and u is the number of cycles of thread work.

3. Results of Simulation Experiment and Analysis of Virtual Model of the Disassembling Devices

3.1 Parameter Results and Analysis of Fixtures in Simulation Experiments of Disassembling Y Devices

The methods of the disassembling devices of the piston pump are different. Taking the disassembling device of the pump components as an example, the 3D virtual prototype model design of the disassembling device of the typical disassembling process of the piston pump is established in turn [20]. The design of the fixture includes determining the material, dimension design, selecting the opening angle, thickness, etc.

The results of the contact stress parameters of the fixture are shown in Figure 10.

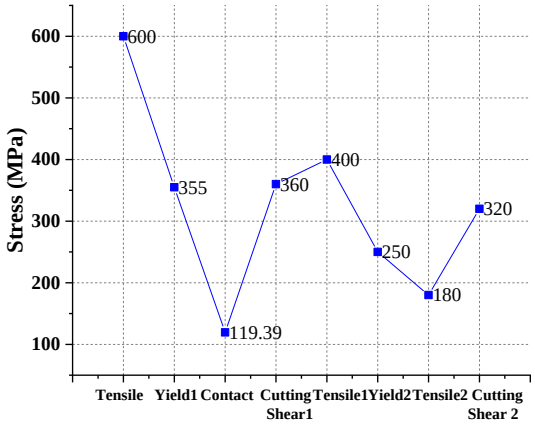


Figure 10: The results of the contact stress parameters of the fixture

Figure 10 shows the results of various parameters of the fixture during simulated disassembly. The material of the fixture is 45 steel, with a tensile strength of 600Mpa and a yield strength of 355MP. The material of the disassembling device pump body is QT400, and its shear strength is 360MPa, Yield strength is 250MPa. The pre-set allowable contact stress of the disassembling device is 180N. According to equation (7), the calculated result of the contact stress is 119.39N, which is less than the allowable contact stress of 180N, so the test result is qualified.

3.2 Parameter Results and Analysis of Forward and Reverse Screw Rods in the Simulation Experiment of the Disassembling Device

The forward and reverse screw rods of the axial piston pump need to be pre-judged before disassembling, to select the appropriate thread size. The calculated results of each index of the forward and reverse screw rods in the disassembling device are shown in Table 2.

Table 2: Each index of the forward and reverse screw rods in the disassembling device

Computational item	Resulting value	Unit	Qualified or unqualified
Screw equivalent friction angle	5.91	Degree (°)	Qualified
Thread lead angle	3.31	Degree (°)	Qualified
Shear strength of threaded hazardous section	10.61	MPa	Qualified
Bending strength of threaded hazardous section	31.847	MPa	Qualified

The forward and reverse screw rods is required to be self-locking after the external force is removed, so the calculation of the self-locking is carried out. According to the size of the sample, a thread with a major diameter of 20mm is selected. During the working process of the screw rods, the thread teeth are the most stressed and most prone to damage. The fixture is designed to be in floating mode. According to the shape of the disassembled piston pump, the adjustment angle is 120°. The friction angle and the lead angle are calculated by the contact stress equation to calculate the friction angle and the lift angle are 5.91° and 3.31°. The results are all within the allowable range of error, so the test is qualified. In the working process of the screw rods, the thread teeth are the most stressed and most prone to damage. The calculated results of the virtual simulation experiment show that the shear strength and bending strength of the thread teeth of the forward and reverse screw rods in the disassembling device of the axial piston pump are 10.61MPa and 31.847MPa respectively, and all the indicators are qualified.

4. Conclusions

Remanufacturing is an important component of advanced manufacturing, which has created huge social and economic benefits and has attracted widespread attention from the whole society. Reasonable and scientific remanufacturing is a manufacturing method of recycling, disassembling and reprocessing waste machinery under the concept of environmental protection and adhering to the principle of harmonious coexistence between man and nature. Therefore, nowadays, it is vigorously advocating waste recycling and recycling, mechanical remanufacturing and other processes.

Firstly, the structure and working principle of each component of the axial piston pump are deeply studied, and then each component of the piston pump is regarded as an independent part and included in the disassembling sequence. Finally, the feasibility of the design scheme is verified through the simulation experiment and analysis of the virtual model of the disassembling device. The research results show that the disassembling effect of the disassembling device is all qualified, and the parts and other adjacent parts are not damaged, which meets the requirements of stability and safety. It has the advantage of being able to operate in batches, which can meet the disassembly of various models and components, and can improve the disassembling efficiency and quality. The disassembling device of the axial piston pump can ensure that the produced products meet the standard quality and can reduce the manufacturing cost, reduce the manufacturing time, and save natural resources. Therefore, the disassembling device of the axial piston pump will be of great significance.

Acknowledgment

This work was supported by Scientific research project of Hunan Provincial Department of Education (No.18C1380).

References

[1] Ye S., Tang H., Ren Y. A, et al. (2020) Study on the load-carrying capacity of surface textured slipper bearing of axial piston pump - ScienceDirect. Applied Mathematical Modelling, 77(1), 554-584.

[2] Kou B., Li Z., Zhang Z, et al. (2021) Tribological Properties of ZrO2 Coating on the Ball Joint of an Axial Piston Pump in High Water-Based Emulsion Medium. Mathematical Problems in Engineering, 20(2), 1.

[3] Zmen Z., Sinanolu C., Caliskan A, et al. (2020) Prediction of Leakage from an Axial Piston Pump Slipper with Circular Dimples Using Deep Neural Networks. Chinese Journal of Mechanical Engineering, 33(1).

[4] Zhou J., Zhou J., Jing C. (2020) Experimental Research on the Dynamic Lubricating Performance of Slipper/Swash Plate Interface in Axial Piston Pumps. Chinese Journal of Mechanical Engineering, 33(1).

[5] Sn A., Ming G. A., Fy A, et al. (2020) Research on fluid-structure interaction for piston/cylinder tribopair of seawater hydraulic axial piston pump in deep-sea environment - ScienceDirect. Ocean Engineering, 2(50), 19-35.

[6] Zhang Z., Chen Y., Song J, et al. (2021) Multiple frequency vibration of the micro lubricating gap geometry between cylinder block and valve plate in an axial piston pump. Journal of Mechanical Science and Technology, 35(11), 4835-4848.

[7] Aka B., Cpg C., Ht A, et al. (2021) Adaptive sensitive frequency band selection for VMD to identify defective components of an axial piston pump. Chinese Journal of Aeronautics, 35(20), 34-89.

[8] Zhang J., Fei L., Xu B, et al. (2021) Simulation and Experimental Investigation on Low Wear Rate Surface Contour of Piston/Cylinder Pair in an Axial Piston Pump. Tribology International, 1(2), 107-127.

[9] Fei L., Zhang J., Sun G, et al. (2020) Research on wear prediction of piston/cylinder pair in axial piston pumps. Wear, 32(11), 456-457.

[10] Zhao B., Guo W., Quan L. (2020) Cavitation of a Submerged Jet at the Spherical Valve Plate/Cylinder Block Interface for Axial Piston Pump. Chinese Journal of Mechanical Engineering, 50(2), 67-84.

[11] Tang H., Fu Z., Huang Y. (2021) A fault diagnosis method for loose slipper failure of piston pump in construction machinery under changing load. Applied Acoustics, 172(1), 107-634.

[12] Ernst M., Vacca A. (2021) Hydrostatic vs. Hydrodynamic Components of Fluid Pressure in the Tribological Interfaces of Axial Piston Machines. Tribology International, 32(11), 456-457.

[13] Yang F., Li Z., Yuan Y, et al. (2021) Numerical and Experimental Investigation of Internal Flow Characteristics and Pressure Fluctuation in Inlet

Passage of Axial Flow Pump under Deflection Flow Conditions. Energies, 14(2), 245-265.

[14] Zhang J., Fei L., Xu B, et al. (2021) Simulation and Experimental Investigation on Low Wear Rate Surface Contour of Piston/Cylinder Pair in an Axial Piston Pump. Tribology International, 32(1), 45-47.

[15] Boyarsky G., Nevzorov M., Khaustov A, et al. (2021) Experimental Research on the Dynamic Lubricating Performance of Slipper/Swash Plate Interface in Axial Piston Pumps. Chinese Journal of Mechanical Engineering, 172(1), 107-634.

[16] Zhang Z., Chen Y., Song J, et al. (2021) Multiple frequency vibration of the micro lubricating gap geometry between cylinder block and valve plate in an axial piston pump. Journal of Mechanical Science and Technology, 35(11), 35-48.

[17] Yu L. J., Yang C., Zhang J, et al. (2021) Effects of oil channels and oil flow rate on cooling performance of closed axial piston transmission. Case Studies in Thermal Engineering, 28(6), 101-375.

[18] Kai S. Y. (2021) Piston Pump with a Hydraulic Diode in the Injection System. Russian Engineering Research, 41(10), 877-879.

[19] Wu Y. F., Ge P. Q., Bi W. B. (2021) Analysis of axial force of double circular arc helical gear hydraulic pump and design of its balancing device. Journal of Central South University, 28(2), 418-428.

[20] Kp A., Bh A., Hm B, et al. (2021) Quantitative analysis of energy loss and vibration performance in a circulating axial pump, 14(2), 24-52.