Development Status and Application of Under Pressure Operation Equipment Technology

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Abstract. With the development and development of unconventional oil and gas reservoirs, the problem of difficult completion and workover has gradually become apparent, and pressured operations have gradually been valued by major oilfields and enterprises. In order to promote the development of pressure-related workover related equipment and technology in our country, and overcome the difficulties of late start and little experience, this article focuses on the development status of pressured operation. The main contents include: a brief introduction to the dangers of annulus pressure and the distribution statistics of annulus pressure wells at home and abroad; introduction to the development process of annulus operations; and introduction of a series of pressure equipment products that have matured or formed an annulus at home and abroad, and The research status of the key components of the pressure-proof operating equipment, such as the blowout preventer and the floating slip, is summarized. Finally, China's domestically developed independent research and development of pressure-operating equipment is analyzed and considered. Based on the operating concept, enhance the trust and confidence of enterprises and oilfields in pressured operation; technical development should be oriented towards integration, characterization, and digitization, and systemized and serialized pressured operating equipment and process technology. The combination of pressure operation technology and equipment with repair and drill forms a drill-finish-repair integrated pressure operation system.

1. Introduction
As conventional oil and gas wells enter the later stage of production, and the exploration and development of unconventional gas reservoirs including shale gas and tight gas, more and more complex geological conditions and special-quality reservoirs continue to emerge, coupled with frequent high-strength transformation measures. The problems of use and casing damage and casing change become more and more serious, which makes the difficulty of oil and gas well development continue to rise [1,2]. There are some problems in the traditional way of injecting high-density killing hydraulic wells into the well or the method of reducing the pressure in the well by overflowing and discharging [3,4]. The injection of killing fluid cannot avoid physical and chemical reactions with the reservoir, leading to blockage of reservoir pores, increasing reservoir oil and gas seepage resistance, affecting oil and gas production capacity and recovery rate. The blasting and depressurization...
operation will cause local formation pressure distribution changes and damage the reservoir pore structure, which will have a greater impact on oil and gas well productivity and future production or maintenance operations. In fact, many wells with pressure will cause a sharp decline in production during the pressure relief process, causing workover costs to be higher than the economic losses caused by the pressure. Therefore, the site often chooses to stop continuing the relief. According to statistics, the killing operation will cause nearly one-fifth of the production loss of oil and gas wells, and at the same time increase the complexity, difficulty and construction cycle of drilling and repairing operations.

In the 1920s, foreign countries put forward the idea of "non-killing" for completions, that is, equipment technology and process methods for downhole operations under pressure. Over the past century, the active foreign investment in the completion operation under pressure has led to the rapid development of its related equipment technology under pressure operation, which has significantly improved and improved the efficiency and productivity of oil and gas production operations. In the past 10 years, foreign countries have continued to develop integrated drilling, completion, and repairing press operations on the basis of the completion of press completion technology, which has made the operation process more comprehensive and widely used in North American land and sea areas. Obtained the reputation of "universal working machine" [5]. my country's research on pressure operation started late, and it is still in the stage of introduction and learning. Existing self-developed pressure operation equipment has problems such as low pressure level and low integrated control level compared with foreign countries. In addition, domestic knowledge and understanding of annulus pressure and pressure operations are still not deep enough, and the penetration rate is insufficient.

However, in the current oil and gas development stage, the workover operation with pressure has broad prospects and necessary significance. Therefore, the research on the localization of the technology and technology of the equipment for the workover with pressure has a far-reaching effect on the development of oil and gas exploration in my country.

2. Advantages of working with pressure
Pressure operation refers to the operation performed in the wellbore with professional equipment and tools under pressure in the wellhead of the oil and gas water well. It is also called Snubbing Operation or Hydraulic Workover (HWO). The scope usually includes Workover, completion, perforation, fracturing acidification, emergency rescue and other special operations. The key components include: controlling the annulus pressure in the oil pipe and the oil jacket; overcoming the jacking force of the pipe string or tool; and applying external working force to the pipe string. Key equipment includes: blowout preventer combination, tubing blockage device and swimming slip. Compared with the traditional conventional workover, the operation of the pressure operation has a huge advantage in the process. As shown in Table 1, the improvement of oil and gas production can be manifested in the following aspects:

- Maintain the original state of the pay zone to the maximum. The biggest advantage of the pressure operation is that no injection of artificial fluids such as killing fluid is needed, and there is no contamination of the formation with the killing fluid. It is beneficial to maintain the original production capacity of the reservoir, minimizes the impact on the reservoir, and provides a good foundation for the long-term sustainable development of oil and gas fields.
- Save operation cycle and operation cost. The use of no kill fluid not only reduces workover costs and processes, but also reduces transportation costs, further reducing the operating cycle. And the pressure operation can be synchronized with the production, which has a smaller impact on output and efficiency.
- Environmentally friendly and green development. There is no need to inject kill fluid in the pressure operation, so there is no back discharge problem. This greatly reduces the pollution of the surrounding surface environment caused by the discharge of construction fluids such as return fluids, meets the requirements of HSE, and has good environmental protection benefits.
- Treatment of hidden dangers. Pressure operation is an important method for the treatment of hidden dangers in oil and gas wells. Some old wells and scrapped wells often cause the trap
pressure at the lower part of bridge plugs and cement plugs to be unable to be released during the closure process. Operation can well avoid these well control safety problems.

Table 1. Advantages of working under pressure.

| Compare items                 | Traditional completion workover | Completion workover operation without kill |
|------------------------------|---------------------------------|--------------------------------------------|
| Killing fluid dosage         | 80-120m³                        | Do not use                                 |
| Discharge cycle              | 5-15d                           | 0                                          |
| Return rate                  | 25-70%                          | /                                          |
| Wastewater treatment capacity| 56-84m³                         | /                                          |
| Operating cycle              | 15-30d                          | 7-12d                                      |
| Reservoir damage rate        | 10-30%                          | 0                                          |
| Resumption after repair      | Mechanical drainage             | No measures                                |
| Yield recovery               | 70-90%                          | 100%                                       |
| Operating expenses           | 100-200million                  | 50-70million                               |

3. Development and application status of pressure operation equipment at home and abroad

3.1. Development and application status of external pressure operation
Pressing operations abroad have been around for a century. In 1929, the American Herbert C. Otis (Herbert C. Otis) put forward the idea of "do not kill well operation", which started the historical process of pressure operation equipment and technology. In 1958, Brown Oil Tool Inc (Brown Oil Tool Inc) developed the first hydraulic pressureless well device, marking the official stage of the equipment under pressure. The milestone events in the development process of the equipment under pressure are shown in Table 2 [6-9].

Table 2. Development history of pressure operation

| time  | Researcher                          | Research results                                                                 |
|-------|-------------------------------------|----------------------------------------------------------------------------------|
| 1929  | Herbert C. Otis                     | Wire rope type lifting and lowering tubing device                                |
| 1939  | Azerbaijan Petroleum Machinery      | The first batch of equipment under pressure in the former Soviet Union            |
|       | Manufacturing Research Institute    |                                                                                  |
| 1958  | Brown Oil Tool Inc                  | The first hydraulic pressureless well device                                     |
| 1981  | VC Controlled Pressure Services LTD.| Car pressure equipment                                                            |

From the earliest wire rope lifting and lowering tubing device that is still an auxiliary equipment, it has only a 1.56kN lifting force and a 193.7mm diameter, to the advent of the first hydraulic pressureless device independent of drilling rigs or workover rigs, and then to pressure With the advent of operation
trucks, the operation under pressure is gradually based on the family of oil and gas development and workover operations. In the 1970s, with the implementation of remote safety control operation technology, long-stroke vehicle-mounted pressure working devices appeared, as shown in Figure 1. After the 1990s, the pressure-operated device developed to be modular and skid-mounted. After 2000, integrated pressure-operating devices also appeared one after another [10].

![Image](a) Short stroke

![Image](b) Long stroke

**Figure 1.** Long-stroke working device under pressure

After nearly a hundred years of development, foreign pressure operation technology has formed a complete system, and the development is quite mature. The operating equipment has achieved full hydraulic lifting and hydraulic remote control, with a maximum lifting capacity of 2669kN, a maximum pressure reduction capacity of 1157kN, and a maximum operating well pressure of 140MPa, and has been widely used in land and offshore wellsites for side drilling, Underbalanced drilling, perforation, small hole drilling, testing, completion, acidizing oil testing, fracturing and workover operations. According to statistics, there are more than 10 companies in the world that manufacture equipment under pressure, provide services under pressure, or provide both manufacturing and operation services, including those produced by High-Arctic, Snubco, ISS, Hydra-Rig, and CUDD. Pressure working devices are most widely used [11], as shown in Table 3 and Table 4 are the models and technical parameters of some typical pressure working devices of Snubco and ISS [12].

**Table 3. Model parameters of Snubco's pressurized working device**

| Model  | S15 | S17 | S18 | S19 | S22 | S23 |
|--------|-----|-----|-----|-----|-----|-----|
| Maximum downforce/kN | 134 | 223 | 285 | 356 | 223 | 223 |
| Maximum tubing size/mm | 101 | 127 | 139 | 152 | 127 | 127 |
| Working pressure/MPa | 21 | 35 | 35 | 35 | 35 | 35 |
| Equipment height/m | 4.7 | 4.8 | 5.1 | 5.4 | 4.7 | 4.5 |
| Stroke/m | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Maximum diameter/m | 179 | 179 | 179 | 179 | 179 | 179 |
Table 4. Model parameters of ISS company's pressure working device

| Model | 120 K | 150 K | 225 K | 340 K | 460 K | 600 K |
|-------|-------|-------|-------|-------|-------|-------|
| Maximum lift/kN | 534 | 668 | 100 | 151 | 204 | 267 |
| Maximum downforce/kN | 267 | 334 | 523 | 757 | 102 | 133 |
| Turntable torque/Nm | 270 | 0 | 470 | 0 | 271 | 271 |
| Stroke/m | 12.2 | 3.2 | 3.0 | 3.0 | 3.0 | 3.0 |
| Maximum diameter/m | 103.2 | 179.4 | 279.4 | 279.4 | 346.1 | 346.1 |

Hydra-Rig's pressure operation equipment is relatively mature, with strong maneuverability, light equipment quality, easy decomposition and transportation, and high reliability. It has two series of independent operation type and cooperative use type, and its parameters are shown in Table 5 and Table 6.

Table 5. Model parameters of Hydra-Rig's independent operation pressure working device

| Model | HRL120 | HRL142 |
|-------|--------|--------|
| Maximum lift/kN | 534 | 632 |
| Maximum downforce/kN | 267 | 316 |
| Power/kW | 169 | 224 |
| Maximum tubing size/mm | 25.4-73.0 | 25.4-139.7 |
| Turntable torque/Nm | 4068 | 4068 |
| Stroke/m | 11 | 11 |
| Maximum diameter/m | 203.2 | 203.2 |

Table 6. Model parameters of Hydra-Rig company's cooperating pressure working device

| Model | HRS150 | HRS225 | HRS340 |
|-------|--------|--------|--------|
| Maximum lift/kN | 667 | 1001 | 1513 |
| Maximum downforce/kN | 294 | 534 | 837 |
| Power/kW | 169 | 224 | 224 |
| Maximum tubing size/mm | 25.4-73.0 | 25.4-139.7 | 25.4-193.7 |
| Turntable torque/Nm | 3797 | 6780 | 8950 |
| Stroke/m | 3.05 | 3.05 | 3.05 |
| Maximum diameter/m | 203.2 | 279.4 | 279.4 |
Figure 2. Hydra Rig's on-board pressurized work equipment

The independent operation type pressure operation equipment can perform pressure operation independently, with wide application range and strong operation ability. This series of equipment is statically sealed between the pipe string and the blowout preventer, so the requirements for the sealant core of the blowout preventer are relatively low. However, since the lifting hydraulic cylinder is used to lift the lower oil pipe string, the performance of the lifting hydraulic cylinder and the sealing element of the hydraulic system are higher, and the overall equipment is larger, which causes difficulties in transportation and installation. Cooperating use-type pressure-operated equipment needs to be used in conjunction with workover trucks or work vehicles, as shown in Figure 2. This series of equipment can perform the drilling and workover tasks of conventional oil and gas fields. It has the advantages of convenient transportation, simple installation and strong operability. It is widely used in pressure operations in my country. However, in the operation of this type of equipment, there is sliding friction between the pipe column, the coupling and the rubber core of the blowout preventer, so there are higher requirements for the rubber core of the blowout preventer.

Figure 3. Distribution of types of pressurized operations abroad

At present, there are more than 800 sets of equipment for the whole press operation in the world, about 400 of which are distributed in North America. The technical team of press work equipment is mainly occupied by equipment manufacturers such as Hydra Rig, Pro-Fab, CRW, and technical service providers and equipment manufacturers such as CUDD, Halliburton (boots & coots), Snubco, and ISS. The process of pressure operation is mainly the most widely used and mature in the United States and Canada. The annual pressure operation reaches 4000-5000 wells, and the comprehensive benefits created are 3 to 5 times higher than the cost of pressure operation [13,14]. More than 95% of Canada and nearly 80% of the United States use auxiliary pressurized operation equipment. Its application scope includes completion operations such as casing under pressure, liner, single tubing or double tubing. Acidizing continuous construction operation, with pressure lowering, recovery packers, bridge plugs and other downhole tools, with pressure flushing, salvage, milling, wax cleaning and other workover operations, with pressure underbalanced drilling, side drilling, perforation And emergency rescue, as shown in Figure 3.

3.2. Development and application status of domestic pressure operation

The research of pressure operation technology equipment in my country began in the middle of the last century. Due to the late start, there is a certain gap between the pressure operation concept and cognition, experience and process design in China. However, as the problem of annulus pressure has
gradually become more prominent, my country has begun to pay attention to annulus pressure. Through the introduction of foreign advanced pressure operation equipment, part of the high-pressure well operation problems have been solved, and a group of operators with professional skills have been trained. However, the high cost of introducing equipment and pressure operation services and the blockade of foreign core technologies have made us realize that it is imperative to develop my own technology for pressure operation equipment. Therefore, all major oil and gas fields have carried out research and development of technical equipment for pressure operation, as shown in Table 7 [15-20].

Table 7. Development history of China’s pressurized operations

| Time | Researcher | Research results |
|------|------------|------------------|
| 70s  | Sichuan Petroleum Administration Bureau | BY30-2 type pressure working device. BYXT15 type pressure working device. |
| 80s  | Jilin Oilfield | The maximum pressure at the wellhead is 6MPa, and the maximum lifting force is 500-700kN. |
| 90s  | Sichuan Petroleum Administration Bureau | The maximum lifting force reaches 600kN. |
|      | Liaohe Oilfield | Full hydraulic type pressure working device. |
|      | Liaohe Oilfield | 7MPa hydraulic pressure equipment. Jilin Oilfield Min 25-2 water injection well field test was successful. |
| 2005 | Xinjiang Oilfield Underground Operation Company | DYZY12-21 with pressure operation device |
| 2007 | Changqing Oilfield | The highest operating pressure reaching 35MPa. The average pipe pressure is 7MPa, the average overflow volume is 153m³, and the empty water volume is 500m³ |
|      | Bohai Oil Company | Operating system with pressure from double roots. Used in water injection wells in Tuha Oilfield. |
| 2017 | SINOPEC | A new type of stand-alone equipment with pressure. Compared with imported equipment, the cost is reduced by 20%. |
At present, after the research and development and field test of the pressure operation technology in major oil and gas fields, the pressure operation device in China has basically achieved full hydraulic control, and there have been pressure operation equipment designed according to the application situation and suitable for the field conditions. Figure 4 shows BYJ60/21DQ stand-alone and BYJ60/21FQ auxiliary press working equipment developed in my country. Table 8 shows the performance parameters of independent and auxiliary press working devices [21-23].

**Table 8. BYJ60 series pressure working device model parameters**

| Model                               | BYJ60/21DQ | BYJ60/21FQ |
|-------------------------------------|------------|------------|
| Maximum dynamic sealing pressure/MPa| 21         | 21         |
| Maximum static sealing pressure/MPa | 35         | 35         |
| Maximum diameter/mm                | 186        | 186        |
| Stroke/m                           | 3.5        | 3.5        |
| Maximum lift/kN                     | 600        | 600        |
| Maximum downforce/kN                | 400        | 370        |
| No-load maximum                    | 39.6       | 18         |
In recent years, more and more attention has been paid to the integrity of pipe strings and oil and gas reservoir protection technologies, and the closely related pressure equipment technology has become a key project, and its research and development have been obtained by major oil companies such as China National Petroleum Corporation. Strong support. The Hanjiang Oilfield, Huabei Oilfield and Changqing Oilfield have all formed their own ability to independently research and develop and produce equipment under pressure, as shown in Table 9.

### Table 9. Domestic equipment parameters under pressure

| Manufacturer               | p/MPa | Stroke/m | Max. lifting/kN | Max. down/kN | φ/mm | H. s/MPa |
|----------------------------|-------|----------|-----------------|--------------|------|---------|
| Hanjiang Petroleum         | 35    | 3.5      | 1568            | 539          | 180  | 21      |
| North China Petroleum      | 35    | 3.5      | 600             | 400          | 186  | 21      |
| Renqiu Tiehu Petroleum     | 35    | 3.5      | 603             | 353          | 186  | 21      |
| Dagang Petroleum           | 35    | 3.5      | 667             | 420          | 186  | 21      |
| Topwell Petroleum          | 35    | 3.5      | 1764            | 821          | 279  | 21      |

China National Petroleum Corporation has actively put tens of thousands of wells under pressure in oil and gas wells, and has achieved very good results in stabilizing the output of a single well, saving energy and reducing emissions, and reducing environmental pollution. However, the domestic pressure operation is mainly based on oil and water wells. The pressure operation technology of gas wells is still not mature enough, and only a few units have certain construction experience and capabilities. The highest wellhead construction pressure is Well Wushen 1, Tarim Oilfield, and the wellhead construction pressure reaches 86MPa.

### Table 10. Statistics of PetroChina under pressure

| time | Total | Oil well | Gas well | Water well | Team |
|------|-------|----------|----------|------------|------|
| 2011 | 2246  | 509      | 30       | 1707       | 102  |
| 2012 | 3096  | 676      | 53       | 2367       | 130  |
With the continuous deepening of exploration and development, the output of single wells has decreased, the workload of comprehensive treatment of old wells has increased, the development of shale gas, tight gas and other unconventional gas, and the increase in environmental protection requirements, the greater the demand for pressure operation technology. The bigger the future, the wider the development prospects of the pressure operation technology.

4. Development status of key components

Among the many components of the equipment under pressure, swimming slips and blowout preventers are the two devices with the highest working frequency. During the operation, the lifting and lowering of the pipe string and the tool rely on the process of alternating movement of clamping and loosening of the slip, which is the "operation" part of the pressure operation. The blowout preventer is the premise of the pressure operation, which is the "pressure" part of the pressure operation. The combination of swimming slips and blowout preventers form a vital action system in pressure-operated equipment, which can be called the "two hands" of pressure-operated equipment. Therefore, the research and development of the two is essential for pressure-operated equipment.

4.1. Current status of traveling kava abroad

The Unislips hydraulic power slip developed by Weatherford of the United States is shown in Figure 5. Unislips hydraulic power slip technology is applied to the 375 turntable, bearing torque reaches 108.5kN·m, maximum bearing capacity reaches 4500KN, opening range is enough to reach 482.6mm, can perform non-standard pipe string operations. As shown in Figure 2.6, there are two working states of Unislips hydraulic power slips: the centering of the pipe column is centered and the sliding clamp along the guide rail. This structure can make the slip suitable for different specifications of the pipe string, avoid the problem of frequent replacement of slips, and greatly improve the efficiency of the pipe string [24].

![Figure 5. Unislips hydraulic power slip](image)

(a) Centering    (b) Sliding the pipe string along the guide rail

**Figure 6. Unislips hydraulic power slip working state**
NOV’s PS21-30 series three-petal hydraulic power slips are widely used, as shown in Figure 7 [25]. PS21-30 series hydraulic power slips mainly have the following structural features:

- Simple structure. The stepped cooperation between the slip body and the slip holder reduces the overall working height of the slip, and it will not change with the operation mode.
- Easy to replace. The unique safety door structure design and replacement device can avoid loosening of fasteners when replacing the jaw box. The spring structure in the replacement tool can realize that the lifting drive device automatically retracts the locking position when replacing the slip body.
- Centering right. Relying on the precise layout of the upper cover, the pipe columns of different specifications can be centered by the lifting drive device, so that the force of the pipe column and the dental forceps is more uniform, thereby improving the service life and efficiency of the slip.

![Figure 7. NOV PS21-30](image1)
![Figure 8. B + V](image2)

(a) Type 350  (b) Type 550  (c) Type 762

**Figure 9. TES hydraulic power slip**

PS series hydraulic power slips of B+V company have extremely high load-bearing capacity, as shown in Figure 8. Its load-bearing capacity reaches 11250KN [26], and the matching method of the stepped cone makes it have a wide range of application. The bottom end of the slip has a double-lip integrated rubber scraper structure with a diameter of 482.6mm, which can quickly clean up the sludge, avoiding the problem of slips and mud packs, and improving the reliability and safety of slip operations. American TES Company is a professional company that produces hydraulic power slips. Its product variety is diversified and all have been serialized, as shown in Figure 9. Due to its compact structure and wide range of product characteristics, the American TES company covers the market needs of most types of land deep wells and offshore platforms.

4.2. Current status of Touring Kava

At present, the domestic new type of pneumatic slip has formed four models of ZP175, ZP205, ZP275 and ZP375, and it has been used in Jiangsu Oilfield and Tuha Oilfield [27]. Compared with manual slips, the new pneumatic slips use the cylinder as the power source for lifting and lowering the column, and the working performance is more safe and reliable [28]. In addition, many relevant researchers have also conducted research on power slips under pressure, as shown in Table 11. However, compared with foreign power slip products, my country is still not mature enough, and the penetration rate of hydraulic or pneumatic slips is not high. Most of them are mainly double elevators or manual slips [29-43].
Table 11. Relevant research on power slip of domestic operating equipment under pressure

| Researcher                          | Research results                                                                 |
|-------------------------------------|-----------------------------------------------------------------------------------|
| Baoji Machinery                     | HS series hydraulic power slips.                                                  |
| North China Petroleum               | Conical shell hydraulic self-locking anti-top slip.                              |
| Coal Science Research Institute     | The effect of different tooth surface slips on the clamping force of the pipe string. |
| SWPU                                | The influence of the kava tooth plate design.                                     |
| Zhongyuan Petroleum                 | The effect of tooth marks on the column.                                          |
| Liu                                 | The relationship between several important geometric parameters of kava teeth and clamping effect. |
| Liu                                 | The influence of kava tooth shape, kava tooth insertion depth, and kava tooth equivalent friction coefficient on kava teeth. |
| Yu                                  | Contact analysis study on the anchoring process of non-metallic bridge slips.     |
| Jin                                 | The maximum allowable stress and the maximum deformation of each part of the slip. |
| Chen                                | Slip clamping causes tooth marks on the surface of the drill rod.                |
| Wang                                | A new type of hydraulic slip device that distributes four slips in the circumferential direction. |
| Dong                                | The optimal range of values for slip body, slip holder, slip shape, and tooth spacing are determined. |

4.3. Development status of BOP
Although there are many structures and series of equipment under pressure, they can not avoid the process of the blowout preventer alternately opening and closing the sealed wellhead when the lower pipe string meets the coupling. According to the characteristics of the pressure operation process, there are already 14~105MPa annulus pressure control system configuration scheme standards for oil and gas wells, as shown in Table 12 [44].

Table 12. Standards for the configuration scheme of annulus pressure control system for oil and gas wells

| Pressure level/MPa | Job control | Safely control | Emergency control |
|--------------------|-------------|----------------|-------------------|
| <14                | Ring        | single gate    | Fully seal        |
| 14-21              | Ring        | single gate    | Fully seal        |
| 21-35              | (Ring+) 2 single gate | 1or2 single gate | Fully seal, Shear |
| 35-70              | (Ring+) 2 single gate | ≥2 single gate | Fully seal, Shear |
BOP, as the core safety control device of the equipment under pressure, is also the basis for the realization of the concept of pressure operation. Therefore, the sealing ability and service life of the BOP rubber core largely determine the reliability and safety of the equipment under pressure. At present, the maximum wellhead pressure of overseas pressurized operations reaches 140MPa, which is widely used in overhaul operations of ultra-high pressure wells and special wells. The pressure range of more mature domestic pressurized operations is below 70MPa, which is also only used in small repair operations of conventional oil and gas wells. The key constraint that limits the pressure level of domestic pressure operations is the BOP. Although looking at the conventional sealing pressure level of domestic BOPs and reaching more than 100MPa, the dynamic sealing pressure level and the reliability of rotating operations applied in the process of pressurization are lower than foreign products, and the seal life is only 50% [45,46].

As shown in Figure 2.10(a), the rubber core of the ram blowout preventer developed by H&H RUBBER Company is shown in Figure 2. The front rubber core is provided with abrasion resistant polymer material blocks, which greatly improves the service life of the rubber core. The rubber core of the ram BOP used by Cameron for pressure operation is shown in Figure X(b). The front rubber core is provided with a wear block composed of ultra-high molecular weight polyethylene (UHMWPE), which is used to adapt Working conditions with pressure [47-49]. The maximum pressure level of the rubber core of the blowout preventer for pressure operation developed by the domestic North China Petroleum Rongsheng Machinery Manufacturing Co., Ltd. reaches 35MPa, but compared with foreign products, the performance of the rubber core seriously restricts the field application of the BOP and the sealing effect is poor, Low reliability, short life and other problems have not been effectively improved [50,51]. In summary, my country's research on blowout preventer for the characteristics of pressure operation, especially the rubber core, still needs further development.

![Figure 2.10(a) and 2.10(b) showing rubber cores of BOP for pressure brake ram]

**Figure 10. Rubber core of BOP for pressure brake ram**

5. Conclusion

According to the above summary, it can be found that the domestic R&D and promotion of pressure operation is still insufficient. The investment and research and development investment in pressure operation technology are limited. The author believes that the main reasons can be attributed to the following points:

- There are relatively few domestic technical service companies providing pressure operation, and the absolute cost of pressure operation equipment or technical services both abroad and domestic is higher than that of traditional operations. The promotion and the economic and social benefits brought about by it are not only understood, so they stop before the high prices;
- Due to the high-pressure risk in the process of pressure operation, there are certain hidden safety hazards, and the process of the pressure operation process is relatively professional. The number of domestically trained operators and professionals is less than that of foreign countries. Traditional operations with higher reliability and safety due to risk considerations;
- At present, there are few relevant national standards and system authoritative materials for pressure operations, which makes the understanding of the tools and processes of the pressure operation not intuitive.
Due to the above factors, the development of pressure operations in China is restricted to a certain extent. In this case, the research and development of pressure-operated equipment is insufficient, which delays the process of localization, resulting in the applicability and advancement of domestic equipment. Pressure-operated equipment is highly dependent on imported equipment, and the cost is difficult to control. Therefore, we should first solve the problem of cognition of oil and gas wells under pressure operation, and comprehensively understand the significant role of the pressure operation technology in the workover of complex well repair operations, the protection of oil and gas layers and the improvement of oil and gas field recovery. In addition, improving the equipment's pressure level and sealing pressure are the basic requirements for the development of pressurized work equipment. Increasing the lifting force and lowering force is the fundamental to improve the scope of application of pressurized work equipment. In the future, the development of pressure-bearing equipment technology should mainly focus on the following aspects:

- At present, foreign vehicle-mounted press working equipment is quite mature, and domestic should also take integrated equipment as the development direction, and push the fragmented press working equipment to serialization to form a press working industry standard and realize the overall equipment. Convenient transportation, avoid frequent disassembly and assembly to reduce operation cycle and process.

- Due to the wide variety of oil and gas wells in China and the strong inconsistency of formation characteristics, in order to make the pressure-operated equipment better adapt to various pressure wells in China, it should be modularized on the basis of integration and integration . The goal is to be able to discretize and standardize common components and feature-dependent components in the whole, and only need to quickly replace the corresponding components under different well conditions to improve the comprehensiveness and adaptability of the equipment under pressure.

- With the rapid development of digitalization and mechatronics technology, all oil and gas production equipment, including equipment under pressure, will be thinking of the higher goal of intelligent and automated development. The realization of intelligent digital simulation and remote control automation can not only improve the reliability and operating efficiency of the equipment under pressure, but also reduce the number of operators on the well, reduce the hidden dangers of safety accidents and the training cost of professional operators.

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