

# Development and experiment of casting and fishing high pressure gas-lift valve in deep well

Zhan min, Cheng xinpeng, Shen qiong, Wang hong, and Li ang

Engineering and Technology Branch, CNOOC Energy Technology and Services Limited

**Abstract:** The deep formation fluid lifting should not only let the oil to the wellhead but also ensure the liquid from the wellhead to gathering platform or remote ground processing. Because the subsea pipeline is long, the liquid flow security must be guaranteed. So the deep mining requires higher gas injection pressure. The gas into the tubing arriving at wellhead still has certain pressure which can ensure the completion fluid flow. The filling nitrogen pressure of conventional gas-lift valve is limited so suppress the depth. At the same time, the pressure loss of traditional gas-lift valve gas is large, critical velocity range is relatively narrow, which is not stable for lifting. In order to solve this problem author develop a high pressure gas-lift valve, The test show that the inflation pressure and opening pressure of gas-lift valve significantly increased. In the meanwhile, the critical velocity range is improved, provide security for deep water lifting.

## 1. Introduction

Offshore oil exploitation has always preferred the lower cost gas-lift system as its artificial lift method, the gas-lift process requires the injection of natural gas through the production of tubing and casing annulus in the well, the injected natural gas can form bubbles in the production fluid in the tubing, thereby reducing the liquid density, traditional gas-lift technology is flawed in design. For example, the limitation on the gas injection rate required to obtain a stable fluid line and casing fluid flow rate, the lower maximum working pressure, and the unreliable back pressure system and so on<sup>[1]</sup>. These constraints are that conventional gas-lift methods cannot meet the safety requirements of high-pressure operations, and therefore cannot be used in a large number of deep water and subsea completions. A deep-water injection type high-pressure gas-lift valve is designed in combination with the characteristics of deep-water gas-lift, which can effectively improve gas-lift. The system suitability will meet the growing demand for future deep wells and subsea completions.

## 2. Structure and technical analysis

### 2.1 Structure

Deep water fishing type high pressure gas-lift valve structure is shown in Fig. 1.

The upper part of the nitrogen booster mechanism has a high-pressure valve core for inflating the chamber, and the chamber is used for storing high-pressure nitrogen to provide power for the bellows; The bellows pressurizing mechanism can enlarge the gas-lift valve opening pressure by a certain multiple under certain nitrogen pressure, and provide axial displacement for the valve ball. The ball and the valve seat are matched by grinding with high precision and different relative position control with different gas throughputs. The upper and lower packing roots are composed of a two-way



three-group V-shaped seal ring and a supporting body for sealing the clearance between the eccentric work-valve valve bag and the air-lift valve. Single-flow valves are used to prevent tubing fluid backflow<sup>[2]</sup>.

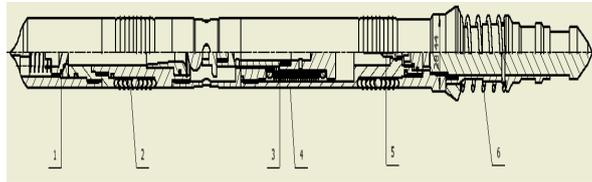


Fig. 1. Deepwater fishing type high pressure gas-lift valve structure  
1- Single flow valve 2- Lower packing 3- Nitrogen booster  
4- Air lift valve housing 5- Upper packing 6- Salvage head

## 2.2 Working principle

Deep-sea fishing type high-pressure gas-lift valve and conventional gas-lift valve have different storage chamber and ball opening structure in the nitrogen chamber<sup>[3]</sup>. The pre-charged high-pressure nitrogen gas is stored in the annular chamber formed between the outside of the bellows and the housing. When the gas-lift valve is working, the chamber pressure  $P_d$  acts on the outside of the bellows, the bellows is compressed, and the valve ball is sealed to the valve. Seat, gas-lift valve closed; The gas-lift valve under the action of the sleeve pressure  $P_c$  and the flow pressure  $P_t$ , the bellows stretches, the valve ball leaves the valve seat, the gas-lift valve opens, the high pressure gas injection from the oil pipe through the oil ring annulus high pressure gas-lift valve venturi gas nozzle. Then enter the tubing and start lifting the tubing<sup>[4]</sup>. Due to the external pressure of the pre-filled nitrogen gas on the outer bellows of the corrugated pipe, compared with the case of the conventional pre-filled nitrogen bellows subjected to the internal pressure, the nitrogen pressure of the same corrugated pipe can be significantly increased, and nitrogen is also added to the corrugated pipe. Externally, the open valve pressure acts on the inside of the bellows. The equivalent effective area on the outside of the bellows is greater than the equivalent area inside the bellows. This result can also amplify the opening pressure. The working principle is shown in Fig. 2.

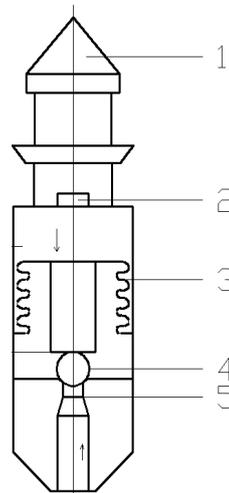


Fig.2. Air lift valve working principle  
1- Fishing head 2- High pressure valve core  
3- Bellows 4-Valve ball 5- Venturi gas nozzle

Analysis of the force of the high-pressure gas-lift valve can be obtained:  
Gas-lift valve is closed

$$F_c = P_d * A_{bl} \quad (1)$$

The force to open the valve

$$F_o = P_c(A_{b2} - A_v) + P_t * A_v \quad (2)$$

$F_c$ —Force to close the valve, N

$F_o$ —Force to open the valve, N

$P_t$ —Flow pressure inside the tubing at valve depth, MPa;

$P_d$ —Inflation pressure in valve chamber, MPa;

$A_{b1}$ —Outer area of corrugated pipe, mm<sup>2</sup>

$A_{b2}$ —Outer area of corrugated pipe, mm<sup>2</sup>

$A_v$ —Valve hole area, mm<sup>2</sup>

When  $F_o > F_c$ , the valve ball is separated from the valve seat. The high-pressure gas-lift valve is opened. High-pressure gas can enter the tubing lift liquid from the gas-lift valve venturi gas nozzle, in contrast, when  $F_o < F_c$ , the valve ball is sealed against the valve seat and the gas-lift valve is closed. High pressure gas cannot enter the oil pipe from the gas-lift valve nozzle.

### 3. Casting and fishing principle<sup>[5]</sup>

The injection-type gas-lift valve is preloaded into the eccentric cylinder at the ground, and the design position of the eccentric mandrel is lowered into the well. When the gas production valve needs to be replaced when the production system changes, it is not necessary to remove the eccentric cylinder and pass the surface at the wellhead<sup>[6]</sup>. The fishing rod, steel wire and fishing tool string are used to realize the replacement of the casting and fishing gas-lift valve.

When casting the gas-lift valve, the ground fishing equipment will send the fishing tool string to the position of the eccentric cylinder where the gas-lift valve is to be replaced and replaced, and a series of processes such as correcting, rebuilding, lowering, and grabbing will be used to make the investment<sup>[7]</sup>. Take the tool string to catch the head of the gas-lift valve, and then through the process of shock and lifting, remove the gas-lift valve from the eccentric cylinder and bring it to the ground; When the gas-lift valve is placed, the delivery tool string equipped with the gas-lift valve is passed through the wire to the position of the eccentric work cylinder, and the gas-lift valve is put into the eccentric work through the steps of correcting, rebuilding, lowering, shocking, and lifting. In the cylinder, the gas-lift valve is replaced.

### 4. Indoor test

In order to test the opening pressure of the design of the high opening pressure lifting valve and the ordinary gas-lift valve under different inflation pressures. First, in the nitrogen chamber of the high-pressure gas-lift valve and the ordinary gas-lift valve, a certain pressure of air is flushed. Two gas-lift valves are installed on the test bench, and air pressure is added to the outside of the air lift valve to check the opening pressure of the two air lift valves<sup>[8]</sup>. Thus, the gas-lift valve inflation pressure and open pressure curve are obtained. When the valve ball is opened, the pressure outside the valve seat is instantly released and has obvious sound characteristics to determine whether the valve is open.

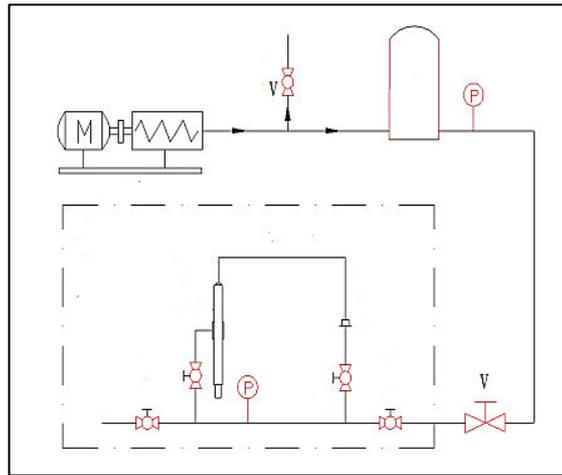


Fig. 3. Valve test flow chart

Table 1. High-pressure gas-lift valve under different inflatable air lift valve pressure gauge

|                           |      |       |      |       |
|---------------------------|------|-------|------|-------|
| No.                       | 1    | 2     | 3    | 4     |
| Inflatable pressure (MPa) | 1.48 | 2.44  | 3.11 | 4.63  |
| Open pressure (MPa)       | 1.65 | 3.28  | 4.56 | 7.13  |
| No.                       | 5    | 6     | 7    | 8     |
| Inflatable pressure (MPa) | 5.41 | 6.13  | 7.16 | 8.04  |
| Open pressure (MPa)       | 8.38 | 9.61  | 11.4 | 12.96 |
| No.                       | 9    | 10    | 11   |       |
| Inflatable pressure (MPa) | 9.2  | 13.08 | 14.5 |       |
| Open pressure (MPa)       | 16.3 | 23.4  | 26.1 |       |

Table 2. Ordinary gas-lift valve different inflatable air lift valve pressure gauge

|                           |      |      |      |      |
|---------------------------|------|------|------|------|
| No.                       | 1    | 2    | 3    | 4    |
| Inflatable pressure (MPa) | 1.02 | 2.17 | 3.11 | 4.84 |
| Open pressure (MPa)       | 0.71 | 1.96 | 2.87 | 4.73 |
| No.                       | 5    | 6    | 7    |      |
| Inflatable pressure (MPa) | 5.32 | 6.24 | 7.65 |      |
| Open pressure (MPa)       | 5.19 | 6.11 | 7.55 |      |

|                           |      |       |      |  |
|---------------------------|------|-------|------|--|
| No.                       | 8    | 9     | 10   |  |
| Inflatable pressure (MPa) | 8.22 | 10.61 | 11.2 |  |
| Open pressure (MPa)       | 8.16 | 10.59 | 11.2 |  |

Through the opening pressure test of the high-pressure gas-lift valve and the ordinary gas-lift valve, combined with the above data, it shows that the normal gas-lift valve inflation pressure and the opening pressure are linearly proportional to each other. The relationship between the normal gas-lift valve inflation pressure  $x$  and the punch pressure  $y$  is:  $y=1.0244x-0.2842$ . Its linear correlation is 0.9999. The high pressure gas-lift valve has a linear proportional relationship between the inflation pressure and the opening pressure, and has a proportional amplification effect on the opening pressure. The relationship between the inflation pressure  $x_1$  and the opening pressure  $y_1$  is:  $y_1=1.8916x_1-1.5855$ , Its linear correlation is 0.9973. The high opening pressure gas-lift valve has a low pre-inflation pressure and a high opening pressure characteristic.

According to the above table, the following chart is formed:

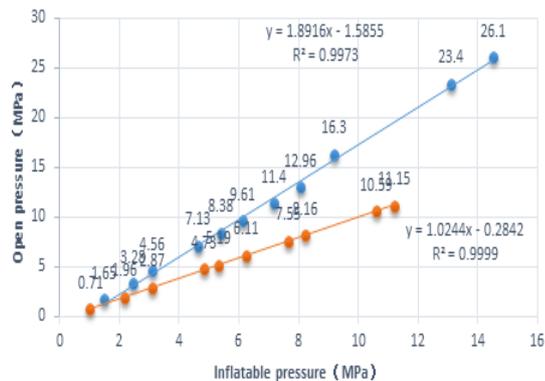


Fig. 4. Gas-lift valve opening pressure curve under different inflation pressure

## 5. Conclusions

The deep water high opening pressure lifting valve has a relatively new type of pressurizing mechanism, which can significantly improve the stress of the bellows and increase the nitrogen filling pressure. At the same time, the new pressurizing mechanism can effectively enlarge the gas-lift by utilizing the equivalent area difference between the internal and external pressures of the bellows. Valve opening pressure, through the indoor test its pressure capacity and the ability to amplify the pressure has also been well verified, due to the deep water and high opening pressure gas-lift valve can withstand higher pressure and can provide a higher injection pressure, which for deep water Large displacement of gas-lift laid a good foundation.

## References

- [1] Norwegian National Oil Company. Technological Innovation in Gas Lift Methods. Oilfield New Technology[J]. winter (2006/2007): 44-53
- [2] Zhao Xiaobo, Han Bingqi, Zhang Jun. Study on the Structure of Gas Lift Valves[J]. Fluid Power Transmission and Control. (2013) **04**: 51-53
- [3] Zhou Heping, Du Zhiwen, Yan Honghe. Performance test and application of ZBT-1 type casting and fishing gas lift valve[J]. Petroleum Machinery. (2002) **30(12)**:26-27
- [4] Zhong Zikai, Wu Xiaodong, Korea Qing, Lu Xinrun, Zhang Weipeng. A dynamic analysis model used for casing head gas assisted lift technologies[J]. Oil Drilling and Production Technology. (2017) **39(01)**:71-76.
- [5] Zhou Heping, Du Zhiwen, Qi Honghe, Li Xiaoqi, Li Lin, Cui Gang. Performance Test and

- Application of ZBT-1 Type Fishing Gas Lift Valve[J]. China Petroleum Machinery, (2002) **12**:26-27+37-59
- [6] Ren Shuang. Casting and Fishing Gas Lift Valve for Gas Lift Production[J]. Oil Forum. (2012) **31(01)**:59-61+72
- [7] Song Xianmin, Liu Qingyou, Sun Chenglin, Xiao Guohua, Hu Huili, Wang Jinzhong, Yan Yanqing. Gas-lift production technology of wire casting and fishing in highly deviated wells[J]. Acta Petrolei Sinica (2014) **35(05)**:979-986
- [8] Liu Xinfeng, Wang Xingen, Li Sanxi, Wang Zhonglu, Xue Yu, Liu Zhengwei, Song Lihui. The Optimization and Experimental Study of Gas-lift Valves Used in Offshore Oil and Gas Fields[J]. Journal of Yangtze University (Natural Science Edition) (2016) **13(14)**:63-65+6