

# Analysis of the current situation of the Chinese iron roughneck

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## Abstract

At present, in China's drilling platforms, hydraulic power tongs are often used to complete the connection of wellhead drill pipes. Hydraulic power tongs require manual operation and complex operation. The working environment is harsh and the work efficiency is general. It is gradually unable to suit modern high-efficiency and high-automation drilling platform's demand. The Iron roughneck is one of the automation equipments of the drilling platform and has gradually replaced the hydraulic power tongs. This article describes the research status of Chinese Iron roughneck in recent years. On this basis, classifies different types of iron roughnecks and analyzes their advantages and disadvantages.

## Keywords

Iron roughneck, drilling platform, research status, construction classification.

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## 1. Introduction

Iron roughneck is a complete functional, safe and efficient rotary drill pipe device. It is mainly composed of columns, moving device, screw clamp, punching clamp, hydraulic control system and hydraulic power station. Moving the clamp body to the wellhead through the migration system, and then driving the rod connector with high-speed rotating screw pliers to quickly connect and remove threads, can integrate low-speed large-torque punching and high-speed low-torque screwing, and complete the connection of the rod parts. In the production process, remote operation can be realized through automatic control or control platform, which can realize rotating screw, punching and cutting, etc., and is a very important auxiliary equipment in the automatic drilling process [1]. Compared with hydraulic power tongs, iron roughnecks have the following advantages.

**Safety:** it is easy to realize automatic control when iron roughnecks cooperate with other equipment on the drilling platform. Operators can work far away from the wellhead, avoid the splashing of mud, and guarantee the safety during operation.

**High efficiency:** iron roughnecks do not need to change the drill pipe diameter when they are working on the drilling platform

**Replace the corresponding jaw plate.** It has high efficiency and simple operation.

**Low technical:** the hydraulic power pliers need at least two staff to operate during the work, and the transfer and delivery stage of the hydraulic power pliers need to be separated from the work stage. This requires more operators and longer training time.

**Low maintenance cost:** low maintenance cost for iron roughnecks. There are relatively many transmission gears and rolling bearings used by traditional hydraulic power tongs. These accessories are easy to damage, which increases the maintenance cost.

Based on the above advantages, the iron roughnecks have gradually replaced the inefficient and high-risk hydraulic power tongs [3] to connect the up, down, down, down, punching and other rotating fasteners to the drill pipe, drill collar and pipe, which has greatly improved the production efficiency

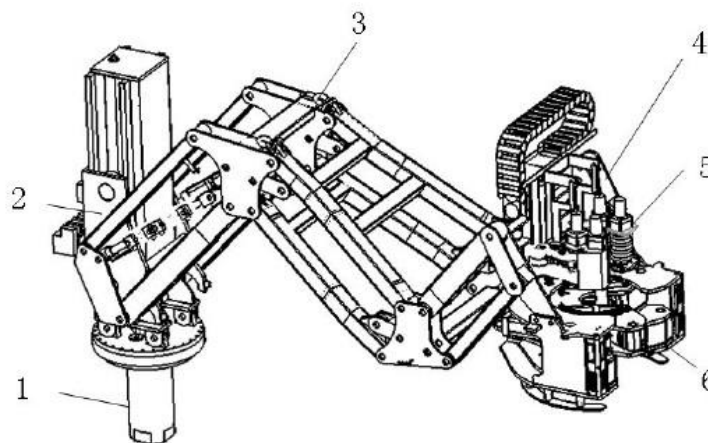
and operation safety. Based on the advantage of the iron roughneck, this paper systematically summarizes and analyzes its common structure forms.

## 2. Structural classification and research status of iron roughnecks

At present, the more mature structure of iron roughnecks is arm type iron roughnecks and floor type iron roughnecks. Most of other types of iron roughnecks are still in the theoretical stage

### 2.1 Arm iron roughneck

Arm iron roughnecks are also known as telescopic arm iron roughnecks and rocker iron roughnecks. Arm type iron roughneck is the most widely used drilling platform of the iron roughneck type, as shown in figure 1, is mainly composed of base, supporting columns, hydraulic system, control system, lift system, arm system, transport system and clamp body (stents, turnbuckle, button punching cutters), different types and manufacturers of the iron roughneck in structure may be slightly different but overall the operation principle of roughly similar. It fixes the iron roughneck system on the frame body system, and move iron roughneck to wellhead by migration system (drilling platform in our country to use more directly by the base fixed in the mouth of the well type), the control system operation, remove the clamp body to telescopic crane lifting system and connection required to drill, fixed by clamping pliers will drill pipe, and then through the spinner and button punching cutters for drill pipe on the buckle clasp and buckle, shackle, etc.



1- support the vertical column; 2- lifting system; 3- arm system; 4-clamp body support; 5- screw pliers; 6 - button punching pliers

Figure 1 Arm drill

Refer to the structure of arm type iron roughnecks, domestic enterprises have gradually developed a variety of iron roughnecks' products through reference, exploration and development. like gem TZG 9 3/4-140 - s, TZG 20-200 - g iron roughneck researched and developed by Baoshi petroleum machinery company, LM - 120 iron roughneck produced by Honghua petroleum equipment company, arm type iron roughneck produced by nanyang clips petroleum equipment company, the iron roughneck ZQF216-110 produced by machinery company in jiangsu province, TZG - 130 I iron roughneck designed by Liaoning luhai petroleum equipment research institute, etc <sup>[4]</sup>. Relevant academic researches mainly include:

In 2007, Zhang Yong and his teammates put forward the design of the new type of portable iron roughneck, using the design of unmovable base. its main characteristic is combined type drill pipe power tongs and B crabs, which apply the principle of bionics, realized the accurate remote control, its structure to meet the requirements of drilling ship " an inch of land values an inch of gold " and cooperate with pipe processing equipment, It applied to the ocean drilling ship and self-raising drilling ship, contenting the breakout of the drill pipe and automation <sup>[5]</sup>. In 2008, Yu Hao studied the

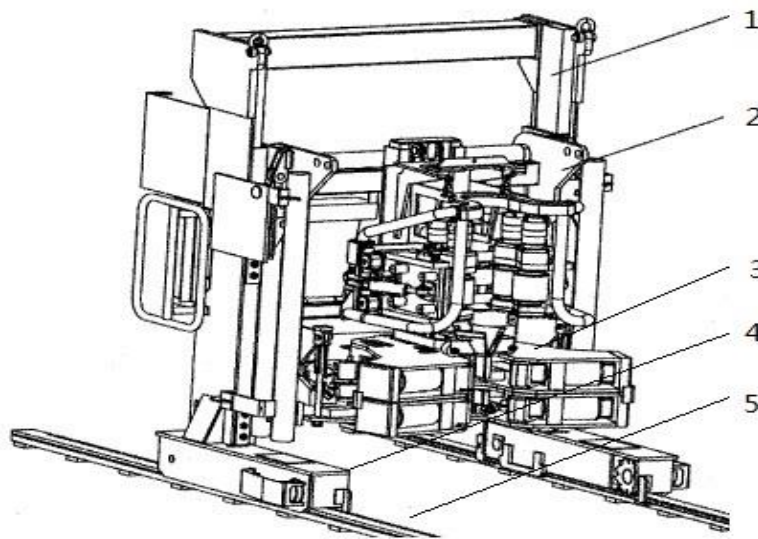
TZG216-110 iron roughnecks. The maximum clamping pipe diameter of iron roughnecks designed by Yu was 216mm, and the maximum unloading torque was 110kn.m<sup>[6]</sup>, which was used to replace the power tongs used by domestic mainstream at that time, The design can meet the needs of conventional tongs at that time as well and the performance can be improved. In 2008, Zhang hongsheng and his teammates completed the design scheme of tzg-130 type iron roughneck, which is the first batch of domestic self-developed iron roughnecks, adopting the immobile base design. The overall structure is relatively simple. The equipment is installed directly on the drilling platform. It is easy to install. When it left idle, the arm can shrink completely and does not occupy the drilling platform space. The improved clamping structure reduces the pressure requirement of hydraulic system. It adopts the full-fluid dynamic method, with smooth and quick movements, simple structure and easy maintenance<sup>[7]</sup>. In 2009, Chinese Baoshi machinery company developed the tzg-130 type iron borer, which was improved on the previous samples. Its advantages include wide range of drill tools, large torque, long telescopic arm and accurate upper torque adjustment. This type of iron borer is also the first iron borer with independent intellectual property rights in China. It is a qualitative breakthrough. In 2014, Li hongbo and his teammates designed a kind of telescopic arm iron roughnecks, which still uses the base type design, but has a breakthrough in efficiency and performance. The telescopic arm iron roughnecks have a fast degree of shackle, and only 10s are needed for up or down 1 drill pipe. The telescopic arm iron roughneck developed by the company has three control modes, advanced performance, compact layout, convenient maintenance, and can realize the "one-key" automatic operation of upper and lower shackles, featuring high positioning accuracy, consistent movement, flexible operation and stable operation<sup>[8]</sup>. In 2016, Xiao suchen optimized the structure of the rocker type iron roughneck, design a kind of advanced and reasonable arm type iron roughneck, on the basis of predecessors' design, made a part of the structure's optimization and improvement, such as pliers head, using the idea of interchangeability in the design, for different tool types and working environment change of different structure types of clamping jaws. At the same time, the structure of the clamping teeth of the iron drilling rig with radial arm was optimized, and an appropriate set of structural parameters of the clamping teeth and the distribution type of the tooth surface were selected to increase the clamping friction without damaging the drill tool<sup>[9]</sup>. Through kinematics analysis, finite element analysis and simulation system, the rationality of its design is verified. In 2016, Huang xianzhen proposed the novel iron roughneck module type design and the base free design as well as the new rotary device. Modular design can minimize manufacturing cost, improve reliability and reduce maintenance difficulty. The non-base design reduces the preparation time before the iron roughneck works, and solves the problem of the whole iron roughneck gravity on the front end of the concentrated iron roughneck, which leads to the bolt damage in the long term.

The arm-type iron roughneck occupies a small wellhead area, is easy to operate, and has flexible work. The working conditions of its components are completely visualized during operation, small in size, convenient for transportation, and easy to maintain. It has become the most widely used iron roughneck. However, it also has shortcomings, such as large arm sway, low load, low torque, small adjustable range of the rotary tongs, and easy error when aiming at the mouse hole and the wellhead.

## 2.2 Floor-standing iron roughneck

Floor type iron roughnecks are mainly rail type iron roughnecks that are laid at the wellhead for migration.

As shown in fig.2, the main structure includes track, base, lifting frame, clamp head frame, clamp body, control system, hydraulic system, etc. Set up the base or lay the track on the drilling platform, and adjust the position of up and down and front and back through the control of hydraulic device. The front-end clamp body and working principle are basically the same as the arm type iron roughneck worker.



1- lifting fram 2-Pliers Shelf 3-Pliers 4-base 5-track

Figure 2 track drill

Domestic rail type iron roughnecks are less used, only Baoshi machinery LLC successfully developed road type 200 iron roughnecks (tzg93/4-200gf iron roughnecks) in 2017 ,it complete various tests, including movements, pressure resistance and functions, and successfully passed China classification society (CCS) certification and the acceptance of cnooc users. Academic research on rail drilling is also limited. In 2011, sun jinting invented a rail-mounted, highly integrated intelligent iron roughneck, whose structure is integrated with lift truck, clamp head frame, main back clamp and guide rail. Its design can greatly reduce the weight of the whole equipment and improve the working efficiency. The iron roughneck can realize the application of high torque, wide range pipe diameter rotary punching device, which is applicable to upper shackle of all size groups of drill pipe <sup>[11]</sup>.

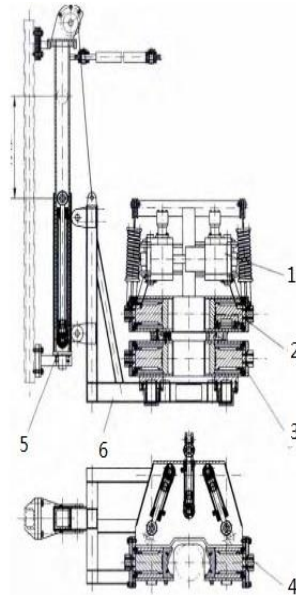
In January 2018, Chunchen and his teammates completed the design of TZG20-200GF orbital iron drill. This type of iron drilling are machine, electrical, hydraulic integrated products. This rail type iron drill structure is light and flexible, easy to use, and the whole equipment can be operated continuously through one-key operation to complete the upper and lower fastening procedures, with high working efficiency <sup>[12]</sup>. The special part of Chunchen and his teammates design is to use electrical control system to operate the hydraulic control system, thus to remote operation of the iron roughneck, when using the offshore drilling platform can reduces the risk of the workers work, the iron roughneck has three operating modes, the roughneck house work station of PLC control, local control, hand remote control box control.

With a wide adjustable range and high overall working efficiency, and due to the limited degrees of freedom of track. the rail type iron drill wrench can be operated precisely in a relatively stable environment However, due to the large number of tracks needed to be laid, large rig platform wellhead area needs to be occupied, and the price is expensive, so it can only be used in some large rig platforms.

### 2.3 Rotary iron roughneck

Yin Yugang and his teammates proposed a rotary portable iron drill in 2014, which is composed of rotating columns, brackets, main tongs, back tongs, rotary tongs and hydraulic control system. The iron roughneck is completely different from the common arm-type iron roughneck and floor-standing iron roughneck. The caliper part is directly mounted on the derrick, and it is moved to the wellhead only by the rotating device, and the turning of the drill pipe is completed. Wait for the operation. Because it is mounted directly on the derrick, there is no need for a frame and base. The compact structure makes it almost no space for the wellhead. This model is lightweight, easy to disassemble

during transport and quick to assemble. It adopts PLC intelligent control and good operation panel design, which makes the operation very simple, and can accurately control the torque. The action is accurate and flexible, and the reliability is high, which can greatly improve the work efficiency [13]. Its design is mainly for coalbed methane drilling rigs, and it needs to be further developed and developed on the structure to be applied to most drilling platforms. However, this idea can provide a reference for simplifying the structure of iron roughnecks.



1-rotating pliers; 2-back pliers; 3-main pliers; 4-hydraulic control system 5-rotating column; 6-bracket  
Figure 3 Rotary Lightweight Iron roughneck

**2.4 Rotary iron roughneck**

The arm-orbit-coupled iron roughneck is both stable and reliable with orbital iron roughnecks, and has the dexterity and coherence of an arm-type iron roughneck. Through the combination of orbital iron roughnecks and arm-type iron roughneck, the researchers have improved the development of arm-track combined iron roughnecks. In 2015, Wu Aiping explored the feasibility of using an arm-orbit-coupled iron roughneck on a drilling platform. The arm-orbit-coupled iron roughneck can run horizontally on the laid track, and the telescopic arm structure can drive the caliper body to expand and contract, and the structural characteristics of the integrated rail-type and arm-type iron roughnecks [3]. As shown in Fig. 4, the arm track combined type iron drill can be classified into arm track parallel, vertical, and skew type. Respond to different types of drilling platforms. However, the arm-orbit-coupled iron roughneck also has the disadvantages of some rail-type iron roughnecks and arm-type iron roughnecks. If the track is required to be laid, the wellhead space will still be occupied, and the mechanical arm used may still cause large shaking.



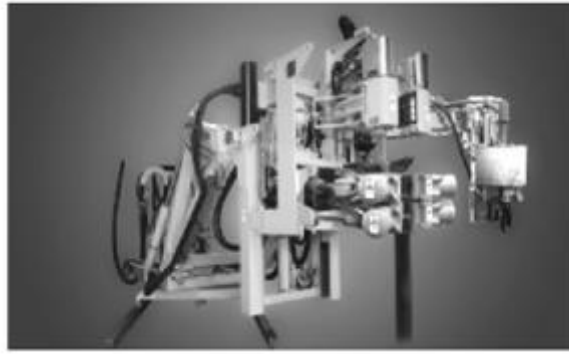


Figure 4 Various types of arm track combined iron roughnecks

### 3. Development and expectations

From the current major industrial countries' research on the development of drilling platforms, it can be seen that the future drilling platforms will gradually change into four aspects: automation, diversification, modularization and high intelligence, targeting different geographical locations and geographical conditions. The mining site, the design and size of the rig, and the weight of the function will vary. Automated and versatile rig design can improve the current waste of resources and ecological damage caused by violent mining energy, while modular and highly intelligent drilling rigs save costs, increase production efficiency, and greatly reduce Workers are involved in the enormous safety and health problems that exist in drilling. The premise of making progress on the drilling platform is inseparable from the improvement of the performance and design of the iron roughneck. From the current development trend of iron roughnecks, the main collection of China's energy will gradually move from land drilling platforms to offshore drilling platforms. Orbital iron roughnecks have gradually failed to meet the requirements of drilling platforms, especially offshore platforms. Under the premise of limited, the arm-type iron roughneck can better reflect its convenient operation and flexible work. With the automatic control of the robot arm by the program, with the cooperation of the handling robot and the automatic detection device and the feedback device, the construction of a small platform or even an unmanned platform can be completed. Rotary iron roughnecks do not occupy the advantages of platform space and may play an important role in the future miniaturization platform. It is a key technology in the diversification and miniaturization of drilling platforms. At present, it is a crucial period for "Made in China 2025" (A strategic plan for promoting industrial development by the government, just like Germany's Industry 4.0). As a key industry strategy for energy exploitation, drilling platforms are related to national economy, national defense construction, scientific and technological progress and people's livelihood. Although there is a big gap with the international advanced level, it is necessary to increase support, shorten the gap, and ensure that the autonomy is controllable. The use and development of iron roughnecks is in line with the future development trend of "machine substitution". The further development and performance guarantee of iron drilling workers in China's drilling platforms relies on the breakthroughs in research on high-end CNC systems and high-performance functional components. The iron roughnecks who have completely developed themselves in China need key cores such as reducers, drives, controllers and sensors. Localization of parts. At present, the development of key components such as cycloidal pinwheel reducer, precision harmonic reducer, high-precision servo motor and driver, and high-performance controller for Chinese robots is expected to make breakthroughs around 2020, when the performance and cost of domestic iron roughnecks will be achieved. It will be greatly optimized and may go abroad to enter the international market.

### 4. Preliminary summary

By comparing and analyzing different types of iron roughnecks, we can see that:

- (1) Arm-type iron roughnecks are currently developed and used more, and their operation is simple and flexible. At present, the arm-type iron drill structure has gradually become stable and mature after many optimizations, and is used on both land and offshore drilling platforms.
- (2) Floor-standing iron roughnecks are safe, fast and efficient when used. The utility model has the advantages of high stability, strong carrying capacity, large adjustable range of the rotary clamp pliers, and convenient installation and disassembly. Suitable for drilling platforms with large wellhead areas.
- (3) The rotary iron roughneck has a simple structure and does not occupy the area of the drill floor, but the scope of use is relatively limited. It has been improved for drilling platforms with a small available area at the wellhead.
- (4) The arm-orbit combined iron roughneck has the characteristics of an arm-type iron roughneck and a rail-type iron roughneck, and balances the advantages and disadvantages of the two-type iron roughneck. Compared with rail-type iron roughnecks, it reduces the laying of multiple sets of rails and saves space. Compared with arm-type iron roughnecks, it improves safety and load-bearing capacity.

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