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Research on Selection of Riser Tensioner System for Hydrate Drilling and Production Ship

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Abstract

When the latest research achievements of riser tensioners are learnt, the basic working principles of traditional riser tensioners, mainly divided into two types, wireline riser tensioners and N line riser tensioners. Seized and the preliminary analysis on the working principle and control of riser tensioners is accomplished. Then basis of the theoretical analysis of the working principles of riser tensioners, aim is to select the correct type.

Keywords

Riser tensioners; Rireline riser tensioners; N line riser tensioners.

1. INTRODUCTION

Drilling is a direct and main technical means to explore and exploit natural gas hydrate resources [1].

With the deepening of drilling depth, the length of the equipment riser connecting the underwater BOP and the diverter at the bottom of the platform is also gradually lengthening, up to more than 3000 meters. Subsequently, the vertical and horizontal movement of the platform driven by waves will produce corresponding forces on the riser string, making it difficult for the riser string to maintain a stable state in the water, and it is easy to break. Therefore, it is very important to equip a set of riser tensioner system. As the key equipment of current drilling operation, riser tensioner system connects drilling platform and riser system to provide sufficient top tension for riser [2].

Riser tensioners are mainly divided into two types: wireline riser tensioners and N-line direct acting riser tensioners [3].

2. DEVELOPMENT STATUS AND RESEARCH CONTENTS

Offshore drilling riser tensioner is a key equipment on the drilling platform or drilling ship during relocation. It is used for the installation and connection between the drilling riser and the floating platform or drilling ship. Its function is mainly to establish a top constant tension system for the drilling riser, protect the riser and eliminate the heave movement of the floating platform or drilling ship relative to the drilling riser. Drilling riser tensioner is a high-tech offshore oil and gas drilling equipment integrating electricity, gas and fluid. Its technology has been monopolized by foreign developed countries for a long time. In addition, with the further increase of China's offshore oil and gas exploration, it is of great benefit to study the use of drilling riser tensioner for supporting floating drilling platform or drilling ship system to improve China's offshore drilling [4].

The design and manufacturing technology of offshore riser tensioning system has been mature, but its design and manufacturing technology is mainly mastered by a few large western

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companies such as Nov, Cameron and Aker MH. The products developed by these companies have been widely used on offshore platforms. According to the design specification, the riser tensioner shall be designed and manufactured in accordance with API 16F-Specification for offshore drilling riser equipment.

There are two types of marine drilling riser tensioners: wireline type and N-line direct action type. The wireline type has mature technology and is suitable for drilling modules in semi-submersible drilling platforms or drilling ships. The N-line direct acting tensioner is difficult to manufacture and advanced in technology. It is suitable for installation at the lower part of the drilling module platform in a large semi-submersible drilling platform or drilling ship, and its tensioning capacity can be larger [5].

Figure 1. Hydraulic cylinder direct acting tensioner system

This paper mainly studies the following two aspects:

(1) Load data, influencing factors and calculation methods of riser under various typical operating conditions;

(2) Configuration demonstration of riser compensation system.

3. ANALYSIS AND CALCULATION OF N-LINE DIRECT ACTING TENSIONER SYSTEM

3.1. Technical Analysis

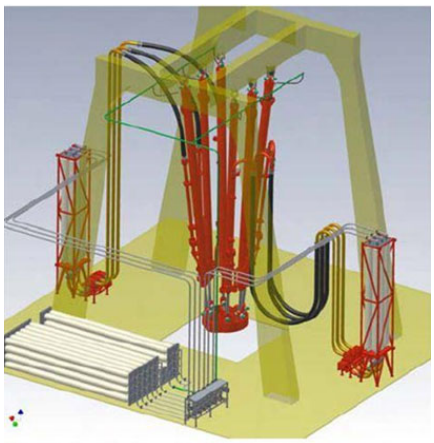

Figure 2. Equipment composition diagram of cylinder-line direct acting tensioner

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As shown in Figure 2, from left to right, there are several long white containers on the ground, which are high-pressure cylinders. Next to it, gray is the pneumatic control valve group, that is, the air control block of riser tensioning system.

On the next floor, there is a light gray bottle device in the red shelf, which is an accumulator. The red thing next to its feet is the shut-off valve block group. Then there is the black hose, and the middle red equipment part is the equipment body of the hydraulic cylinder direct acting tensioner. There is also a lack of equipment in the figure, high-pressure air compressor[6].

Starting from the air power source, the high-pressure air compressor generates gas with a pressure of up to 300 barg, which enters the pneumatic control valve group and is reduced to 207 barg. There are 6 sets of pneumatic controllers (generally, our tensioner system has only 6 tensioners). First introduce the pneumatic valve group, which can control the flow direction of high-pressure gas from the air compressor, high-pressure gas cylinder and gas in the accumulator. There are 5 valves in one set, which respectively control[7]:

1. The compressor inflates the high-pressure cylinder to increase the pressure inside.

2. The main valve and high-pressure gas cylinder supply working gas to the accumulator.

3. Vent the gas in the high-pressure cylinder to reduce the pressure inside.

4. Bypass the main valve.

5. Discharge the gas in the accumulator to reduce the pressure inside.

Since it is a pneumatic control valve, there must be control air supplied.

207barg of high-pressure gas can then enter the accumulator group. They are usually arranged on both sides of the moon pool, with one on each side to control the tensioner on each side. Each accumulator group is divided into 3 groups with 2 accumulators in each group to control one tensioner. (The picture in the figure is the picture of the drilling platform of Sevan company in Norway, and the accumulator group is in the red frame.)

An accumulator is a bottle containing half liquid and half gas. So its full name should actually be called gas-liquid accumulator. The volume of each accumulator is about 1800l, which is equipped with accessories such as safety valve, liquid level gauge and differential pressure sensor. Obviously, the liquid is in the lower part of the accumulator and the high-pressure gas is in the upper part. Thus, the pipeline at the lower part of the accumulator is a high-pressure hydraulic oil pipe.

We can see from Figure 2 that the high-pressure oil pipe of the accumulator is connected to a device, which is also the red part, which is the closing valve block. Similarly, like gas-liquid accumulators, one is arranged on both sides of the moon pool. Similarly, each is also divided into three groups, and each group is connected with two corresponding accumulators.

The shut-off block is a hydraulic control valve group. Its main valve is a hydraulic differential control valve. The main valve controls the opening of the valve by controlling the movement of the valve core through the spring and piston hydraulic cylinder. A linear variable differential sensor is installed on the control hydraulic cylinder. Other pilot, reversing and check valves control the flow direction and pressure of the fluid entering the main valve.

Each shut-off valve block has an external power unit as the pilot oil into the hydraulic control valve. These pilot oil is stored in a small accumulator pre filled with oil, and the pressure is maintained by a small pneumatic pump. The start and stop of the pneumatic pump depends on the pressure fluctuation of the accumulator and is controlled by PLC.

Therefore, the closing valve block is a control equipment to control the flow of hydraulic oil in and out of the tensioner. In case of disconnection of the riser, this equipment can cut off or lock the hydraulic oil entering the tensioner to reduce the impact of recoil of the riser. Therefore, it is also called riser return spring system.

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Figure 3. Outline drawing of direct acting tensioner

The direct acting tensioner is composed of cylinder block, piston and lower tensioning ring. It will also be equipped with safety valve and position measurement system. Figure 3 shows the shape of the tensioner. Figure 4 shows the state of the separated riser tension ring in the non-working state.

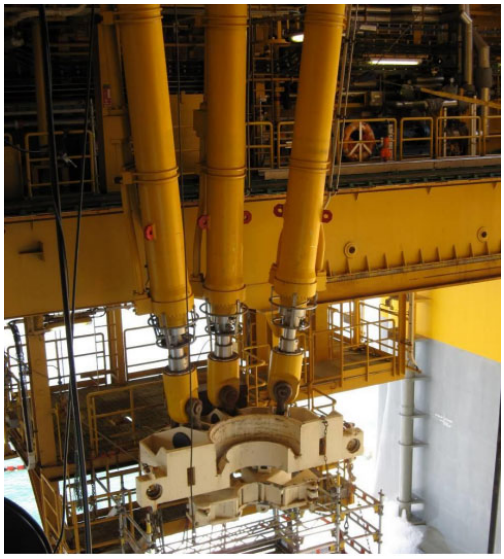

Figure 4. Schematic diagram of riser tension ring

3.2. Tension Calculation

The tensioner provides a nearly constant upward tension acting on the riser string to balance the movement impact of the lifting platform on the riser string. The riser string is connected to the wellhead on the seabed, and the tensioner must be able to offset the difference in motion between the riser string and the platform [8].

According to the national standard GBT 30217.1-2013 Part 1, in the design and operation of offshore drilling riser equipment, the minimum value Tmin of riser string top tension can be determined by the following formula:

Tmin=TSr min x N [Rf (N-n)]

TSrmin——Minimum tension of tensioning ring:

TSr min= W +A1(ρmHm-ρwHw)

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W——861-208.2=652.8T;

A1——internal cross-sectional area of riser;

A1=π/4/[Driser^2+(2xDc&k^2) +Dbooster^2] =0.22m^2

ρm——drilling fluid density(ρm =2.2T/m^3);

Hm——drilling fluid column height (Hm =3600-9+33=3624m);

Pw——Seawater density, (Pw =1.025T/m^3);

Hw——Sea water column height, (Hw =3600-9=3591m);

TSr min=652.8+0.22(2.2x3624-1.025x3591)=1596.24T

Tmin= TSrmin x N [Rf (N-n)]=1596.24x6/[0.95x(6-2)]=2520.37T

Due to the use of n-line tensioner, there are six separate hydraulic cylinders. Therefore, N in the above formula is 6; The number of failures is a pair, which is 2; RF value is 0.95.

According to the above table and calculation, the load of riser tensioning system under the following two typical working conditions is as follows:

1. Operating condition (riser in water):1596.24t
2. Living condition (riser in water): 2520.37t

3.3. Planning

Based on the analysis and calculation in the previous chapters, the configuration of direct acting riser compensation system is as follows:

Table 1. The configuration of direct acting riser compensation system

No	Equipments	quantity	parameter
1	N-line direct acting tensioner	1	6 cylinder -2520T
2	Riser Tensioner Ring	1	2520T
3	Working air bottle 2600L	36	207BAR
4	Spare air bottle 2600L	12	300BAR
5	Low pressure nitrogen cylinder 500L	6	8BAR
6	control device	1	Six cylinders are controlled separately

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