Application of Downhole Camera Technology in Fault Diagnosis of Coalbed Methane Wells

Liu Yin-hua1st*,a, Xing Xue-jie2nd, Wang Yu-bin3rd, Xu Wan-yong4th, Liu Kai5th, Lv Yuan6th

1Engineering Technology Research Institute of PetroChina Coalbed Methane Company Limited Xi’an, China
2Hancheng Branch of PetroChina Coalbed Methane Company Limited Hancheng, China
3Engineering Technology Research Institute of PetroChina Coalbed Methane Company Limited Xi’an, China
4Engineering Technology Research Institute of PetroChina Coalbed Methane Company Limited Xi’an, China
5Engineering Technology Research Institute of PetroChina Coalbed Methane Company Limited Xi’an, China
6Qixian Youyuan Photoelectric Technology Company Limited Qixian, China
*a442063054@qq.com

Abstract. In the production process of coalbed methane well, due to casing damage, falling objects, sticking and other reasons, the continuous production is affected. In order to accurately identify the complex conditions of the gas well, the underground real-time camera technology can be used to diagnose the complex conditions of the underground, and provide a reliable operational basis for the next step of the overhaul construction measures. Through field application, the downhole camera technology can provide an accurate real-time picture of the gas wellbore, clearly capture the complex situation in the casing from the wellhead to the bottom of the well. It is of great guiding significance to analysis the causes of downhole faults and develop accurate repair measures.

1. Introduction

As a kind of clean energy, coalbed methane (CBM) has been paid more and more attention because of its environmental benefits. China is rich in coalbed methane resources. The exploration and development of coalbed methane is an important supplement to conventional natural gas resources. Coal seam has the characteristics of low permeability, low pressure and heterogeneity [1-3]. The production mode of coal-bed methane is coal seam fracturing, drainage and depressurization [4]. In the production process, complex faults such as casing damage, downhole falling objects, pipe string sticking and so on often occur, resulting in shut down for repair, which affects the continuous production of gas wells. Therefore, it is necessary to repair and recover the failed gas wells through downhole operations [5].

The downhole fault diagnosis technology is the basis of gas well fault repair. The traditional fault diagnosis methods mainly include lead mold printing, thin-walled tube casing inspection, 40 arms
caliper logging, casing side printing, etc. In the field application process, technicians need to judge according to rich operation experience, which has low efficiency and large error.

In order to enhance the accuracy of fault diagnosis in coal-bed methane wells, based on the eagle eye test technology [6-7], this paper studies and forms the downhole camera logging technology. Through the downhole real-time shooting, technicians can obtain clear and continuous images.

According to the real-time diagnosis of downhole fault, the downhole camera logging technology can improve work efficiency and accuracy. It also can provide important reference for taking reasonable and effective treatment measures.

2. Principle of downhole camera logging

The working principle of downhole camera logging technology can directly obtain downhole images by using underwater optical detection method. The system consists of three functional modules, which are downhole module, transmission module and ground module. Downhole module includes light source, camera system and signal conversion system. Transmission module is mainly logging cable, which is used for signal transmission and power supply between underground and ground. Ground module includes power system, signal processing system and image display. Its working principle is to use the logging cable to lower the camera and image conversion machine into the wellbore. In the process of lifting and lowering the instrument, the light source irradiates the wellbore, and the reflected light is acquired by the camera. After the video signal amplifier and signal conversion system, it is converted into digital signal, which is transmitted to the ground function module by the logging cable. After being processed by the ground signal amplification receiver and de-coding chip, the clutter is filtered out, and the image is re-edited and converted into image signal. The image is played and recorded through the display and video recorder, so that the technicians can diagnose the downhole fault in time.

3. Composition and matching technology of downhole camera logging

3.1. Equipment composition

The downhole camera logging system is mainly composed of acquisition host (Fig.1), camera and image conversion integrated machine (Fig.2), encoder, logging cable, cable winch, liquid crystal display and notebook computer. The camera in the integrated camera and image conversion machine can realize 360° rotation focusing, which can meet the requirements of full wellbore shooting. The equipment connection is shown in Figure 3. The network interface of the acquisition host is connected to the notebook computer through the network cable. The Liquid crystal display (LCD) interface is connected to the LCD through the VGA cable. The main cable interface is connected to the cable winch through the 5-core aviation socket, and the depth interface is connected to the coder through the 7-core aviation socket connection line.

![Figure 1 Image-capturing Machine](image)

Figure 1 Image-capturing Machine

3.2. Matching well flushing technology

According to the field practice, the downhole camera logging technology based on visible light shooting needs good transmittance of the media in the well and can take clear images, which puts forward higher requirements for downhole targets and wellbore media. However, the media in CBM wells are mainly natural gas, formation water and pulverized coal. The presence of pulverized coal affects the clarity and transparency of underground media. In order to improve the effect of downhole camera logging, it is necessary to evaluate the well condition before logging. For long-term stationary CBM wells, camera
logging operation can be carried out directly. For CBM wells with serious pulverized coal production, the well washing is taken first, and the wellbore liquid is replaced with clean water, and then the downhole camera operation is carried out to reduce the impact of pulverized coal.

4. Application of downhole camera technology in complex diagnosis
In the workover operation of coalbed gas wells, the underground camera logging technology is used to diagnose the complicated situation of the underground well, and the good results are obtained. With the help of this technology, the downhole falling objects, sand deposition, casing opening, fracture, fault, deformation and tripping can be clearly captured. It provides a reliable basis for determining the cause of underground fault and formulating effective workover measures of coalbed methane.

4.1. Underground falling objects
Well MZ-022 encountered resistance at about 175m many times in the process of running pipe string, so the downhole fault could not be determined after lead printing. The downhole camera logging technology was used to photograph the downhole fish as tubing at 175.65m. As shown in Fig. 4, the ratio calculation was made by using the inner diameter of the casing of Φ124mm, and the fish top of the falling object was determined to be a Φ 73mm tubing coupling, and the tubing coupling had been seriously fractured and deformed after the previous operation, with an outer diameter of about 80mm. According to this, a fishing barrel was made, with fishing diameter of Φ90mm and closing diameter of Φ73mm. The downhole tubing was successfully fished out.
4.2. Casing window
After fracturing, the well H-041 was unable to be put into production when sand flushing was blocked. There was no footage for sand washing for many times. The drilling footage was slow when milling operation was used. Sand returned and a little iron filings were stopped. Therefore, lead molds of different specifications were used to print lead seals for 4 times, which could not accurately determine the downhole resistance position. The downhole camera logging technology is used to test the casing condition of the well. The camera enters the liquid level at 521.73m to clearly see the casing coupling and perforating hole; it reaches the bottom hole resistance position at 659.81m, as shown in Figure 5. The image shows that there are double holes in the well. It is judged that the casing has been windowed during milling, and the tool can not re-enter the original wellbore. The centralizer is used to re-enter the original well Tube.

4.3. Casing crack
During the fracturing process of well H-056, the annular steel plate cracked and water gushed from the wellhead.
When the operation team looked for the leakage from the wellhead down, it was found that the leakage occurred in the 65-75m section of the wellbore. Four fractures were found in the well after downhole camera test, including two fractures at 66.86m and 68.1m, 1.06m and 0.31m in length, and
two fractures at 101.76m, 1.58m and 0.82m respectively (Fig. 6). According to the image of casing fracture, the method of taking shallow casing and changing casing is adopted to replace fractured casing.

4.4. Casing fault
After Y-014 well was tested by downhole camera, as shown in Fig. 7, it was found that the casing at 742m was wrongly broken, and the position had moved more than 50%, so the operation was suspended because the simple overhaul could not be completed. Formulate sleeve milling and sleeve changing operation plan and contact overhaul team.

![Figure 7 Casing fault of well Y-014](image)

4.5. Casing trip
During the fracturing operation of well H-021 with casing tripping, the wellhead jumped up and the pressure returned to zero. The downhole camera logging operation was carried out for the well, and the tool was lowered to 198.92m depth.

![Figure 8 Casing trip of well H-21](image)

As shown in Fig. 8, the casing tripping image was successfully photographed, and casing matching and fastening operations were taken to improve the wellbore repair operation.

5. Conclusion
a). The field application shows that the downhole camera logging technology can provide timely and accurate downhole casing condition for workover technicians by photographing the wellbore conditions, which improves the efficiency and correctness of downhole fault diagnosis for technical personnel, and provides basis for formulating effective workover measures for CBM fault wells.
b). With the help of the downhole camera logging technology, the gas production in the perforated section, the corrosion of the wellbore and the casing thread up can be photographed, which will broaden the application scope of the technology. The technology can be used to judge the main gas producing layer, detect the downhole corrosion, judge whether the casing tightening is qualified or not, and establish the visualization file of CBM single well.

c). In addition to the matching well washing technology, the next step needs to continue to explore other technologies to reduce the impact of coal powder, which is suitable for down-hole camera quality.

Acknowledgment
The project is supported by National major science and technology project (Number :2016ZX 05065) and Major science and technology project of CNPC (Number :2017E-1406).

The authors wish to thank National major science and technology project (Number :2016ZX 05065) and Major science and technology project of CNPC (Number :2017E-1406), for providing necessary financial assistance.

The authors also would like to thank anonymous reviewers who gave valuable suggestion that has helped to improve the quality of the manuscript.

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