American Journal of Mechanical and Industrial Engineering
2022; 7(6): 84-88
http://www.sciencepublishinggroup.com/j/ajmie
doi: 10.11648/j.ajmie.20220706.11
ISSN: 2575-6079 (Print); ISSN: 2575-6060 (Online)

Research on Signal Transmission Device of Multi Adaptive Coiled Tube Measurement and Control System

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To cite this article:
Zhuocheng Yin, Fuqiang Zhang, Wenyi Duan, Qing Ma, Jun Hao, Zhongcheng Zhou. Research on Signal Transmission Device of Multi Adaptive Coiled Tube Measurement and Control System. *American Journal of Mechanical and Industrial Engineering*. Vol. 7, No. 6, 2022, pp. 84-88. doi: 10.11648/j.ajmie.20220706.11

Received: December 4, 2022; **Accepted**: December 8, 2022; **Published**: January 10, 2023

Abstract: As an important technology for oilfield development and oil and gas reservoir reconstruction, the demand for coiled tubing logging, perforating, fracturing and acidizing and other process operations has increased dramatically, and downhole testing and control operations must be completed through downhole data acquisition and transmission and control signals. However, at present, the special cable coiled tubing roller device and logging roller operating machine mainly used at home and abroad have problems such as single function, high cost, complex structure, and poor versatility. Therefore, based on the structural characteristics of the conventional coiled tubing machine, through the analysis of the existing coiled tubing testing and control data signal transmission system, the research and design of the signal transmission device for the multi adaptive coiled tubing measurement and control system was completed, and a kind of signal transmission device for the multi adaptive coiled tubing signal testing, acquisition, transmission and feedback control system with strong versatility and high transmission efficiency was studied and designed, It eliminates the high cost of traditional equipment customized processing and manufacturing and the high labor intensity of operation and maintenance operations caused by the single adaptability of operation process, which are caused by complicated structures. It is of great significance for realizing the transformation and upgrading of the multi-function of intelligent measurement and control integration of coiled tubing machine, and is extremely important for the innovation of the digital network real-time monitoring system for future oilfield development.

Keywords: Coiled Pipe, Signal Transmission, Measurement and Control System, Device

1. Introduction

In recent years, the key equipment technology of coiled tubing has been widely used in the development of major oil and gas fields in China, with an annual operation volume of more than 5000 wells [1, 2]. Among them, coiled tubing logging, perforating, fishing, fracturing acidification and other processes, as important links in oil and gas field development, account for a particularly prominent proportion. It is necessary to cooperate with downhole data acquisition and transmission, surface control signal transmission and execution to complete downhole testing and supporting tool control. As the signal center of downhole data test transmission and supporting tools feedback control, the coiled tubing supporting signal transmission device plays an important role in ensuring the effective transmission of data signals during the normal operation of coiled tubing, and has become a key technology in ensuring the efficient transmission and acquisition of coiled tubing test and control signals, and the digital upgrading process of oilfield development.

However, at present, at home and abroad, coiled tubing is mainly used for downhole testing, supporting tool control and signal feedback operations, mainly in two ways: special coiled tubing roller device with cable or customized special coiled tubing logging roller operator. There are single operation function, high processing cost and complex structure, which cannot be used with other conventional coiled tubing operators, and insufficient adaptability of construction technology The overall size of the drum affects road transportation [3, 4]. Therefore, in the face of the development demand of the future oilfield development to be efficient and intelligent, this paper studies and designs a kind of signal transmission device for the multi adaptive coiled

tube signal testing, acquisition, transmission and feedback control system with strong versatility and high transmission efficiency, which saves the high cost of traditional equipment customized processing and manufacturing and the high labor intensity of operation and maintenance due to the single adaptability of operation process, Realized cost reduction and efficiency increase of coiled tubing equipment matching operation, which is of great significance for ensuring efficient transmission and acquisition of coiled tubing testing and control signals, and digital upgrading of oilfield development.

2. Coiled Tube Measurement and Control Technology

The coiled pipe measurement and control technology was first developed in the 1960s. It is to place test and control cables in the coiled pipe and use the coiled pipe to cooperate with various tool joints, so as to transport cables and operation tools used for testing and operation to the downhole and complete various downhole measurement, data acquisition and other development operations [5, 6]. However, the application of this technology was slow at that time due to the processing performance of the coiled pipe itself, pipe defects and higher requirements of the working environment for supporting tools and test cables. Until the recent 30 years, with the significant improvement of the processing quality of the coiled pipe itself, supporting equipment, tools and the performance of the measurement and control cable, the measurement and control technology of the coiled pipe was gradually re emphasized by the industry, and has been rapidly developed and comprehensively applied in recent years.

The operation process and key equipment of coiled tubing measurement and control technology mainly need to combine the coiled tubing operation technology to apply the key equipment and supporting tools of the coiled tubing operating machine to the field of oilfield downhole parameter testing and operation control. Its working principle is mainly to put the downhole test cable into the coiled tubing in advance on the ground, and use the supporting operation tools to correspond to the connection joints to conduct downhole operations and connect the test instrument tool string at the end of the coiled tubing. By using the ground equipment system supporting the measurement and control of coiled tubing, depending on the superior toughness and stiffness of coiled tubing itself, it can realize the operation under pressure, without the need to connect a single continuous trip, and the long extension distance of the horizontal section. It can take the measurement and control cable, instrument and tool string to efficiently send to the target horizon of various vertical wells, horizontal wells, and highly deviated wells to complete downhole data testing and other operations. As an important link of oilfield development, coiled tubing logging, perforation, fishing, fracturing and acidizing and other technologies need to cooperate with downhole data acquisition and transmission, surface control signal transmission and execution to complete downhole testing and supporting tool control.

According to the different types of operation processes in the field of coiled tubing testing and control, the main field applications can be divided into the following categories: (1) Production well testing: downhole formation parameter testing and monitoring operations conducted during the development period after the oil and gas wells are run into casings, which are used to evaluate the downhole oil and gas reserves, etc. Currently, they are mostly used for highly deviated wells or horizontal wells; (2) Open hole well testing: the testing operation for formation wellbore parameters when the oil and gas well is drilled to the well depth of the design horizon, which is used to evaluate the formation structure and components to verify the oil and gas reserves. Currently, it is mainly used for vertical well operations. (3) Geological parameter test: it is applied to downhole seismic test technology, mainly used for downhole source measurement, seismic wave frequency scanning, etc. The coiled tube measurement and control technology has a wide range of applications and many potential functions to be further developed [7, 8].

3. Coiled Pipe Measurement and Control Operation Process

The whole process operation system of coiled tubing measurement and control is mainly composed of three parts: downhole tool testing system, data signal transmission system and ground data acquisition and control system [9, 10]. Among them, the downhole tool testing system includes various downhole parameter testing instruments and measuring instruments sensitive to various rock formation information. When the system conducts downhole testing operations, it first sends various instruments to the deep layer of the well designated by the logging through the testing cable, and then detects the geological information and wellbore parameters of different downhole layers by constantly adjusting their depth and orientation. Under the centralized monitoring and control of the surface data acquisition and control system, the downhole tool test system will feed back the detected formation wellbore parameters to the test data signal transmission system in real time according to different commands provided by the surface data control system, and then the test data transmission system will perform modulation, demodulation and decoding on the received data signals, and then transmit them to the surface data acquisition and control system, At the same time, the test data processing module also sends various control commands to the downhole tool testing system through the data signal transmission system. Finally, the surface data acquisition and control system will analyze and sort out the data signals collected from the feedback and draw and convert them into downhole test parameter information charts. At the same time, the collected downhole test data will be classified, recorded and stored [11, 12]. After

finishing the sorting, the data will be submitted to the downhole data analysis center to complete the data analysis of the test parameters and obtain the corresponding downhole formation interpretation. In the coiled tubing measurement and control system, as the signal center of downhole data test transmission and supporting tool feedback control, the data signal transmission system plays an important role in ensuring the effective transmission of downhole test data signal and ground control signal during the normal running of coiled tubing, and is the most critical link in the whole process operation system.

The process flow of coiled tubing measurement and control on the oilfield site is mainly divided into the following steps [13, 14]:

(1) Complete on-site preparation for process matching of coiled tubing measurement and control operation supporting equipment, tool string, well media, etc., align coiled tubing operation equipment to the wellhead for operation, and complete installation of coiled tubing and ground signal acquisition equipment, as shown in Figure 1;

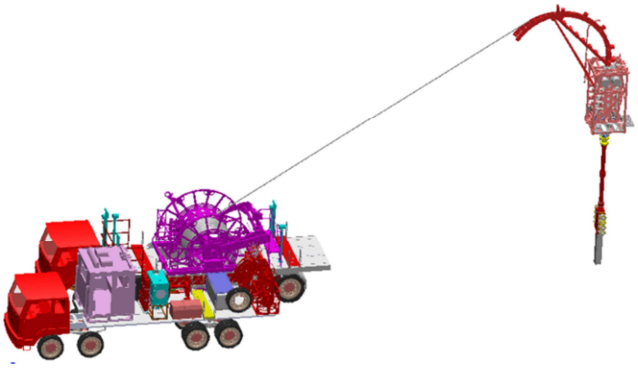

Figure 1. *Schematic Diagram of Coiled Pipe Testing Operation.*

(2) Before the coiled tubing testing tool is put into the well, run the conventional optical coiled tubing into the well to conduct the well trip test, evaluate the depth of the testing well, ensure that the well bore is smooth, and complete the well bore preparation;

(3) Install the blowout preventer at the wellhead of the test well, and then lower the coiled pipe with the test cable. During the running process, continuously pump the metal drag reducer, slippery water and other reagents to increase the maximum depth of the coiled pipe during the running process;

(4) When the coiled pipe with testing tool string and signal transmission cable is lowered to the designed depth of operation or it is confirmed that the lowering depth cannot be continued, the coiled pipe testing operation can be started; At the same time, the surface data acquisition and control system can send commands to adjust the orientation and angle of downhole testing instruments in real time according to the test results, and can also pump clean water into the coiled tubing to control conventional auxiliary operations such as drilling and perforating;

(5) After the coiled tubing measurement and control system completes the downhole parameter test and other operation plans of each layer, the coiled tubing can be lifted to the wellhead. On the way, real-time spot testing can also be carried out. When the coiled tubing is lifted to the wellhead, the ground equipment can be disassembled to check the data quality.

4. Coiled Pipe Measurement and Control Supporting Signal Transmission Device

At present, the data signal transmission system in the whole process operation system of coiled tubing measurement and control, as the signal system center for the transmission of downhole test signals and tool control commands, plays an important role in ensuring the correct and efficient transmission of downhole test data parameters and ground control signals in the process of coiled tubing tripping, and is the most critical link in the whole process operation system. Therefore, the reliability, economy Universality is very important for oilfield development.

However, traditionally, coiled tubing is used for downhole testing, matching tool control and signal feedback, mainly in two ways: special coiled tubing roller device with cable and customized coiled tubing logging roller machine [15]. Among them, the special coiled tube roller with cable is adopted. One end of the connecting pipe needs to be fixed on the internal support frame of the roller to connect with the coiled tube filled with cable, and the other end is connected with the rotary sealing device, so that the cable can be connected in the pipe and led out through the rotary sealing device. This method must use special coiled tube roller equipment with cable. Its single operation function can only be used to transmit cable signals, poor adaptability of operation process, large overall size and complex structure, high processing and manufacturing costs, complex supporting connecting devices, and complex construction and maintenance operations. The other is to customize a special coiled tubing logging roller. The logging roller is driven by a motor and a reducer to drive the chain wheel at the end of the roller shaft. One end of the roller shaft supports a rotary joint and connects the connecting pipe filled with cables through an internal manifold and cable sealing head. The other end of the roller shaft supports a bearing and a cable slip ring, The cable is connected with the cable sealing head and the cable slip ring respectively in the support frame of the drum body, and the cable is led out through the slip ring. In this way, the special coiled tubing logging roller operator must be used. Its single operation function can only be used to transmit cable signals. Its overall size is large and its structure and supporting equipment are complex. It cannot be used with other conventional coiled tubing operators. Its processing and manufacturing costs are high. Therefore, the above existing technical deficiencies lead to complicated construction procedures, complex structure and high cost of supporting equipment, which seriously

restricts the operation efficiency and process adaptability of coiled tubing equipment.

In view of the technical status quo and existing shortcomings of the data signal transmission system in the existing coiled tubing measurement and control system, through years of research, design and application of the key equipment technology of coiled tubing, fully combining the oilfield field operation needs and industry development trends, and analyzing the existing coiled tubing testing and control data signal transmission system, an innovative research and design of a multi adaptive signal transmission device for the coiled tubing measurement and control system is carried out, The structure realizes the universal adaptation to the coiled tube drum and rotary joint structure. Its overall dimensions are very compact, with an internal diameter of 172mm and a thickness of ≤ 50mm. It includes multi-layer sealing rings, bearings and other components. It can be directly installed on the existing conventional coiled tube drum, and is simple and convenient for disassembly and assembly. It can not only ensure the routine operation of circulating fluid in the coiled tube, but also realize the signal data transmission of the downhole testing instrument and supporting tools of the coiled tube, and can also realize the transmission and conversion of optical and electrical signals through the external photoelectric signal converter. It completely solves the problems such as single operation function, insufficient adaptability of construction technology, inability to be universal with other conventional coiled tubing operation machines, large overall size of the drum which affects road transportation and so on that traditional coiled tubing signal transmission relies on the specially made coiled tubing roller device with cable or customized special coiled tubing logging roller operation machine, and eliminates the high cost caused by customized processing and manufacturing of traditional equipment and single adaptability of operation technology The high labor intensity of operations and maintenance operations caused by complex structures has realized cost reduction and efficiency increase of coiled tubing equipment matching operations. The invention of the signal transmission device for the multi adaptive coiled tubing measurement and control system expands the application scope and field of coiled tubing technology, and provides an economical and efficient key equipment for the data signal transmission and acquisition system of coiled tubing downhole testing instruments and supporting tools.

5. Conclusion

The signal transmission device matched with the multi adaptability continuous pipe measurement and control system has good adaptability to the existing continuous pipe roller and rotary joint structure. It can be directly installed on the existing conventional continuous pipe roller, and it is easy to disassemble and assemble; In the process of use, it can not only ensure the routine operation of circulating fluid in coiled tubing, but also realize the signal data transmission of coiled tubing downhole testing instruments and supporting tools; It can fully adapt to the efficient transmission of coiled tubing downhole test signal, supporting tool control and power signal, and can realize optical and electrical signal transmission and conversion through external photoelectric signal converter; During operation, signal shielding, impedance matching and shielding of external noise and electromagnetic interference between multi-channel signals can be realized; It is well aligned with the rotating shaft of the drum, and the running process is stable, and outdoor waterproof and anti-corrosion operations can be realized. Compared with the traditional technologies of the same type at home and abroad, the use of multiple adaptive coiled tubing measurement and control system to support signal transmission devices saves complicated operation and construction procedures and high cost supporting equipment, greatly expands the functional adaptability and operation process matching of existing conventional coiled tubing operators, and will accelerate the downhole testing Automation upgrading in the field of oilfield development communication such as supporting tool control and signal acquisition feedback.

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