

Features of the tripping mechanization with the horizontal pipe laying

Aleksey Markelov, Lyudmila Gavrilova, and Sergey Belov

Ural State Mining University, 620144, Ekaterinburg, Russia

Abstract. The relevance of the work is due to the need of the oil industry in the tripping mechanization when working with the drilling, casing and compressor tubes with simultaneous reduction in the installation, disassembly and transportation of the pipe storage units while ensuring the required technological capabilities. The purpose of the article is to consider the possible design improvement of the mechanized V-door ramp in order to simplify the oil well construction or repair. The article presents an analysis of existing equipment for the operation mechanization with the horizontal pipe laying, as one of the most common type of laying. The requirements for the mechanized V-door ramp are determined. The advantages of automation of the drill-pipe connection operations using the mechanized V-door ramps are analyzed. The results are as follows: the functional analysis of the means and equipment for the tripping mechanization allows to compile the functional and constructive classification of pipe stand receivers and mechanized V-door ramps. The task is set to use the systematic approach to find the ways for the efficiency improvement of the tripping mechanization means with the horizontal pipe laying.

1 Introduction

The tripping operations (TO) are one of the main components of the oil well drilling process, as well as the well overhaul and maintenance. Therefore, the degree of the TO mechanization significantly affects the performance of drilling rigs and well servicing rigs.

The issues of the mechanization influence on the efficiency of technological processes were considered in the papers [1-3]. They show the relevance and areas of the equipment improvement [4-6], but do not reflect the full range of the systematic approach application for selection of the drilling equipment designs for the specific operating conditions.

2 Materials and methods

In the course of the study, the possible options of the TO mechanization, the features of its structure and application conditions are considered. The TO process, its duration during the pipe extension, largely depends on the pipe laying method in relation to the working space, the wellbore axis.

Depending on the arrangement method, the pipe placement systems are classified as follows:

- by the systematization degree: structured and unstructured;
- by location: vertical and horizontal.

The horizontal pipe laying is more common and provides more efficient tripping operations.

One of the problems that negate the TO efficiency is the process of supplying the drilling, casing tubes and tubing to the drill site from the pipe stand receivers, as well as the tube placement and storage after drilling or the tubing string pulling out.

The pipes are delivered to the drilling floor using a winch system. Such a pipe delivery process is very slow, energy intensive and traumatic for the drilling rig personnel. In addition, the use of flexible connections makes it difficult to position the pipe on the wellbore axis. An intermediate stage of such pipe string extension is the installation of a pipe (or pipe stand) in the shot pit that lengthens the extension cycle period.

The use of a mechanized V-door ramp simplifies and significantly speeds up this process. The technological process with this drilling equipment arrangement excludes the winch using procedure or string extension through the shot pit.

On the mobile units, the V-door ramps are used for the tubing receipt and storage during the tripping operations in the wells by the workover and overhaul crews. The V-door ramps are available in the sliding, sled-wheeled or wheeled versions with the retractable or attached racks with the skates. The carrying capacity of the racks is up to 100 tons. The V-door ramp design is performed in accordance with the federal standards and rules in the field of industrial safety "Safety Rules in the Oil and Gas Industry" and ensures safe operation during the various well repair works. The released V-door ramps must have a certificate of conformity. The advantages of the V-door ramp design include the ease of installation, dismantling and transportation to the site.

The tripping efficiency is increased depending on the mechanization level, on increase in the proportion of operation combinations in time. Therefore, the efficiency enhancement potentials of the TO must be in the close interconnection between the technological and design parameters.

When drilling the deep wells, it is becoming more significant, since a significant number of the TO cycles requires the operation mechanization for the pipe delivery to the drilling site. Therefore, the use of an already mechanized V-door ramp is relevant.

The classification of the mechanized V-door ramps (MVDR) is represented by two main types:

- mechanized ramps for pipe delivery to the drilling site with the subsequent vertical pipe lifting due using the casing block,
- mechanized hydraulic lifts of vertical position, installing the pipe vertically and independently, without the block.

Types of the MVDR are as follows:

- Mobile biaxial V-door ramps on a special trailer with the special equipment: for pipe storage during the oil and gas well repair (Fig. 1).
- Mobile triaxial V-door ramps on a special trailer with the special equipment: for the repair of oil and gas wells. The design of such V-door ramp provides for its installation and dismantling at the wellhead without involving additional lifting means.
- Mobile triaxial V-door ramps on a special trailer with the special equipment: for pipe storage during the oil and gas wells repair.
- Special triaxial V-door ramps on a special trailer (curved frame): for pipe storage during the oil and gas wells repair.
- Triaxial V-door ramps with a sled-wheeled chassis with a carrying capacity of 40 tons on a special trailer: for the repair of oil and gas wells. The design of such V-door ramps

provides for the possible transfer from one type of chassis to another without the use of additional lifting means when changing the seasonality of equipment use.

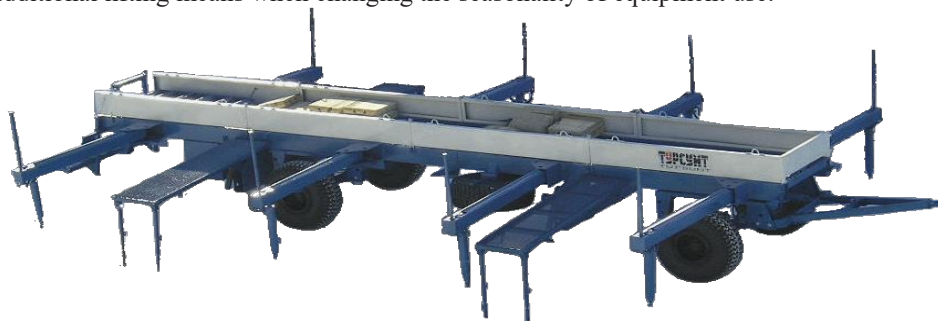


Fig.1. Mobile biaxial V-door ramps.

The following requirements for the V-door ramps are highlighted:

- they must ensure ease of installation, dismantling and transportation to the site;
- they must ensure safe operation during the various well maintenance and repair.

In order to provide well construction technology with the horizontal pipe laying, the mechanized V-door ramp (MVDR) (Figure 2) of the drilling rigs has two racks (on the right and on the left). The drill pipes are stored on one rack, the casing pipes are stored on another rack.



Fig.2. Mechanized V-door ramps.

During the analysis of various mechanized V-door ramp designs, special attention was paid to the MVDR design that provides quick and efficient pipe removal to the drilling site, with its subsequent installation above the wellhead.

The principle of the MVDR operation is as follows: the pipes are automatically and individually captured from the racks by the rack and thrown into the central trough, at the end of which the central pusher is located. After falling into the trough, the pipe is reliably protected from falling or rolling.

The MVDR lifts the pipe with its subsequent thrust on the drilling site due to the central pusher. The pusher pushes the pipe through the trough until the pipe end reaches a position outside the trough for its capture by the elevator.

The pipe is captured by the elevator in two ways: either using the assistant driller, or automatically.

When the pipe is captured by the elevator, the pipe is lifted for its subsequent installation above the wellhead and extension on the string.

For the pipe extension on the string, the spinning wrench or top drive is used for automatic pipe spinning up.

The MVDR is controlled by one person. As a rule, such person is located directly near the <VDR, or performs the remote control.

The use of automated V-door racks significantly increases the personnel safety and reduces the amount of manual operations both during the pipe removal and its laying after completion of drilling.

In addition, such racks are unified and do not need modifications when delivering the drilling pipes, casing pipes, additional drilling equipment or geophysical tools. The maximum diameter of the delivered pipe can reach 51 cm.

The mechanized V-door racks have various technical specifications: from the relatively small pipes (delivery of the pipes up to 10 m long and weighing up to 400 kg) to the marine pipes (delivery of the pipes up to 14 m long with the carrying capacity of up to 4500 kg).

The system of such racks does not need additional power supply plant, and is connected to the drilling derrick systems by several cables, as a rule, with the voltage of 400-650 volts.

As necessary, the pipes are transported to the racks using the forklifts.

3 Results and discussion

Thus, the consideration of the various MVDR designs allows to identify their advantages and benefits and use them to develop new or modernize existing structures and layouts.

Advantages of the mechanized V-door racks:

- the connection of the sliding racks between themselves is performed by the jumpers that prevent them from twisting;
- flaring of the V-door racks prevents equipment and the working platform from falling out during transportation;
- special shielding to protect lighting equipment (lamps and corner reflectors) and the official registration plate from pollution and mechanical stress during transportation and well repair;
- the use of multipurpose attached pyramid-shaped racks for installation on either side of the rack due to the connecting part unification, stepless height adjustment through the use of screw jacks. The ability to adjust the MVDR capacity due to the assembly of additional racks that are designed for pipe laying during the TO, process pipe storage at the well.

When the crew is moving to the next well, the racks are transported together with a set of pipes. Its use excludes the pipe transportation to an additional rack.

- Reinforcement of the upper part of the device for the pipe delivery height adjustment with the additional pipes to prevent them from crushing.
- The draft bar construction, consisting of a support with a jack, allowing to attach the racks to the towing coupler of the drive track without the use of additional lifting devices.
- The transport system design that provides transportation of racks on the public roads is represented by the axles from a square beam with the wheels on collapsible disks, a brake system with pneumatic drive and a set of 24 V electrical equipment.

Evaluation of perfection of the drilling rig as a whole, as well as its modules, components, equipment separately is allowed due to the systematic approach methodology [7-9]. The use of a systematic approach in the design of drilling equipment allows to determine the field of equipment development, including production of a fundamentally new equipment.

The basis of a systematic approach to the equipment design is to consider the functional purpose of the technical system elements. The functional analysis of the means and equipment for tripping mechanization is used as the basis for the functional and constructive classification of the pipe stand receivers (Table 1) [10] and mechanized V-door racks (Table 2).

Table 1. Functional and constructive classification of the pipe stand receivers.

Function	Name of the assembly	Classification feature (method)	Options						
			1	2	3	4	5	6	
Pipe warehousing (storage)	Pipe stand receiver	Systematized vertical	<i>Loader</i> 	<i>Sector</i> 	<i>Drum</i> 	<i>Sectional rack</i> 	<i>combined</i>		
		Systematized horizontal	<i>Loader</i> 	<i>Sector</i> 	<i>Drum</i> 	<i>Sectional rack</i> 	<i>Rack</i> 	<i>Combined</i> 	
		Unsystematized vertical	<i>In bulk</i> 						
		Unsystematized horizontal	<i>Rack</i> 						

Table 2. Functional and constructive classification of the V-door racks

Function	Options		
	1	2	3
Pipe fixation on the racks	Locking pins	Limiting device	
Pipe fixation during transportation to the drilling floor	Trough		
Provision of pipe delivery to the gravity chute	Trolley feeder	Pusher	
Delivery to the drilling floor	Cylinder	Chain	Cable rope
Pipe location	Withdrawable racks	Attached racks with the skates	
Pipe capture from the trough for lifting to the vertical position	Elevator	Elevator as an attachable equipment of the top drive	Manually
Transfer of the tubing unit	Swing sled	Sled-wheeled drive	Wheeled drive

to another site			
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4 Conclusions

Mechanization of the pipe laying and delivery to the wellbore axis using the mechanized V-door racks can increase the tripping efficiency during drilling and repair of oil wells.

Use of a systematic approach during the mechanism design for the horizontal pipe laying and ensuring the pipe string extension when drilling or repairing wells can greatly simplify the design, manufacturing technology and installation of equipment while maintaining the necessary strength. It can also optimize its parameters [11].

The issues discussed disclose the prospects of applying the capabilities of a systematic approach to finding the ways of efficiency improvement of the tripping mechanization equipment with the horizontal pipe laying.

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