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Technical Research on Flexible Fracturing Manifold System

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Abstract

In recent years, there have been many risk accidents in the high-pressure manifold system, coupled with the increase in pipeline connection time and pipeline layout space; it has also increased the difficulty of fracturing construction site layout and operation. The flexible fracturing manifold system is used to upgrade the technology. It seems particularly important. First, the overview and technical standards of flexible pipes are explained. Secondly, the technical development statuses of high-pressure flexible fracturing pipes are analyzed. At the same time, the technical characteristics of flexible fracturing manifold systems are also discussed, and flexible fracturing manifolds are also developed.

Keywords

Flexibility; fracturing manifold; oilfield development.

1. Introduction

With the deepening of oilfield development, the development of tight oil and gas and shale oil and gas has become the focus of oilfield development. Based on the experience of North American shale oil and gas development, large-scale volume fracturing has become the main means of tight oil and gas and shale oil and gas development. Limited by the well site and construction scale, the job site needs to connect multiple 3", 4" rigid high-pressure pipelines to complete the layout and connection of the fracturing manifold. Especially in the cluster well operation site, the economy and timeliness of the manifold connection the performance has severely restricted the speed and efficiency of fracturing construction. The use of a large number of high-pressure pipes and valves leads to an increase in the cost of fracturing construction; the complicated high-pressure pipelines cause the operators to easily change the gates and cause errors in construction quality; numerous high-pressure pipeline connections bring higher pipelines According to incomplete statistics, since 2014, there have been more than 800 high-pressure pipeline punctures and more than 40 high-pressure pipe bursts during fracturing tests in Sichuan and surrounding areas. Meanwhile, the increase in pipeline connection time and pipeline layout space also increases the difficulty of fracturing construction site layout and operation. In view of this, it is necessary to upgrade and optimize the technology of the high-pressure manifold system. This paper conducts technical research on flexible fracturing manifold system. it special performance superior to other conventional rigid pipes. The flexible pipe body is usually composed of two major functional layers: inner and outer sealing layer and reinforcement layer.

2. Overview and technical standards of flexible pipes

2.1. Overview of flexible pipe

Under normal conditions, the bending stiffness of the flexible pipe is much lower than its tensile stiffness. Under the same pressure-bearing condition, the radius of curvature of the flexible pipe is smaller than that of the ordinary homogeneous steel pipe. In the meantime, due to its special structure, it gives of functional layers, flexible pipes can be divided into bonded flexible pipes and non-bonded flexible pipes. The functional layers of the bonded flexible pipe are treated by a vulcanization process to become one body; there are annular gaps between the functional layers of the non-bonded flexible pipe, and relative sliding between the layers is allowed. Bonded flexible pipes are usually short, such as bonded risers for oil and gas transportation and bonded choke-killing hoses. The typical length of a single piece is generally 30m; non-bonded flexible pipes are relatively long and single It can reach hundreds of meters or even several kilometers.

According to the different materials used in the reinforcement layer, flexible pipes can also be divided into two categories: Metal-Based Flexible Pipes (Metal-Based Flexible Pipes) and Composite-Based Flexible Pipes (FCP). The former usually only uses spiral steel materials as the reinforcement material; the latter usually uses composite materials such as glass fiber reinforced plastics and aramid fibers as the reinforcement material. Generally, composite material-based bonded flexible pipes are also called reinforced thermoplastic pipes (Reinforced Thermoplastic Pipes, RTP).

2.2. Technical standards for flexible pipes

About the technical standards for flexible pipes, the American Petroleum Institute (API) has issued several recognized industrial hose specifications, covering requirements from function definition to installation.

API 17B "Recommended Practice for Flexible Pipe" is a general specification for hose design and use in land, offshore, and deep sea environments. This specification applies to the design of bonded flexible pipes, non-bonded flexible pipes and flexible pipe auxiliary components.

API 17K "Specification for Bonded Flexible Pipe" is suitable for the design of metal-based and non-metal-based bonded flexible pipes.

API 17L1 "Specification for Flexible Pipe Ancillary Equipment" and API 17L2 "Recommended Practice for Flexible Pipe Ancillary Equipment" are suitable for the design of flexible pipe auxiliary components such as bend guards, bend limiters, and underwater buoys.

API RP 15S "Qualification of Spool able Reinforced Plastic Line Pipe" is only suitable for onshore RTP pipe design, DNVGL-RP-F119 "Thermoplastic Composite Pipes" is suitable for marine environment RTP pipe design.

3. Technical development status of high-pressure flexible fracturing pipe

Abroad, high-pressure flexible pipes have been extensively tested on fracturing construction sites in North American shale gas regions. Large-scale foreign oil companies Schlumberger, NOV, FMC, etc. have all carried out large-scale field applications. Through field tests, flexible fracturing pipes can effectively replace part of high-pressure elbows and straight pipes, simplifying on-site layout; longer flexible pipelines (8-10m) reduce on-site connection points; flexible pipes can maximize the buffering of liquid flow Internal stress can absorb vibration and extend the service life of pipelines; it can realize quick assembly and disassembly on the job site and improve work efficiency.

Schlumberger flexible fracturing pipe is completed in cooperation with Continental-Contitech. Its flexible pipe structure is a vulcanized bonded pipeline, using rubber as its wear-resistant

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layer, and the pressure-bearing skeleton is made of steel wire, and the external rubber + PE spiral the sheath acts as a wear-resistant layer. There are two types of flexible pipe joints: union and flange, and it adopt the embedded installation method. The inner diameter of the flexible pipe is the same as the inner diameter of the joint. The flexible manifold used at the job site is mainly 2"-6" diameter, pressure bearing 15000psi, temperature resistance -40~70℃, 5" inner diameter maximum displacement up to 17.5m3/min. For flexible fracturing pipe site For the application effect, Schlumberger compared flexible manifolds, rigid fracturing pipelines and fracturing manifold systems with four cluster-well zipper fracturing construction sites. The flexible fracturing manifold only needs to be connected. It only takes two operators to complete the installation of high-pressure manifolds in one hour for each pipeline. The number of manifolds used and the timeliness of pipeline connections have been greatly improved.

National Oil Well mainly cooperates with Gates for the development of flexible fracturing pipes. The structure, composition and joint method of flexible pipes are similar to those of Schlumberger. The manifold used on site is 2 "-7" diameter, with a pressure of 15000 psi, and is resistant to Temperature -40~70℃, the maximum displacement of 5" inner diameter can reach 13.3m3/min. FMC and Technip cooperate to carry out the field test of flexible fracturing pipe. The flexible pipe adopts non-adhesive structure design, and the internal wear-resistant layer is made of engineering plastics. , Steel belt and heterogeneous steel are used as the pressure-bearing framework, and the outer wear-resistant layer is protected by plastic + outer armored steel sleeve. The embedded joint design is adopted, and the joint ends are all connected by union or HUB clamps. Pipes are used on site. The sink has a diameter of 2"-5.5", a pressure of 15000psi, a temperature resistance of -40~70℃, and a maximum displacement of 15.9m3/min with an inner diameter of 5".

In general, high-pressure flexible fracturing pipes have been used in large-scale field applications abroad, and their economy and effectiveness have been significantly improved compared with conventional rigid high-pressure pipelines. They have gradually replaced rigid high-pressure pipelines for cluster wells. The trend of large-scale fracturing construction is the main high-pressure pipeline. There are no cases of successful application of high-pressure flexible pipes in domestic fracturing sites, and there are no ready-made reference cases for on-site connection methods, connected supporting equipment and safety protection facilities. In view of this, the development of a flexible fracturing manifold system with independent intellectual property rights has important practical significance for realizing the safe, fast and efficient connection of high-pressure manifolds at fracturing construction sites. At the same time, it can break the technology and equipment of foreign companies. The monopoly of China has filled the domestic technological gap.

Technical features of flexible fracturing manifold system

(1)The use of flexible hoses instead of rigid high-pressure pipelines is applied to fracturing construction. Its excellent bending performance and processing length are not restricted by materials, which can fully meet the high-efficiency, fast and diversified connection requirements of different well sites, which can be greatly reduced It is difficult to connect the high-pressure manifold at the job site, which improves the efficiency of pipeline connection.

(2)The flexible fracturing manifold system replaces the elbows and some straight pipes in the conventional connection, reducing the number of connection points, reducing operating costs and the risk of high-pressure puncture.

(3) Since there is no need for rigid elbows for connection, when large-diameter flexible pipes are used to replace 3" and 4" rigid high-pressure pipelines for fracturing construction, it can not only fully meet the requirements of the fracturing site construction scale, but also greatly reduce the high-pressure pipe valves. The number of parts used reduces the labor intensity of personnel.

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4. Field test of flexible fracturing manifold system

The developed flexible fracturing manifold system has been used for no less than 400 hours of field test and demonstration application in the fracturing construction area of PetroChina Chuanqing Drilling Engineering Co., Ltd. Through the field test, the following results are obtained:

(1) Flexible fracturing pipe and its manifold system materials, structural optimization design and manufacturing technology: design, optimization and processing of flexible fracturing pipes, the use of flexible fracturing pipes at ambient temperature -29～55℃, working pressure 15000psi, resistant The acidity and alkalinity meet the requirements of fracturing and acidification construction liquids. The rated displacement of the 3" pipeline is 3.0m3/min, and the rated displacement of the 51/8" pipeline is 14.6m3/min. The flexible fracturing manifold system meets the requirements of large-scale cluster wellsite manifold connections. The flexible fracturing manifold system has been finalized through field tests, and has conditions for mass production and large-scale field applications.

(2) Performance evaluation technology of flexible fracturing pipe: In accordance with the relevant technical standards of rigid fracturing manifolds and flexible high-pressure pipelines, the material experiments and physical and chemical performance evaluation experiments of flexible fracturing pipes are carried out. Assemblies carry out erosion test tests that simulate on-site working conditions, comprehensively evaluate the performance indicators of flexible fracturing pipes, and lay a good foundation for the on-site application of flexible fracturing pipes.

(3) On-site application technology of flexible fracturing manifold: design and process auxiliary connecting equipment and safety protection facilities of flexible fracturing manifold, and form a set of flexible fracturing manifold on-site layout technology through field tests. At the same time, it has passed a large number of field tests , To carry out comparative technical research on flexible fracturing pipes and rigid high-pressure pipelines and research on flexible pipe damage assessment methods, formulate flexible fracturing pipe use, maintenance, and maintenance specifications to ensure all-round application of on-site. Flexible fracturing manifold fracturing site high-pressure pipeline connection points are reduced by 60%, and the overall manifold connection time is reduced by 30%.

(4) Digital full life cycle management technology: Use embedded RFID chips to build a flexible manifold management system to realize digital management of the full life cycle of flexible manifolds. The coverage rate of embedded RFID tags reaches 100%, and the data acceptance rate during the life cycle is 100 %.

5. Conclusion

In a word, the technical research of flexible fracturing manifold system can effectively simplify the layout of the operation site manifold, fundamentally change the connection method of high-pressure fracturing manifold, improve the connection efficiency of high-pressure manifold, and achieve high pressure on the fracturing construction site. The safe, fast, and efficient connection of manifolds can achieve the purpose of speeding up and increasing efficiency of fracturing operations, which has a good application and promotion prospect.

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