Research and Application of Clean Operation Technology for Rod and Tubing

Hua Huang(✉), Tao Wang, Jin-xia Wang, Xiao-ping Yuan, Peng-fei Lei, Guang-qing Gu, Lu-lu Ping, and Wen-jing Zhang

Engineering Technology Institute of Huabei Oil Field, Hebei, China
cyy_huangh@petrochina.com.cn

Abstract. Oil carried out from well hole by rod or tubing is unavoidable to pollute the well site in pulling operation of production or water injection wells. When cleaning oil and hard paraffin on rod or tubing, the anti-pollution technology including washing, mechanic oil wiper cause incomplete cleaning and formation damage for wells with low pressure, water sensitivity reservoir and severe paraffin trouble. On account of efficient pollution prevention and control, a whole process of clean operation technology for source control was developed for characters of wellbore and wellhead. An online closed style heat cleaning device and technology for lifting rod and tubing was developed. According to operation characteristics of lifting rod, a down hole short range circulating path is designed, which realizes jet cleaning and steam cycle control by closed device and double-ended pressing. The characters of nozzle is optimized to realize thorough coverage and instant cleaning of oil and paraffin without influence on rod job efficiency. Aiming at instantly cleaning tubing during pulling operation, integrated tool of wellbore stream flushing and oil wiper, tool of internal wall rotary scraping and process of negative pressure liquid collecting are designed. Utilizing high-speed steam flowing through annular space close to both sides of tubing, internal and external walls are cleaned rapidly. The flow velocity of steam is 8 times of direct steam flowing in the tubing. The liquid is recovered in a closed manner by wellhead negative pressure liquid collector. The process of washing internal and external of tubing can be carried out at the same time in pulling work. Field application indicates that online closed style heat cleaning technology had characteristics of convenient use, reliable performance and well

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site adaptation. Clean operation and environment protection intention is realized that oil and water is prevented from falling down in pulling operation. The technology possesses a good prospect of application in oilfield green mine construction.

Keywords: Down hole operation · Rod · Tubing · Closed style · Clean · Green operation

1 Introduction

With the implementation of the new environmental protection law, more stringent requirements for pollution prevention and control are put forward in oilfield production. As one of the important links in oilfield production and maintenance, it is necessary and urgent to eliminate the environmental pollution caused by operation. Oil and water adhering to the outer surface of sucker rod and the inner and outer wall of tubing are the main pollutants during pulling work.

In recent years, the main anti-pollution measures adopted in domestic oilfields are hot washing, rod and tube scraping, wellhead fluid collection and so on. Although hot washing technology can remove crude oil and hard paraffin adhering to sucker rod and tubing surface, it can cause reservoir damage to formation with leakage and water sensitivity. The integral sucker rod scraper commonly used in oilfields is not suitable for the sucker rod with paraffin scraper and centralizer. The multipartite sucker rod scraper has poor scraping effect on hard paraffin and cannot meet the cleaning requirements of pulling rod. The sucker rod and tubing often need to be washed by steam on site. The falled oil and water during the cleaning process will cause damage to environment. If the sucker rod and tubing are pulled back to the tubing plant for centralized cleaning, much transportation costs will be increased. The existing wellhead collector can only recover most of the sewage in the tubing, and there is still sewage splashing around the wellhead during operation [1–6].

Aiming at environmental protection in the current operation process, a series of on-line closed heat cleaning technology and matching tools for sucker rod and tubing are developed to solve the problems of centralized recovery of waste oil and sewage, cleaning of sucker rod and tubing in the operation process and realize clean production in pulling operation.

2 Research Strategy

For wells with low pressure and water sensitivity formation that cannot adapt hot washing technology, a new type of closed cleaning device is developed.

(1) By introducing thermal field, the problem of blind spots and incomplete cleaning of mechanical oil scraping could be solved, and the steam which could be well controlled is selected as heat transfer medium.
(2) In order to improve the cleaning efficiency and ensure the cleaning effect, thermal cleaning is carried out in the wellbore space at the lower part of the wellhead, which is carried out simultaneously with pulling and uncoupling operations.

(3) Turn passive wellhead liquid collecting into pressure controlled collecting.

The cleaning and recovery problem of oil and water brought by rod and tubing is solved on site.

3 Online Closed Style Heat Cleaning Technology for Rod

The online closed style heat device for sucker rod consists of a sucker rod flusher, an tubing-casing connector and a negative pressure device. By down hole short range circulation, the steam flow control and booster flushing are realized by using the wellhead closed style cleaning and pressure control device.

3.1 Down Hole Short Range Circulation and Online Heat Cleaning Device

In order to solve the problem of space occupied by sucker rod cleaning and liquid scattering, the wellbore space is utilized to realize integrally thermal cleaning for rod body, and the device volume is minimized. A tubing-casing connector matched with the length of sucker rod is designed. Before pulling the rod, the lower part of the tubing hanger is connected with tubing-casing connector and put into down hole again. The negative pressure device is connected with one side of the casing gate to establish a controllable short range steam circulation channel.

The thermal flusher device is connected to tubing lift sub and consists of a steam anti-leakage mechanism, a control valve, a tubing tee joint and an internal booster flushing nozzles. The nozzles with inclination of 30° are distributed in two rows of annular chamber, and the diameter is adjustable. In order to ensure safety control, special steam control valves are used to meet the requirements of high temperature and high pressure resistance, and sucker rod blowout preventer sub is provided to meet the requirements of well control (Table 1).

Table 1 Main technical parameters for online closed cleaning of sucker rod

Parameter	Value
Steam temperature, °C	130–150
Steam pressure, MPa	0.7–1.0
Depth of connector, m	<20
OD(connector), in	$2^{7}/_{8}$ or $3^{1}/_{2}$
OD(tubing), in	$2^{7}/_{8}$ or $3^{1}/_{2}$

3.2 Technological Principle

The heat source sub of the control valve is connected with the steam hose of the boiler truck, so that the steam can flow rapidly along the annular space between rod and tubing, continuously flushing the oil attached to body of sucker rod. Oil enters the annulus through connector and goes up. By the negative pressure, the oil water mixture is forced to be pumped out and discharged into the recovery tank through the casing gate. During pulling operation, the steam flushes the rod body at a high speed. During screwing off and laying operation, the steam continues to clean the lower sucker rod.

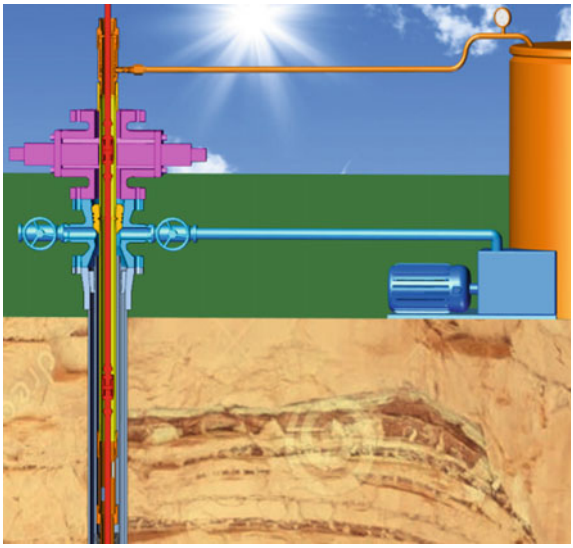

Fig. 1 Online closed style heat cleaning device for sucker rod

The device turns the horizontal open cleaning on pipe bridge into vertical closed style integrally cleaning without blind spots. There is no restriction of sucker rod specifications or paraffin scrapers. The operation doesn't affect time-effect of pulling rods. There is no leakage of oil and sewage (Fig. 1).

4 Online Closed Style Heat Cleaning Technology for Tubing

The online closed style heat cleaning device for tubing is composed of steam pipeline, cleaning cap, inner wall steam scraping tool, wellhead closed liquid collecting device, etc. Closed style cleaning for both sides of tubing wall and pulling operation are completed simultaneously.

4.1 Closed Cleaning and Collecting Device for Tubing

The inner wall steam scraping tool is composed of tubing coupling locking mechanism, centralizer, rotary nozzle and scraper. The tubing coupling locking mechanism has elastic expansion slips which locates the lower tubing coupling and stops tool to ensure continuous operation. Steam is utilized as downward driving force of tools. Compared with direct steam flowing into the tubing, the steam flow velocity is 8 times at the same flow rate. All steam thoroughly flows through the annular gap and is effectively utilized.

Table 2 Technical parameter of inner wall steam scraping tool

Tubing OD	Tool OD, mm	Tool length, mm	Expansion slips control mode
73.02 mm	58	230	Press tool downward to retract and the jaw resets automatically
88.9 mm	72	230	

In addition, the flow passage, rotating nozzle, scraper and synchronous rotation mechanism are designed. The rotating nozzle uses self-lubricating material to reduce friction, and forces steam to directly flush the inner wall of the tubing. The mechanical scraping and steam flushing are utilized together to improve the cleaning effect.

The closed liquid collecting device at the wellhead is pneumatic-driven, which can move along the slide way to adjust the position of buckling and releasing. The liquid collecting mechanism is split barrel-shaped, and the liquid collecting arm is controlled by the cylinder with strong controllability (Table 2).

4.2 Working Principle

Before pulling operation, the inner wall steam scraping tool is put into the pipe, and the upper end of the tubing is coupled with a cleaning cap. When lifted out of wellhead, the tubing is screwed off and lifted up 50–100 mm. Then the liquid collecting device is fastened. The inner wall scraping steam tool is driven down by steam which flows through the cleaning cap. The oil, paraffin and dirt on the inner wall are flushed and scraped. The liquid collecting device is connected with the vacuum pump, which provides the suction to promote steam flow. All the dirt is recovered in a closed manner.

The process turns horizontal open cleaning on pipeline bridge into vertical closed cleaning, which greatly improves cleaning timeliness of inner wall, effectively saves steam consumption and fuel consumption, and solves the problem of on-site cleaning of tubing (Fig. 2).

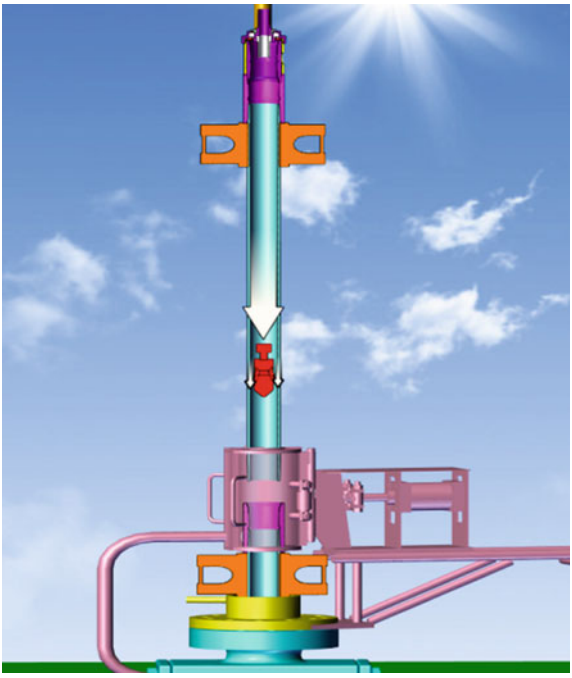

Fig. 2 Online closed thermal cleaning device for tubing

5 Skid-Mounted Cleaning Device

By the integration of vacuum device, liquid collecting device and boiler, the power and heating source are contained. It improves adaptability to the field, realizes quick installation, and reduces equipment cost. The popularization and application of the technology could be more convenient (Fig. 3 and Table 3).

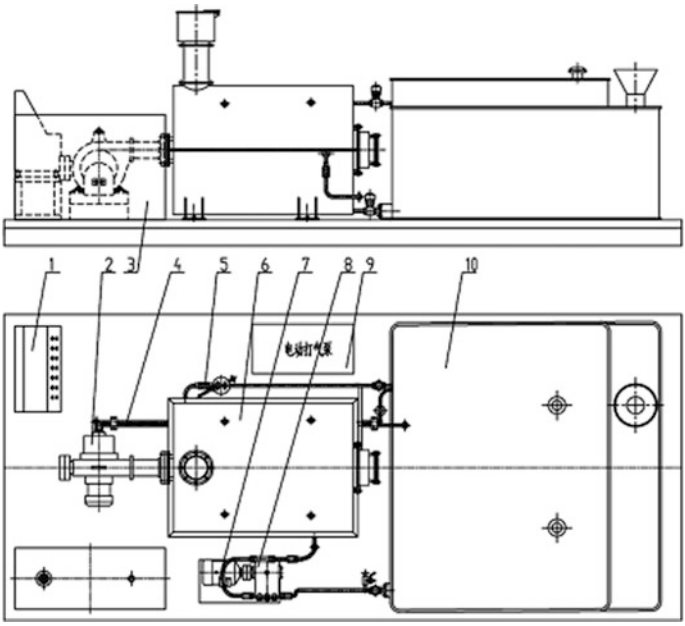

Fig. 3 Sketch of skid-mounted structure. (1, Control Cabinet 2, Burner 3, Generator 4, Diesel Pipeline 5, Boiler Exhaust Pipeline 6, Vehicle Special Boiler 7, Motor Drive 8, Ceramic Piston Pump 9, Electric Air Pump 10, Oil and Water Cabinet)

Table 3 Main technical parameters of skid-mounted cleaning device

Parameter	Value
Max working temperature, °C	200
Max pressure of boiler, MPa	6
Max flow rate, m^3/h	1.26
Working medium	Clear water
Working voltage, V	380

6 Field Application

Taking well T47-6 as an example, this well was an oil production well with KY21/65 wellhead, D73.02 mm NU tubing. Depth of plunger was 2132 m. There was a tubing drain in the string. The sucker rod assembly was D22 mm scraper rod and D19 mm sucker rod. The scraper rod had a centralizer joint. When mechanical oil scraper was used in the same block, oil was left at the coupling and centralizer, and the effect of scraping was poor. Paraffin deposition was serious in tubing from wellhead to depth of 1500 m, and thickness of black hard paraffin was 3–5 mm.

Table 4 Application chart

Technology	Specification	Pulling time/h	Water consumption/m^3	Fuel consumption/L
Online closed style heat cleaning for rod	D19 mm/D22 mm rods (with scraper and centralizer)	4.2	4.5	150
Online closed style heat cleaning for tubing	D73.02 mm tubing	3.8	8	260

The sucker rod and tubing had been cleaned by applying on-line closed style heat cleaning device. When sucker rod was pulled, the steam pressure was 0.8–1 MPa, the steam temperature was 130–140 °C. The pulling speed was about 60 rods per hour, and the total time was 4.2 h. After cleaning, there was no oil left on body of rod, and no sewage was took out of wellhead. The pulling speed of the sucker rod was comparable to the conventional process, and there was no obstruction when the scraper or centralizer was passing through.

During tubing pulling operation, the steam pressure was 1.5–2 MPa, the steam temperature was 120–140 °C. The pulling speed was about 60 pipes per hour, and the total time was 3.8 h. There was no crude oil or paraffin in the inner and outer walls of the tubing, and all the cleaning liquid was collected without leakage. The pulling speed of the tubing was comparable to the conventional process.

The technology is being popularized and applied on a large scale (Table 4).

7 Conclusion

In view of the well with serious water sensitivity, low pressure or paraffin deposition in reservoir, an online closed style heat cleaning device for sucker rod and tubing is developed, and a set of cleaning operation technology has been formed.

(1) The online closed style heat cleaning technology for sucker rods is developed. The sucker rods are cleaned comprehensively by short range down hole circulation and steam flow direction control. It is not restricted by rod body specifications, centralizers or paraffin scrapers, and does not affect the working time.
(2) The developed tubing inner wall cleaner with automatic positioning function greatly improves the efficiency of closed style heat cleaning of tubing and realizes efficient utilization of steam. With the pneumatic control of slide way type negative pressure liquid collector on wellhead, the oil and water are recovered while inner and outer wall of tubing is cleaning. The pulling operation is carried out at the same time.

(3) Field application shows that the technology is convenient to operate, reliable in performance, adaptive to the field. The goal of cleaning and environmental protection operation has been achieved while no oil or sewage falls out in operation. The technology has broad prospects for application in the construction of green mines in oilfields.

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