The Venting System for Ultrahigh Pressure Sulfur Gas Wells in the Northwestern Sichuan Basin

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Abstract. Due to the high pressure, large gas handling capacity and high acid medium content in the development and construction of high-pressure sour gas fields, the conventional venting system cannot meet the demand of production. By investigating the relevant standards and specifications of natural gas venting system at home and abroad, the main methods and principles that should be followed in the design process of the venting system of ultra-high pressure sour gas wells are summarized. Combined with the technological characteristics of venting and venting of ultra-high pressure sour gas wells, the two technological processes are integrated, and the integrated venting/venting process of ultra-high pressure sour gas wells is obtained.

Keywords: Sichuan Basin; venting system; ultrahigh pressure gas well; high-H₂S natural gas purification plant.

1. Introduction

The venting system is a vital part of the safety facilities of the natural gas gathering and transportation station. According to GB50183-2015 "Code for Fire Protection Design of Petroleum and Natural Gas Engineering" and other relevant regulations, natural gas gathering and transportation station should be installed with flare and venting system, send the corresponding gas to be burned in the flare and then discharged into the atmosphere [1]. However, with the development and construction of large ultrahigh pressure sulfur-containing gas fields in the northern part of Sichuan, the setting problem of conventional venting system is more underscored when processing design of natural gas projects with high gas amount, high pressure, high acidic media content and complex systems.

The venting process consists of two categories: test blowout and production venting. On the one hand, there are safeties, environmental protection and economic problem in the existing process when testing blowout, after go through chock and kill manifold, the gas combustion in the line will cause flame spray phenomenon, and there is also a risk of H₂S diffusion while damaging the surrounding environment. On the other hand, in allusion to emergency/overhaul venting, in case of emergency or equipment overhaul, the gas production pipeline or equipment at the well site is flowed to the flare for combustion and then venting through the venting pipeline, it is a more convenient venting process for operation and management.

In summary, if the blowout system can be integrated with the production venting system, it will not only simplify the process and is easy for management, but also make the venting operation safer, more...
economical and environmentally friendly. Based on this, in this paper, the blowout/venting process of ultra-high pressure sulfur-containing natural gas well sites was studied, the safe and environmentally friendly venting process was studied, then the integrated design method of safe, economical and reasonable blowout/venting system was obtained, and the design of future blowout/venting system applicable to this kind of ultrahigh pressure sulfur-containing natural gas well sites was obtained.

2. Blowout Process of Ultrahigh Pressure Sulfur-Containing Gas Well

Gas well blowout is an essential part of the surface testing process, at present, the main standards and specifications on the blowout of ultra-high pressure sulfur-containing gas wells in China are: AQ2043-2012 "Standardization for Work Safety of Petroleum Industries: Conduction Rule of Land Gas Extraction", SY/T 6581-2012 "The Technical Code of Practice for High Pressure Well Testing", SY/T 6610-2017 "Specification For Workplace Safety Of Hydrogen Sulfide Environment", SY/T5727-2014 "Safety Rules of Downhole Services". According to the relevant standards and specifications, the design of the test and blowout process for ultra-high pressure sulfur-containing gas wells should meet the following requirements.

1. The testing process of high-pressure gas wells and high-H2S gas wells needs to have the basic processes of blowout, testing, sampling, recovery, and well pressure, while adding two additional functions: emergency shutoff and emergency decompression.

2. The process pressure level of ultra-high pressure sulfur-containing gas wells was determined by the highest pressure level at the wellhead, and the throttling and pressure reduction level is determined in the same way.

3. The selection and design of the wellhead equipment need strictly follow the requirements of SY/T 5727-2014 and other relevant standards.

4. The selection of pressure level of the ground test equipment need refer to the maximum pressure and temperature when shutting well, the stratum pressure of the target stratum and the control pressure at the wellhead during construction.

5. The determination of ground process throttling and decompression level should refer to the maximum pressure of wellhead when shutting well and the working pressure of equipment, these two parameters can also determine the number of process equipment and pipeline selection.

6. When planning and designing the number of ground process and pipeline specifications, the types of stratum fluid, gas well output, safety conditions and equipment handling capacity must be taken into account.

7. Ultrahigh pressure sulfur-containing gas wells should be no less than two sets when it is applied in double-wing blowout, and each set of ground process blowout pipeline needs more than two.

8. Steel pipeline as the standard for testing the inner diameter of pipelines, its standards are as follows: single-wing gas output is not greater than 80×104m³/d: inner diameter is greater than or equal to 62mm; single-wing gas output is more than 80×104m³/d: inner diameter is greater than or equal to 76mm.

9. SY/T 5323 is the design standard of kill manifold and throttle manifold.

10. The separator which ultrahigh pressure sulfur-containing gas wells select should be matched with the relevant requirements in SY/T0515.

11. When the sand production condition of stratum is more serious, the equipment which follows the standard is needed on the ground.

12. H2S-resistant materials should be selected as the material of ground process equipment and pipelines of gas wells containing H2S [2].
The blowout process was designed in accordance with the above requirements. Taking the X-well in the north of an area as an example, considering the characteristics of gas wells with high pressure, high yield and sulfur, moreover, test wells required blowout with high yield and long times, as well as the requirements of rapid well closure and emergency response needs, blowout process selected and used two sets of three-level decompression process, among which the steering manifold and the previous all adopted 140MPa equipment, and the ground was set up with hydraulic control valve before the first-level throttling for open-and-shut well operation, in order to ensure the safety of open-and-shut well as well as the requirement of quick well shutoff. Concerned with safety, the process was connected to the 140 MPa pressure line on No.7 gate valve in advance, the105MPa kill manifold was connected to the casing gate end for emergency kill treatment , and connected the casing to the test process , the casing pressure was controlled within a reasonable range by adding pressure, decompression, etc., and protected well completion tube piles and tools in the pit. If the gas produced gas well contains H2S, the corresponding ground process equipment and the pipeline material should select H2S material. This set of process can be installed in the form of skid-mounted, and it is convenient to transfer after the gas well operated stably and go into operation.

3. Venting Process of Ultrahigh Pressure Sulfur-containing Gas Well

The venting system is a vital part of the safety facilities of the natural gas gathering and transportation station. In daily operation, especially when unexpected accidents occur, a large amount of flare gas or discharging gas will be discharged from the production equipment, in order to maintain the system stability and safety of production-related equipment, ensure that the normal operation of production equipment and surrounding equipment is not affected [3], furthermore, protect the ecological environment around the production area, follow the GB50183-2015 "Code for Fire Protection Design of Petroleum and Natural Gas Engineering" and other relevant standards and regulations, all natural gas gathering and transportation stations should set venting system and flare , so that Therefore, the corresponding gas can be gathered and transported into the flare for combustion and then discharged to the atmosphere [4].

The complete venting system of the gathering and transportation station usually consists of two parts: the venting pipeline and the venting flare system. The vent pipeline is the part from the venting valve of the venting pipeline to liquid separation tank. The venting flare system includes venting flare and venting liquid separation tank, fire-resistant facilities, ignition facilities and other supporting facilities.

(1) Venting liquid separation tank

The purpose of setting the venting liquid separation tank is to ensure the effective separation of liquid droplets with diameter greater than 300μm in the gas, the construction location of this equipment can be selected within the well site fence, the flare area or the lowest point of the venting pipeline [5].

(2) Fire-resistant facilities
Gathering station engineering usually uses flare water sealing tanks for liquid sealing, so as to prevent the return of flare gas and flame, moreover, it is necessary to set a set of backup facility to prevent the shutoff pressure of venting system after failure. In addition, there are molecular sealing in fire-resistant facilities, there are fewer practical applications due to the need for more supporting systems [6] [8].

(3) Ignition facilities

Normally, the flare ignition device is ignition device of continuous combustion without separate settings, but when the ignition device is put into operation for the first time or the flare ignition device is extinguished, the ignition device must be re-ignited through the ignition device. Fig. 2 is the operating principle diagram of the ignition device, this device relies on the negative pressure caused by the throttling of the fuel gas metering (sometimes the air bath fuel gas is separately metered), it inhales and ignites by fully mixing the air in the external atmosphere under the action of the gas flow. The air and fuel gas measured by separate throttling hole, then mixed and re-ignited via the mixer, the purpose of this is easy for the control of the mixing ratio of fuel gas and air, and ensure the stability of the ignition device [7].

![Fig. 2 the schematic diagram of structure of flare ignition device](image)

Therefore, for the venting system of ultra-high sulfur-containing pressure gas well, its flow chart is shown in Fig. 3. The inlet temperature of the liquid separation tank is between -31~99℃, the outlet temperature is between 4~99℃, and separate liquid drops whose diameter is not less than 300μm, it is used to further deeply separate part combustible liquid generated or carried by the venting pipe network during the large-displacement venting. If necessary, U-shaped heating tube can be set in the liquid separation tank to integrate the liquid separation tank and the heater into one device, which saves investment and land. The high and low pressure venting pipe network system can set multi-point purification natural gas blow point at the initial end of the pipe network, use purified gas to continuously blow the high and low pressure venting pipelines throughout the network, maintain the mobility of the gas in the pipe network, and prevent the high-sulfur venting gas from staying in the pipe network and cause corrosion to the pipe network [5] [8].
According to the above requirements, the venting process was designed. Taking the X well in the northern part of a certain area as an example, it needs three throttling treatments without heating. After the recovered natural gas is throttled by the needle valve at the wellhead, it passes through two throttle valves for three high-pressure throttling, and after the three high-pressure throttling, hydrate inhibitors are injected to prevent natural gas hydrate from being generated in the subsequent throttling process. A portion of the gas after injected into the hydrate inhibitor goes to vent the flare, and the ultrahigh pressure natural gas after three throttling finally enters the desulfurization device.

4. Blowout/Venting Process Design of Ultra-High Pressure Sulfur-Containing Gas Wells

The technological parameters of the integrated blowout/venting process flow should be determined by hydraulic calculations, and the size of the venting flare should be determined by calculations of venting volume and thermal radiation. In order to ensure the full combustion of the venting gas, the Mach number does not exceed 0.5 when venting, and the Mach number does not exceed 0.2 for the venting of sulfur-containing natural gas. Under the conditions of large processing capacity and high processing pressure, high-pressure flare can be used to reduce the diameter of the flare and the venting pipeline at all levels. However, the back pressure increases, the pressure level of the venting pipeline will increase, so it needs to be determined after comprehensive comparison of economics and operations based on the specific venting volume of each project[7] [9].

The blowout/venting process after integration has the following characteristics in comparison with the blowout process and venting process before integration:

(1) At present, combustion pool ignition and blowout are more used in ground test of high-temperature and high-pressure gas wells. However, this handling has many drawbacks, for example, the combustion pool is very close to the ground, the heat radiation is very high when the blowout gas is ignited and burned, and it has a great impact on the surrounding residents and the ecological environment, the manpower and material resources are invested a lot, and the safety is poor. The gas well blowout process is integrated with the flare venting system, which can make the blowout operation safer, more environmentally friendly and efficient via the overhead flare ignition blowout method.

(2) The integrated blowout/venting process use overhead flare ignited and vented, and two flare liquid separation tanks are set up to separate the liquid carried in the gas, and prevent the occurrence of fire rain; another set of water sealing tank is set up for prevent flame backflow and seal.

(3) In allusion to the sulfur-containing characteristic of the gas, the venting system sets multi-point purification natural gas blow point at the starting end of the pipe network, and uses purified gas to continuously blow the venting pipe to maintain the mobility of the gas in the pipe network, prevent H2S stay in the pipe network to cause corrosion of the pipe network, in addition, ground process equipment and pipelines select H2S-resistant materials as well.

(4) If the sand content in the gas produced by the gas well is large, corresponding sand removal equipment can be added in the blowout process to separate solid impurities.
5. Conclusion
The main methods and principles that should be followed in the design process of the current ultrahigh pressure sulfur-containing gas well venting system were summarized via research of the relevant standards and specifications of natural gas venting system design at home and abroad. The process characteristics of blowout and venting of ultrahigh pressure sulfur-containing gas well was combined, the process flow of the two was integrated, thus meeting both large blowout at the wellhead at the beginning of the well opening and the emergency/overhaul venting when the gas wells were in stable production, and obtained the integrated blowout/venting process of ultrahigh pressure sulfur-containing gas wells.

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