Study On Vibration and Vibration Reduction Strategy of Water Injection Pump Outlet Pipeline in Oilfield

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Abstract: At present, the most widely used oil extraction in oil fields is water injection. The flushing line of water injection pump is an essential facility in the overall water injection system. In the process of oil recovery, the effect of vibration directly affects the stability of oil field exploitation and the quality and efficiency of oil recovery. If the vibration of the water-output injection pump line is too large, it will cause huge economic losses and accidents. Therefore, it is of great significance to study the vibration of the water injection pump pipe and related control strategies. By analyzing the vibration causes of the imported pipe of the injection pump, this paper studies the current shock-absorption strategy and provides reference opinions for the future oil-well mining technology.

Keywords: Oil field injection pump; Water-output pipe line; Vibration and shock-absorption; Strategy study

1. Introduction

The vibration of the input and output pipeline in injection pump has been the main problem affecting the normal injection of oil field. If problems appeared in the injection pump, it will lead to frequent pipeline rupture with a growing maintenance and restrict the efficiency of mining witha increasing operating costs of oil fields. So, the effect of vibration directly affects the stability of oil field exploitation and the quality and efficiency of oil production. For the water injection pump, its small range and high pump head can well meet the requirements of ultra-low permeable reservoir water injection in the process of oil recovery. By studying the operation of the water injection system, analyzing the causes of vibration and reasonable theoretical calculation, this paper puts forward the corresponding vibration reduction strategy, which is intended to provide rationalization opinions for efficient and stable oil recovery.

2. The Current Oil Recovery Status of the Water Injection System

At present, for the injection pump system, reciprocating volume pump is used. In the periodic operation of its pump, the flow pulsation will occur, resulting in uneven discharge of the flow rate and resulting in the discharge of the non-quantitative flow experience on the tube force. The pipe will vibrate after being hit, a serious hit leading to rupture of the pump input and output pipe, thus affecting the overall water injection system operation and water injection efficiency.

At present, fluid transmission has always been an important problem in various engineering fields. As one of the most common media in nature, fluid is transported mainly by means of fluid pipe in the process of transmission. As an important equipment for transporting fluids, pipelines are widely used in petroleum, chemical, electric power and so on. For the exploitation technology of oil field, the use of water-filled oil extraction technology is one of the important means of oil field oil recovery. At present, in order to better produce crude oil, it is necessary to optimize the extraction technology, which plays an important role in maintaining the stable production of oil fields. The current water injection system can safely and steadily ensure the production of oil, and the oil field water injection system is also an indispensable part of the water injection pump pipeline system. So, the study of its stability is a very meaningful research project.

However, for the vibration of the pipe, because of its reciprocating pump, the working elements will be interfered when the drainage system is carried out periodically and indirectly in transportation, resulting in local fluid pulsation phenomenon, which causes the vibration of the pipe. Especially for pulsating frequencies and the structure of pipes, mechanical resonance occurs when the frequencies are consistent, which can lead to increased vibration of the whole. The intensity of pipe vibration will cause different damages to the components and structures in the pipe. For example, when strong vibration occurs, it can damage the connection part of the pipe and the component, causing loose connection area, component fatigue damage, etc. For the equipment, it

also reduces the power and operation life of the equipment. For the measuring instrument in the system, distortion and other damage will also occur in continuous vibration. In addition, the sound produced by the violent vibration of the pipe will also cause noise pollution, which will cause certain harm to the staff.

When the pipe vibrates strongly, it can cause serious economic loss and accidents. An Italian researcher in the survey pointed out that, at present, the damage caused by pipe vibration accidents is very serious. In the United States, losses brought by pipeline vibration each year is about $10 billion. In the overall damage accidents, the accident caused by pipe vibration reached 19%. Besides mechanical accidents, damage caused by pipe vibration accounts the most.

Therefore, injection pumpin oil field and the corresponding pipeline vibration has the same significant safety risks. In order to ensure the safety and stability of the oil recovery link, it is necessary to study the vibration reduction strategy of the injection system. It has great significance for the project's stable operation to analyze the practical problems in engineering and ensure the efficiency of oil recovery.

3. An Overview of Pipeline Vibration

For pipes, in the transport of convection fluid host and the corresponding valve container needs to be installed at both ends of the input and output. In both ends of the host connection plate and others should also be paid attention. The design of support frames in piping systems can effectively connect individual equipment to form complex mechanical systems. In the case of vibration, the system will produce vibration. From a mechanics point of view, the vibration occurring in the pipeline system belongs to a special vibration, known as the typical dynamic problem.

The vibration of an object means reciprocating motion is required in a stable position. The vibration of the pipe is a periodic vibration, which is caused by the vibration force. For the fluid in the pipeline, the resulting pressure is also the vibration force. As for the characteristics of the compressor and the pipeline system's power machine, the reciprocating pump pipe transport will produce a certain pulsation of the pipe flow. In the course of operation, when the resulting pulsation encounters elbows, blind plates and other pipe components, vibration force will appear for a certain time due to its indirect, periodic features. Under the action of the vibration force, it will produce vibration to the system. In addition, in the design process, due to improper design and poor power balance performance such as the host, it will also lead to basic vibration. Random equipment vibration will cause connected pipe vibration, which is also a cause of pipe vibration. The vibration state caused by the exclamation force is quite complex. When the pulsating pressure of the pipe fluid, the pulsating frequency and the corresponding mechanical structure frequency coincide, mechanical vibration will be produced, which is also one of the main research contents to avoid mechanical vibration caused by the structure vibration.

There are also many excitation sources for the vibration of the oil field injection pumping pipeline. These include basic excitation, unbalanced inertia of plunger pumps, and vibrations caused by pressure pulsations caused by the working principle of the reciprocating pump. The following is a detailed analysis of pipe vibration.

4. Overview of the Water Injection System

At present, for the development of oil fields, because of the high water content, the production of crude oil production is decreasing year by year. Therefore, in order to improve the economic efficiency, in the process of oil field development and construction, it is necessary to carry out comprehensive technical research on energy conservation and consumption reduction so as to slow down the rising rate of production costs. At present, by using water injection mining method, we can effectively save resources and reduce energy consumption, and this is the most widely used method in current mining technology. In the process of oil field exploitation, water injection is the embodiment of the huge consumption of resources. With the increase of water injection on the corresponding, the consumption of electricity is also increasing. In order to cooperate better, it is necessary to consider the efficiency of the injection pump for the injection station to ensure the maximum efficiency of the injection pump through specific pressure and flow distribution.

The application of water injection system is a comprehensive technical embodiment. The injection efficiency also reflects the economic indicators of oil field water injection system. The water injection efficiency directly affects the production cost of crude oil. With the continuous development of the current process, there are different ground technology for the water injection system. With the increase of the current development difficulty, the water injection system has not reached the standard for most oil fields.

At present, the oil field water injection system mainly includes the study of the vibration of the water pipeline, and it is necessary to carry out the operation scheduling management of the whole system in view of the operation process of the water injection system. In this process, with the change of water injection process parameters, it needs to be constantly adapted, correctly judge the operating efficiency of the ground water injection system, and carry out optimal control in the overall operation process. In the process of oil field development, with the changing nature of oil layer, it is necessary to set the parameter index according to water con-

sumption, oil drive efficiency, etc., and to modify the water injection system, so as to ensure the development and recovery rate of the oil field reach the standard. In the optimization of oil field water injection system, it is necessary to analyze the reduction of the operating efficiency of the water injection system, and to plan systematically on the basis of the current energy saving and consumption reduction, so as to improve the operation of the whole system and reduce the energy consumption of water injection to improve the overall economic benefits. In the process of water injection, it is necessary for the staff to design, according to the specific situation of the oil field, in order to reduce the overall investment costs.

Therefore, in the specific oil recovery process, it is necessary to strictly manage the pipeline in the water injection system, adjust the water quantity according to the size of the water injection, in order to ensure the effective operation of the pipeline. In the open pump adjustment, it is also necessary to use valves to adjust the flow rate, to avoid strong impact caused by pipe damage as far as possible.

5. Strategy Research on Water Injection Pumping Pipeline Vibration and Vibration Reduction in Oil Field

In the study of vibration of injection pump pipeline, it is necessary to analyze the water pump, find out the location of vibration, carry out vibration test and flow-solid coupling simulation to carry out the overall vibration control. The cause of vibration is determined by looking for energy sources in the vibration position. Numerical modeling and state analysis of the emerging vibration pipelines are carried out by flow-solid coupling so as to help staff to get specific solutions design ideas and improve the overall water injection system vibration situation, effectively reduce the vibration amplitude.

5.1. The elements of pipeline vibration

At present, for the vibration of pipeline, different operating states such as equipment components havedi fferent vibration frequency. It is analyzed through start-up and shutdown status of the pump and vibration frequency in the water injection system. In the process of vibration, the power end is more stable than the hydraulic end. The pipeline vibration direction in the horizontal direction is more intense, and the high frequency vibration caused by the plug-post pump also makes the state of the injected medium flow change. At the turning point of the pipeline, changes in path are the cause of the high vibration. In addition, vibration control is more passive vibration reduction transformation, lacking of resonance system design.

5.2. Model and coupling analysis

In the vibration analysis of pipeline outlet, it is necessary to establish the corresponding model and flow-solid coupling analysis. Through the analysis of the state and force of the fluid, the corresponding vibration performance data are obtained, and the vibration effect of the pipe is changed by adjusting the boundary conditions and structural parameters.

When the pipeline in the water injection system is buried in the state, it can better weaken the vibration effect, which is also the ideal state of complete vibration resistance at present. It is assumed that the buried pipeline portion is idealized so that the buried part of the pipe can be completely earthquake-absorbed by fusion with the earth. It can also be found through simulation that the ideal state of burial can completely block the vibration of the pipeline and the effect on the vibration of the water injection system.

When the buried pipeline is in a non-constrained state, for the consideration of the boundary, only the pipe network itself should be analyzed by weight. Pipeline constraints ensure that buried pipes are not constrained. By simulation, it can be found that the vibrations between the junction pumps pass to each other and produce vibration interference.

For the analysis of flow-solid coupling under constraint conditions, the influence of buried pipeline and flow characteristics on system coupling will cause the vibration of the pump and the impact of deformation on the pipe.

In summary, the flow-solid coupling state analysis shows that the impact of the water hammer is obvious, and when testing the site, it is found that the fluid shock of the plug pump is the main cause of the vibration of the pipe wall, and also the main factor in controlling the pulsating flow rate. In the simulation of pipe vibration, the vibration effect can be reduced to a certain extent by using support. And the improper arrangement on components and pipe network in the overall water injection system will also cause vibration. In arranging it, according to the horizontal distance of the input and output pipeline, the vortex negative pressure zone formed by the elbows at both ends should be considered. For internal fluids, vibration reduction is also required through structure optimization.

5.3. Vibration reduction measures

It is designed for shock absorption for the current cause of pipeline outlet vibration.

First of all, under the premise of ensuring the quality of production, the plunger pump is adjusted frequency. The number of shocks caused by pulsating flows can be changed to ensure reduced coupling with the water hammer of the surrounding working pump. Secondly, it is also necessary to expand the pipeline, reduce the flow rate and the speed of the fluid by increasing the space

area of the pipeline, in order to avoid high-intensity impact on the pipe wall. In addition, by adjusting the pipe spacing, the proportion is divided to ensure the pulse flow of a single pump, and the number of couplings can be reduced. The simulation also shows that by changing the distance of the pipe, the impact force on the fluid can be effectively reduced.

In the design of the pipe network, it is necessary to take into account the arrangement of components and the direction of pipelines. Avoiding 90-degree bending should be considered as much as possible. When setting its structure, the bending situation of the space should be controlled and small diameter bends (9-10) are not taken consideration. For the arrangement of components, heavy mass components need to be considered on a number of trade-offs, such as valves, flow meters, etc., During installation, it should be as close to the ground as possible in order to reduce vibration.

6. Conclusion

All in all, in order to extract oil fields more efficiently, it is necessary to work the vibration of the injection pump pipeline. Through the analysis of the causes of vibration, the implementation of specific vibration reduction measures is carried out. In the specific governance process, the staff needs to plan strictly according to the parametersso as to reduce the role of water hammer coupling through the use of inverter adjustment. When designing the pipeline, the staff should also minimize the vibration. For the current vibration test and coupling simulation technology, it is more effective to find out where and why pipeline vibration occurs. Through the corresponding modeling and state analysis, it is instructive to ensure the timely optimization treatment of the vibration, which is the high-quality exploitation of oil field.

References

[1] Ma Ke. Research on the vibration of the outlet pipe of the reciprocating water injection pump. China University of Petroleum (Beijing). 2019.

[2] Hu Yongpan. Vibration analysis and improvement measures of plunger pump water injection pipe network. Northeast Petroleum University. 2017.

[3] Cai Wei, Zhu Bo. On the control of the vibration of the water injection pump pipeline in the South 201 water injection station. Chemical Management. 2017, (16), 202.

[4] Feng Haoran. Research on pipeline vibration reduction technology and rotor vibration control based on dynamic vibration absorber. Beijing University of Chemical Technology. 2017.

[5] Wang Bin. Process design of integrated water injection station integrated device. China University of Petroleum (East China). 2017.

[6] Lu Hongfang. Stress and vibration analysis of reciprocating pump piping system. Southwest Petroleum University. 2016.

[7] Zhang Hao. Application research of reciprocating water injection pump in Changqing Oilfield—Optimization of accumulators at pump suction and discharge ports. Xi'an Shiyou University. 2015.

[8] Zhang Hao, Ji Xiaoke, Chen Lirong. Overview of innovative technology of reciprocating water injection pumps in Changqing Oilfield. China Equipment Engineering. 2014, (10), 50-51.

[9] Ye Lvhua. Research on the vibration and damping strategy of the oil field water injection pump outlet pipeline. Huazhong University of Science and Technology. 2009.

[10] Lin Mu. Research on theories and methods for improving the efficiency of water injection systems. China University of Petroleum. 2008.