Research on the Development, Testing, and Evaluation of the Dual-Opening Anti-Blowout Oil Draining Device

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Abstract. During the tripping of the sucker rods and tubing from the wells with sucker rod pumps (SRP) in Tarim Oilfield, there are multiple challenges encountered, such as heavy oil, deep pumping, substantial load differences, and corrosive gas like H_2S, etc., making the traditional anti-blowout oil draining device inefficient for operational needs and environmental requirements during pumping and intervention of the producing wells. In order to resolve such problems, Tarim Oilfield has developed a novel anti-blowout oil draining device with dual-opening function of rupturing + impacting by referring to the structure of high-pressure rupturing oil draining device with high opening success rate and conducting structure analysis, strength checks, and flow capacity calculations of the oil draining valves. The novel anti-blowout oil draining devices have passed a series of mechanical tests, corrosion resistance tests, and functional tests, such as indoor constant tensile stress-corrosion test, tensile strength test, collapse strength test, HIC test, electrochemical corrosion test, and tests of tool opening and closing, making up and breaking out, etc. The theoretical calculation and test show that the novel dual-opening anti-blowout oil draining device can not only meet the requirements of deep pumping, high gas-liquid ratio, substantial loading differences, and H_2S corrosion resistance, but also be used in highly deviated wells, horizontal wells, and heavy oil producers. To conclude, the novel anti-blowout oil draining device will not pose any impacts on pump colliding operations. Moreover, the pump colliding operation can be used to eliminate the gelled debris attached to the pump valve and ball seat while ensuring anti-blowout oil drainage, returning the producer back to normal production.

Keywords: Dual-Opening Function; Anti-Blowout Oil Draining Device; Wells with sucker rod pumps (SRP); Oil Draining and Environmental Protection; Tarim Oilfield.

1. Introduction

There are more than 300 wells with sucker rod pumps (SRP) in the Taipeng Field of Tarim Oilfield with an average pump setting depth of 3,000m and some wells with more than 3,500m. During the intervention, the tubing string and the pump will be pulled back to the surface along with a large amount of crude oil, which not only causes great waste of crude oil, but also creates pollution to the environment. Therefore, with the application of the anti-blowout oil draining device, all the above-mentioned problems will be effectively solved. The anti-blowout oil draining device is installed between the oil pump and the fixed valve. While RIH with tubing string, the inner cavity of the tubing will be sealed with anti-blowout valve plate assembly, which will prevent the oil and gas influx and blowout from the tubing while RIH with tubing and sucker rods in order to achieve the anti-blowout function. When draining oil, RIH with the sucker rods to TD to conduct the pump collision operation. The sliding sleeve will be pushed down by the plunger to open the valve plate assembly for normal production. While POOH with tubing string, the anti-blowout oil draining device will be opened via rupturing or impacting so as to open the tubing and casing channels for oil drainage and the subsequent operations.

However, even though various types of conventional oil draining device with diverse functions are available across the world, there are still very limited anti-blowout oil draining devices which can meet the stringent requirements of the wells with sucker rod pumps (SRP) in Tarim Oilfield. Moreover, there are no successful case studies or publications from the major domestic oilfields.

Table 1 Comparison of technical principles, advantages, and disadvantages of the common oil draining device at home and abroad

Name of Oil Draining Device	Technical Principle	Advantages	Disadvantages
Impacting Oil Draining Device	The tool is installed between the pumping barrel and the fixed valve with hollow shearing pin. After POOH with the sucker rods to surface, drop the rod to impact the hollow shearing pin to enable the oil draining.	Repairable with low cost.	Poor performance in the highly oil and wax depositing wells. Also, the tool needs to stay away from the pump.
Lifting Oil Draining Device	The oil draining device is made up of both an oil drain and a rotary tubing anchor, which are both for oil draining. The oil drain is set above the pump while the tubing anchor is below the pump.	To solve the problems of sucker rod twisted off or oil draining difficulty while pump gets stuck, which is good for enlarging the scope of application.	The pressure-bearing capacity of the seal is limited, which is not applicable to deep wells.
Rupturing Oil Draining Device	The tool is connected to the top of the pump in deep wells with ports on the tool wall. Rupture discs are embedded inside and secured with clamp rings. Pump from the ID of the tubing so that the disc can be ruptured for oil draining.	The rupture discs can be optimized according to the pump setting depth and used along with the cleaning tool running inside of the tubing for solving the tubing ID cleaning issues during POOH.	The material and processing of the rupture disc are tightly controlled, but the rupture pressure is hard to control.
Oil Draining Device with a Controllable Bottom Valve	The tool is a replacement of the fixed valve with a reversing mechanism in the valve. The plunger collides with the pressure cap in the valve to induce the reversing mechanism to lift the fixed valve ball for oil draining. The entire process can be reversed.	The tool features repeatability with good corrosion-resistance and applies to the producers with tubular pumps, especially for the wells with higher gas/oil ratio, highly deviated wells, and producers with sand and mud.	Its reverse mechanism features failure and has higher requirements of processing precision. It cannot be used in the wells with bad scale deposits.
Oil Draining Device with a Sliding Sleeve	The tool has a through-hole inside and a sliding sleeve outside and can be sealed and secured with 4 rings and pins. Pump pressure in the tubing to move the sliding sleeve to cut the pins for oil draining.	The strength of the pins and the sectional area of the sliding sleeve can be adjusted according to the pump setting depth, and the tools can be reused if necessary.	Poor performance in the highly oil and wax depositing wells. Also, the tool needs to stay away from the pump.
Shearing Oil Draining Device	Oil draining passage is set on the upper connector and is clogged with the oil draining device. Drop the impacting rod into the well to shear the pins to activate the oil draining device for oil draining if necessary.	Both the inside and outside of the tool have been treated with an anti-corrosion system and the corrosion rate is less than 0.076mm/a, which could help to improve the life and efficiency of the oil pumps.	It is not applicable to heavy oil producers and those with severe sand production.
Anti-Blowout Oil Draining Device	When RIH with the pump, the sealed gate can prevent the blowout. The pins can be sheared during the intervention for oil draining.	The tool features anti-blowout capability.	It has no auto-lock system and the valve will reset itself once the differential pressure of the oil draining device is excessively high.
Rotary Oil Draining Device	When picking up the tubing string, the center tubing will move reversely to the oil draining device. Once the stopper of the center tubing reaches the top of the reversing sleeve, the center tubing will coincide with the oil draining ports, then the oil draining ports will move out for the oil draining.	Oil draining can be achieved only after slacking off the tubing, rotating clockwise, and picking up. There is no auxiliary operation on the surface.	It is not applicable to the wells with tubing anchors, otherwise, the oil draining will fail.

In order to solve the above-said problems, Tarim Oilfield, based on its own conditions, has developed and fabricated a novel anti-blowout oil draining device with dual-opening function of rupturing + impacting by conducting an extensive investigation and in-depth analysis of the structures, principles, and drainage functions of the conventional oil draining devices and referring to the

structures of high-pressure rupturing oil draining devices with higher opening success rate on the basis of structure analysis, strength check and flow capacity calculations of the oil draining devices. The novel anti-blowout oil draining device not only ensures the establishment of the circulation channel during the workover operations to realize the goal of cleaning tubular operations but also meets the blowout prevention requirements of the snubbing operations, influx wells, shale oil wells, and the wells with blowout risks (the bottom valve can be closed anytime for blowout prevention). Its application prospect in the wells with sucker rod pumps (SRP) in Tarim Oilfield is promising.

2. Structure Design and Working Principle of Dual-Opening Anti-Blowout Oil Draining Device

2.1. Structure Composition of Dual-Opening Anti-Blowout Oil Draining Device

The dual-opening anti-blowout oil draining device is composed of a guide head, circlips, slide sleeve, bottom valve, spring, bolt, nut, washer, oil draining pin, and other components (see Fig. 1). With such a composition, the anti-blowout oil draining device features dual-opening function of rupturing and impacting and can also meet the blowout prevention requirements in the wells with high gas and liquid ratio. See Fig. 2 for the details of the tool.

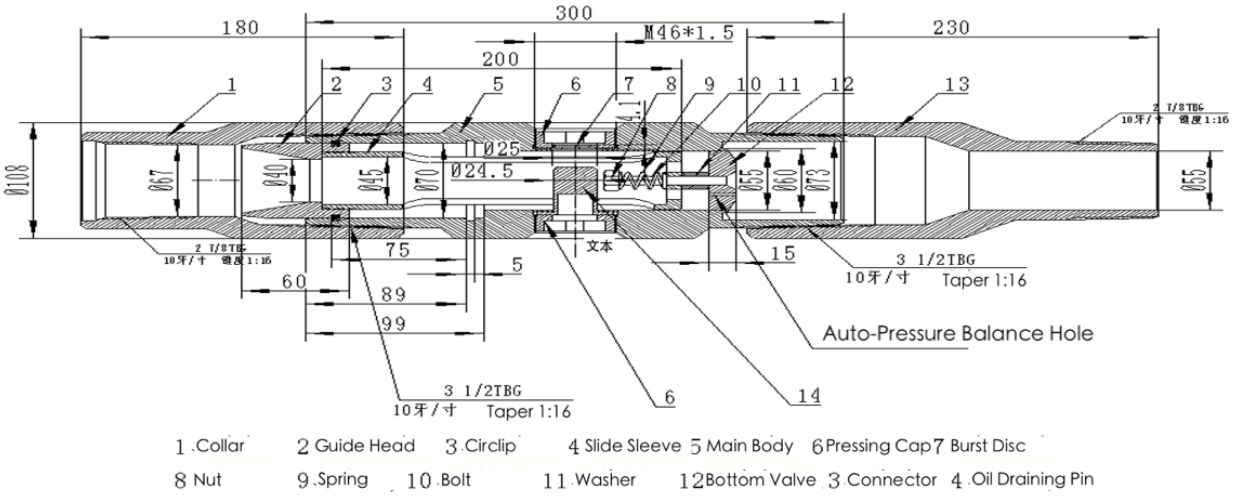

Figure 1 Internal Structure Diagram of Dual-Opening Anti-Blowout Oil Draining Device and Dimensions and Specifications of the Spare Parts

Fig. 2 Picture of the Dual-Opening Anti-Blowout Oil Draining Device

Table 2 Specifications of the Anti-Blowout Oil Draining Device

OD (mm)	Length (mm)	Starting Pressure (MPa)	Diameter of the Oil Draining Ports(mm)	Thread Type of both Upper and Lower Ends	Minimum Diameter(mm)	Pump Setting Depth(m)	Rupturing Pressure(MPa)
90-108	400-600	20-50	25	27/8TBG-31/2TBG Pin/ 27/8TBG-31/2TBG Box	30-40	3500	45

Table 3 Dimensions of the Critical Spare Parts

Name	Dimension(mm)
Guide Head	OD: ¢62, Inner Thread Type: M46×1.5
Tool Body	Body Shoulder ID: ¢64, Minimum ID: ¢50, Inner Thread Type of the Pressure Cap: M46×1.5, Length: 250
Pressure Cap	Outer Thread Type: M46×1.5
Oil Draining Pin	Maximum OD: ¢43, Minimum OD: ¢24.5; Minimum ID: ¢20, Length: 45
Slide Sleeve	Outer Thread Type: M46×1.5, ID: ¢40, Maximum OD: ¢50, Length: 175
Bottom Valve	Maximum OD: ¢54, Minimum OD: ¢48, Angle of the Sealed Shoulder: 45°, Thickness: 18
Rupture Disc	Maximum OD: ¢44, Minimum OD: ¢24.5, Thickness of the Rupture Disc: 1.1

2.2. Principle of Blowout Prevention

The dual-opening anti-blowout oil draining device consists of a guide head, circlips, slide sleeve, bottom valve, spring, bolt, nut, washer, oil draining valve and other components. When RIH with pumps, the anti-blowout oil draining device will be installed between the oil pump and the standing valve and is closed, the oil and gas will not migrate upward and influx with the pressure, which can effectively prevent the blowout. When the plunger gets into the pump barrel, the plunger will press down the guide head of the oil draining device (Fig. 1(Part 2)), and the circlip(Fig. 1(Part 3)) will leave its groove to enable the guide head (Fig. 1(Part 2)) to drive the slide sleeve (Fig. 1(Part 4)) move downward and the bottom valve(Fig. 1(Part 12)) will open to achieve pressure balance. Keep pressing down, the guide head will move downward along with the slide sleeve. Then the circlip will snap into the second groove and lock up, and the bottom valve will open completely. The fluid will get into the pump barrel through the slots of the sliding sleeve body and the four inlets of the slide sleeve to enable the normal oil producing.

2.3. Oil Draining Principle

2.3.1. Principle of Impacting Oil Draining

The impact oil draining mechanism consists of the main body (part 5), a pressure cap (part 6), and an oil draining pin (part 14), as shown in Fig. 3. The oil draining pin is made of copper alloy with surface coated for corrosion resistance. After POOH with the plunger during the intervention, a sucker rod with an OD of 19mm and length of 4m will be put into the tubing to break it, which can enable oil drainage.

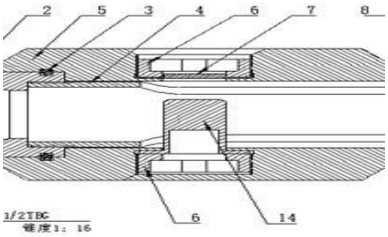

Figure 3 Schematic of the Impacting Oil draining device

2.3.2. Principle of Rupturing Oil Draining

The rupturing oil draining mechanism is composed of the main body (part 5), a pressure cap (part 6), and a rupture disc (part 7), as shown in Fig. 4. The rupture disc is made of copper alloy with surface coated for corrosion resistance. After POOH with the plunger during the intervention, pump in liquid with a pump truck to the tubing, and the disc will be ruptured with 15MPa for oil drainage.

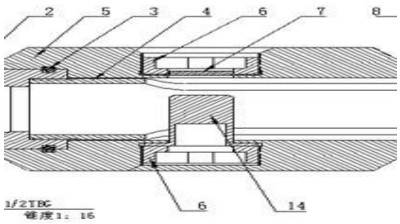

Figure 4 Schematic of the Rupturing Oil draining device

3. Strength Check and Flow Capacity Calculation of the Dual-Opening Anti-Blowout Oil draining device

In order to meet the stringent requirements of the tool strength under high load in Tarim deep wells, it is necessary to conduct strength checks of the anti-blowout oil draining device based on the design sizes and optimized material strength, along with the deepest 3,500m condition of the wells with sucker rod pumps (SRP) so as to ensure the safety and effectiveness of the anti-blowout oil draining device. At the same time, according to the design of both parameters and specifications of the anti-blowout oil draining device, combined with the flowrate requirements of the 38mm and 44mm pump diameters of the wells with sucker rod pumps (SRP) in Tarim Oilfield, the flow capacity of the anti-blowout oil draining device would be evaluated to ensure that it meets the minimum flow area requirements of the wells with pump units.

3.1. Selection of Materials

In view of the well depth of the wells with sucker rod pumps (SRP) in Tarim Oilfield and the high-pressure bearing requirements for the tools, the 45# carbon steel which is commonly used for the downhole tools has been discarded for the body and the upper/lower tool joints of the anti-blowout oil draining device, and the high-quality 35CrMo alloy steel is selected instead for its higher static strength, impact toughness and fatigue limit. The tensile strength of the 35CrMo steel alloy is no less than 985MPa, and the yield strength is no less than 835MPa, both of which can undertake even higher strengths.

Considering the high content of H_2S in the wells with sucker rod pumps (SRP) in Tarim Oilfield, aluminum bronze alloy is selected as the primary material of the rupture discs instead of the brass alloy for the enhanced long-term corrosion resistance. Even though the brass features higher strength, toughness, and excellent friction-reduction performance, it tends to corrode and crack when used in the hole conditions with higher H_2S content, therefore, it is ruled out. The aluminum bronze alloy features higher wearing and corrosion resistances when used in the conditions of atmosphere, seawater, and organic acids than brass. The surface coating with nickel phosphorus composite can meet the long-term corrosion-resistant requirements.

The components of the guide head, circlips, slide sleeve, bottom valve, spring, bolt, nut, rupture disc, and pressure cap are made of superior 304# stainless steel, which features not only high strength, but also superior H_2S resistance.

3.2. Strength Check

3.2.1. Stress Modeling of Up and Down Strokes

The anti-blowout oil draining device is connected to the lower end of the plunger pump barrel through thread connections, and the stress condition is the same as that of the plunger barrel. In the up and down strokes, the pump barrel is subject to multiple axial loadings, including liner weight, pump barrel weight, annulus pressure (axial), axial liquid pressure in the pump barrel, and the liquid friction between the plunger and the pump barrel, as shown in Fig. 5.

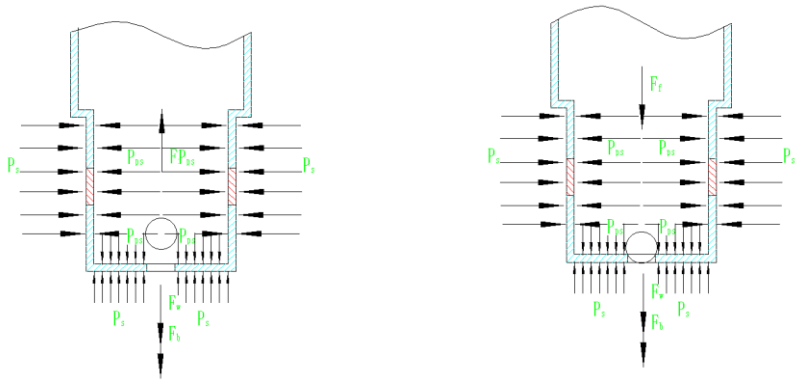

Fig. 5 Stress Modelling of both Pump Barrel and Anti-Blowout Oil Draining Device in both up and down stroke

3.2.2. Load Calculation of Up and Down Stroke

Based on the stress analysis of the anti-blowout oil draining device (see Fig. 5), the calculation of static up-stroke and down-stroke load is shown below:

Formula for the up-stroke static load:

$$F_{上} = F_w + F_x - F_f + P_{ps}\pi(r_1^2 - r_3^2) - P_s\pi\left(r_2^2 - r_3^2\right) \tag{1}$$

Formula for the down-stroke static load:

$$F_{下} = F_w + F_x + F_{fx} + p_{pd}\pi r_1^2 - p_s\pi r_2^2 \tag{2}$$

Where, F_w is the weight of the liner, N; F_x is the weight of the pump barrel, N; F_f is the up-stroke friction between the pump barrel and liquid, N; F_{fx} is the down-stroke friction between the pump barrel and liquid, N; r_1 is the inner radius of the pump barrel, m; r_2 is the outer radius of the pump barrel, m; r_3 is the radius of the fixed valve, m.

In which,

$$F_f = \pi L_P D_p\left[\frac{\left(p_d - p_{ps}\right).\delta_p}{2L_p} + \frac{\mu_L v_p}{\delta_p}\frac{1}{\sqrt{1-\varepsilon^2}}\right] \tag{3}$$

$$F_{fx} = \pi L_p D_p\left[\frac{\left(p_{pd} - p_d\right)\delta_p}{2L_p} + \frac{\mu_L v_p}{\delta_p}\frac{1}{\sqrt{1-\varepsilon^2}}\right] \tag{4}$$

Where, L_p is the plunger length, m; L is the length of the anti-blowout oil draining device, m; D is the pump barrel ID, m; D_p is the nominal diameter of the plunger, m; δ_p is the radial spacing between the plunger and the pump barrel, m; δ is the wall thickness of the anti-blowout oil draining device, m; μ_L is the viscosity of the liquid, Pa.s; v_p is the moving speed of the plunger, m/s; ε is the

eccentric distance between the plunger and the pump barrel, m; e is the eccentric ratio, $e = \varepsilon/\delta_p \rho$ is the liquid density in the well, kg/m^3.

Assuming the sucker rod pumps (SRP) are setting at the depth of 3,500m, the detailed operating parameters are shown in Table 4, and the load on the both up-stroke and down-stroke can be calculated.

Table 4 Operating Parameters of the wells with sucker rod pumps (SRP) (Depth: 3,500m)

F_w, N	F_x, N	r_1, m	r_2, m	r_3, m	L_p, m	L, m	ρ, Kg/m^3	p_{ps}, MPa
12000	260	0.022	0.02835	0.015	0.61	0.601	1000	45
D, m	D_p, m	δ_p, mm	δ, mm	μ_L, Pa.s	v_p,m/s	ε, m	e,m	p_{pd}, MPa
0.044	0.0435	0.19	6.35	53	1.1	0	0	45

The calculation shows that the up-stroke load on the anti-blowout oil draining device is $F_{up} = -4.03 \times 10^4$N, and the down-stroke load is $F_{down} = 1.79 \times 10^4$N. Based on the up-stroke and down-stroke loads, the stress load during the operation of the anti-blowout oil draining device can be calculated to ensure the stress loads needed for the strength requirements.

Formula (5) is for stress load calculation:

$$\sigma_r = \frac{F}{S} \cdot n \tag{5}$$

Where, σ_r is the stress on the anti-blowout oil draining device, MPa; F is the up-stroke and down-stroke stress on the anti-blowout oil draining device, N; S is the dangerous sectional area, m^2; n is the stress concentration factor, n=1.7.

In order to calculate the stress load, it is necessary to determine and calculate the dangerous sectional area S. According to the tool structure, the threads at both ends are the dangerous sectional area of the anti-blowout oil draining device, as shown in Fig. 6. The sectional area is annular, the dangerous sectional area of the tool is S=1,356.38mm^2 based on the calculation formula of the annular area and the structural dimension of the tool.

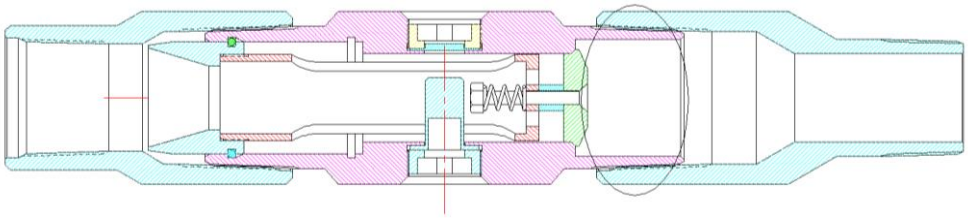

Fig. 6 Dangerous Sectional Area of the Anti-Blowout Oil draining device

After calculation, the up-stroke stress on the anti-blowout oil draining device is $\sigma_{r1} = 21.81$MPa, and the down-stroke stress is $\sigma_{r2} = 50.51$MPa. The average up-stroke and down-stroke stress is the averaged, that is 36.16MPa.

The stress requirements of the anti-blowout oil draining device are as below:

$$\sigma_{xd4} \le [\sigma] = \frac{\sigma_s}{n} \tag{6}$$

Where, σ_{xd4} is the calculated equivalent stress, MPa; $[\sigma]$ is the allowable safe stress, MPa; σ_s is the yield stress of the material, MPa; n is the safety factor, n=1.2~2.0, 1.5 for the pump in the tubing. The yield stress of 35CrMo alloy steel is 207MPa. When the safety factor is 1.5, and the allowable stress is 138MPa, which is far greater than the maximum stress and average stress on the anti-blowout oil draining device in both up and down strokes, satisfying the high load strength of the 3,500m deep wells.

3.3. Calculation of Flow Capacity

The calculation of the flow capacity of the anti-blowout oil draining device is to ensure the minimum flow area is no less than the allowable flow area for φ38mm and φ44mm pumps for the wells in Tarim Oilfield, enabling the normal production of crude oil. When the pump size is φ38mm, the flowrate of the pump is within 14.76~32.60m^3/d; while the pump size is φ44mm, the flowrate is within 20.70~44.60m^3/d; Assuming the pump setting depth is at 3,500m, the produced liquid is fresh water (ρ=1000kg/m^3), then the economic flow speed of the oil in the tubing is 1.5m/s.
Based on the economic flow speed and rate of the pump, the allowable tubing size would be:

$$d = \sqrt{4Q / \pi V} \tag{6}$$

Where, Q is the rated flowrate, m^3/d; V is the liquid flowing speed within the tubing, m/s; d is the allowable tubing size, m.

Assuming the pump size is φ38mm, the allowable pipe size is $d_{38} = 12.04\sim17.09\text{mm}$, and the corresponding allowable area is $S_{38} = 113.79\sim251.64\text{mm}^2$. Assuming the pump size is φ44mm, the allowable pipe size is $d_{44} = 14.04\sim20.93\text{mm}$, and the corresponding allowable area is $S_{44} = 154.74\sim344.05\text{mm}^2$.

The minimum flow area of the dual-opening anti-blowout oil draining device is shown in Fig. 7(1) with a diameter of 40mm (the flow area is 1,256.63mm^2). The minimum flow area of the oil draining part is shown in Fig. 7 (2) with a diameter of 45mm (the flow area is 1,590.43mm^2). The minimum flow area of the anti-blowout part is shown in Fig. 7 (3) with a diameter of 55mm (the flow area is 2,375.82mm^2).

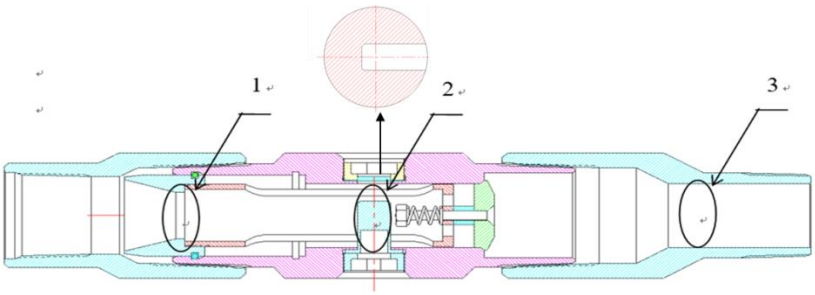

Fig. 7 The minimum sectional flow area of the dual-opening anti-blowout oil draining device

After comparison and analysis, the minimum flow area of the dual-opening anti-blowout oil draining device is greater than the minimum flow area of both φ38mm and φ44mm pumps, therefore, the flow area is sufficient for the tool requirements.

All in all, the above calculation and analysis show that the novel dual-opening anti-blowout oil draining device is sufficient for the requirements of blowout prevention and oil drainage in Tarim Oilfield in terms of materials, downhole working strength, and minimum internal flow area.

4. Indoor Performance Test of the Dual-Opening Anti-Blowout Oil Draining Device

To further validate the stability and operability of the anti-blowout oil draining device under the conditions of deep pumping well, substantial load differences and high content of H_2S, Tarim Oilfield has conducted the indoor mechanical property test, corrosion resistance test and other performance evaluations on the novel anti-blowout oil draining device so as to meeting the operational requirements of the wells with sucker rod pumps (SRP) in Tarim Oilfield.

4.1. Preparation of Testing Samples

In terms of the tools processing standards of Q/JT218.01-2020 and the operational requirements of Tarim Oilfield, all the testing samples are processed and prepared accordingly (see Fig. 8). Dual-

Opening Anti-Blowout Oil draining device (①), the sample of a slide sleeve (②), rupture disc (③) and the oil draining pin (④). Please check Table 3 for the detailed sample dimensions.

Table 3 Processing Dimension and Testing Items of the Testing Samples

Tool Material	Parameter(mm)	Testing Items
1. Anti-Blowout Oil Draining Device	Maximum OD: 106, Minimum ID: 53, Length: 250	Tensile Strength Test, Collapsing Strength Test, Functional Test of Opening, Closing, Making Up and Breaking out
2. Rupture Disc	Maximum OD: 44.3, Minimum ID: 24.5, Thickness (Maximum:4, Minimum: 1.1)	HIC Test
3. Slide sleeve Sample	115×15×4与30×20×4	Constant Tensile Stress and Corrosion Test for 218h
4. Oil Draining Pin	Length: 45, ID: 20, Maximum OD: 43, Minimum OD: 24.5	Electrochemical Tests

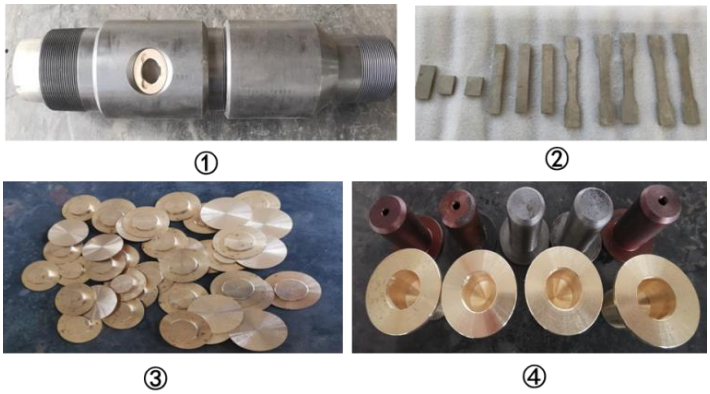

Fig. 8 Photos of the Testing Samples

4.2. Constant Tensile Stress and Corrosion Test without Autoclave

The test is primarily for verifying the stress and corrosion resistances of the slide sleeve. Based on the executive standard of GB/T 15970.1-2018, the testing slide sleeve will be placed in the corrosion tester with constant tension. At the same time, the testing slide sleeve is soaked in the H_2S saturated acidified sodium chloride solution for 218 hours, and it would be accepted without cracking.

Fig. 9 Photos of the Testing Process

After testing, all the samples have successfully passed the stress and corrosion resistance tests. The fabricated slide sleeve part is sufficient for stress, corrosion and high H_2S environment of Tarim Oilfield, as shown in Table 4.

Table 4 Test Results of Constant Tensile Stress and Corrosion Test without Autoclave

NO. of Test	Test Condition	Stress(MPa)	Testing Duration(h)	Test Result	Remarks
1	3.5%NaCl Room Temperature	60	218	Passed	Tensile testing the standard sample with distance >10mm and thickness <3mm.
2	3.5%NaCl Room Temperature	60	218	Passed	
3	3.5%NaCl Room Temperature	60	218	Passed	
4	3.5%NaCl Room Temperature	60	218	Passed	
5	3.5%NaCl Room Temperature	60	218	Passed	

4.3. Tensile Strength Test

This test is mainly to determine the tensile strength of the anti-blowout oil draining device. In terms of the executive standards of GB/T 15248-2008 and GB/T228.1-2010, the three samples are clamped on the tensile tester in sequence before starting the tester to apply tension till the samples fail while recording the tensile strength. See Fig. 10 for the test.

Fig. 10 Tensile Test

(1) #1 sample is connected to the 100T tester via special tool before starting the tensile strength tester. The sample remains intact without any cracks even with the tensile force up to the upper limit of 800kN.

(2) #2 sample is connected to the 100T tester via special tool before starting the tensile strength tester. The sample remains intact without any cracks even with the tensile force up to the upper limit of 800kN.

(3) #3 sample is connected to the 100T tester via special tool before starting the tensile strength tester. The sample remains intact without any cracks even with the tensile force up to the upper limit of 800kN.

All three tests show that both the design concept and the fabricated product of the anti-blowout oil draining device met the high load tensile strength requirements of the wells with TD of more than 3,500m in Tarim Oilfield.

4.4. Collapsing Strength Test

This test is mainly to determine the collapsing strength of the anti-blowout oil draining device. In terms of the executive standards of GB/T 15248-2008 and GB/T228.1-2010, all three samples are clamped on the collapsing strength tester in sequence before starting the tester, then apply compression till the samples fail while recording the collapsing strength. See Fig. 11 for the test.

Fig. 11 Collapsing Test

(1) #1 sample is compressed by a 500t compression tester while observing the sample deformation in real-time. When the compression force is up to 980kN, the sample was deformed and failed.

(2) #2 sample is compressed by a 500t compression tester while observing the sample deformation in real-time. When the compression force is up to 980kN, the sample was deformed and failed.

(3) #3 sample is compressed by a 500t compression tester while observing the sample deformation in real-time. When the compression force is up to 980kN, the sample was deformed and failed.

All three tests show that both the design concept and the fabricated product of the anti-blowout oil draining device met the high compression collapsing strength requirements of the wells with well depth of more than 3,500m in Tarim Oilfield.

4.5. HIC Test

In order to test the capability of rupturing discs to resist the hydrogen-induced cracking and in terms of the execution standard of GB/T 8650-2006, the testing solution is mixed as per Table 5, then place the rupture disc into the testing unit for resistance test, as shown in Fig. 12.

Table 5 HIC Test Details

pH of 5% NaCl+0.50%Glacial Acetic Acid Distilled Water Solution			H_2S Content of the H_2S Saturated Solution	H_2S Content of the Solution after Test
Initial Solution	H_2S Saturated Solution	When the test ends		
2.71	3.02	3.67	2333mg/L	2623mg/L

Fig. 12 Rupture Disc HIC Test

The test results demonstrate that the design concept and the fabricated product of the rupture disc met the hydrogen cracking resistance under the condition of a high content of H_2S in Tarim Oilfield.

4.6. Electrochemical Corrosion Test of the Oil Draining Pin

In order to test the electrochemical corrosion resistance of the oil draining pin and in terms of the executive standard of GB/T 13671-1992, secure the sample onto the electrochemical corrosion tester and load it into the electrochemical corrosive solution till the test ends. Then check the sample with a 20x magnifier to see whether corrosion takes place on the sample. See Fig. 13 for the test and results.

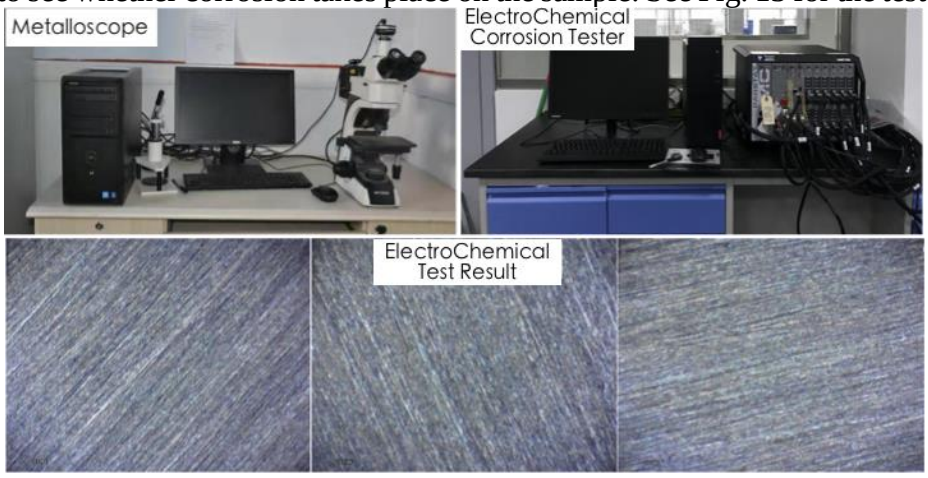

Fig. 13 Electrochemical Corrosion Test of the Oil Draining Pin

The test demonstrates that the design concept and the fabricated product of the oil draining pin does not have any electrochemical corrosion, which is fully in agreement with the requirements of corrosion resistance under the condition of high content of H_2S in Tarim Oilfield.

4.7. Functional Test of Opening and Closing

This is to test the opening function of the bottom valve and the sealing performance of the bottom valve when it is closed. In terms of the executive standard Q/JTHB-JS01-2020, the assembled anti-blowout oil draining device is installed onto the hydraulic tester by using the hydraulic tools and the pressure testing pump, then apply pressure on the guide head to move the slide sleeve downward and enable the circlips to come out from the 1st groove and snap into the 2nd groove while opening the bottom valve. Place the anti-blowout oil draining device into the pressure-testing barrel, apply 30MPa reversely, and hold for 5 minutes. If there is no pressure drop, then it means the bottom valve functions well. After 5 minutes of pressure holding, the pressure sustains at 30MPa without any drop, which indicates a successful test.

Fig. 14 Anti-Blowout Oil Draining Device (Left) and Hydraulic Tools & Pressure-Testing Pump (Right)

4.8. Test of Making Up and Breaking Out

This is to check the processing of the threads and spare parts. In terms of the executive standard Q/JTHB-JS01-2020, clamp the tool on the straightening machines with booth straightening tools and

thread gauge, then connect the tubing coupling to the upper and lower ends of the tool and screw 6.7cm evenly, then undo the coupling to test whether the tool and the thread connection are in good condition. After the test, it is found that all the spare parts are within the tolerance range with smooth make up and breaking out. The entire test is successful.

Fig. 15 Straightening Machine and Tools (Left), Manual Inspection and Test (Right)

4.9. Test Summary

The above test data and results demonstrate that the tensile strength, the maximum collapsing strength, and the bending stress of the anti-blowout oil draining device are 60MPa, 980kN, and 375kN, respectively. During the test, various functions like assemble and disassemble went on smoothly. According to the above test results, the anti-blowout oil draining device is sufficient for the wells with pump setting depth at 3,500m in Tarim Oilfield.

Table 6 Summary of Test Results

Name of Tests	Objective	Test Results	Results
Tensile Strength Test	To evaluate the tensile strength of the anti-blowout oil draining device	The sample is intact without any crack at the upper limit (800kN) of the tester.	Good
Collapsing Strength Test	To evaluate the collapsing strength of the anti-blowout oil draining device	The sample is intact at 800kN, it deformed and failed at around 980kN.	Good
Functional Test of Opening and Closing	To evaluate the opening and sealing performance of the bottom valve when it is closed	No pressure drops after holding 5 minutes of 30MPa	Good
Test of Making up and Breaking out (Initial)	To evaluate the thread processing	Make up and break successfully	Good

5. Conclusion

The novel dual-opening anti-blowout oil draining device features dual functions of rupturing and impacting and can also meet the blowout prevention requirements of the high gas-liquid ratio wells. After simulation and evaluation of the indoor tests, the novel dual-opening anti-blowout oil draining device can meet the design objective and operational requirements under special conditions of the wells with sucker rod pumps (SRP) in Tarim Oilfield.

(1) Installed between the pump and the fixed valve, the dual-opening anti-blowout oil draining device is closed, and the oil and gas will not flow upwards or influx along with the pressure, thus achieving the function of blowout prevention. When it is necessary to drain oil, the guide head of the oil drain device will be pressed down by the plunger, making the circlip leave the groove so that the guide head will move the slide sleeve downward and open the bottom valve. Then the guide head will keep moving downward along with the slide sleeve till the circlip snap into the second groove, and

the bottom valve opens completely. The fluid goes into the pump barrel via the slots of the sliding sleeve and the four oil inlets of the slide sleeve so as to achieve normal pumping.

(2) The main body and the upper/lower joints of the oil draining device are made of 35CrMo alloy steel, and the 35CrMo alloy steel features a tensile strength of no less than 985MPa and a yield strength of no less than 835MPa. The primary material of the rupture disc is made of optimal aluminum bronze alloy with nickel phosphorus composite coating on the surface, which is good for long-term corrosion resistance of the rupture disc and competent for the corrosive hole condition with higher content of H_2S in Tarim Oilfield. The components of the guide head, circlips, slide sleeve, bottom valve, spring, bolt, nut, rupture disc, and pressure cap are made of superior 304# stainless steel, which features superior hydrogen sulfide corrosion resistance on the premise of meeting the operational requirements.

(3) With the well depth of 3,500m in Tarim Oilfield, the up-stroke stress load on the dual-opening anti-blowout oil draining device is $F_{up} = -4.03 \times 10^4$N, and the down-stroke load is $F_{down} = 1.79 \times 10^4$N. However, the yield stress of 35CrMo alloy steel is 207MPa. When the safety factor is 1.5, and the allowable stress is 138MPa, which is far greater than the maximum stress and average stress on the anti-blowout oil draining device in both up and down strokes, satisfying the high load strength of wells with sucker rod pumps (SRP) in Tarim Oilfield.

(4) The minimum flow area of the dual-opening anti-blowout oil draining device is 1,256.63mm^2, of which the minimum flow area of the oil draining part is 1,590.43mm^2, and the minimum flow area of the anti-blowout part is 2,375.82mm^2. The minimum flow area of each part of the dual-opening anti-blowout oil draining device is greater than the minimum flow area of both φ38mm and φ44mm pumps, therefore, the flow area is sufficient for the tool requirements.

(5) The dual-opening anti-blowout oil draining device has passed multiple functional tests, including tensile strength test, collapsing strength test, a functional test of opening, closing, making up and breaking out, etc., therefore the application prospect of the anti-blowout oil draining device in challenging conditions of wells with sucker rod pumps (SRP) in Tarim Oilfield is promising.

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