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The Application of Fiber Bragg Grating in the Real-time Casing Damage Monitoring Work

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ABSTRACT: *With the unceasing exploitation of gas fields, casing damage is an important element which restrict oil-gas throughput. In this paper we present an distributed optical fiber Bragg grating analysical method in the Real-time Casing Damage Monitoring Work which through the study of the main type and damage of casing damage, analysis and comparison of the casing damage monitoring method, responding to the trait of oil casing. The results prove that sensing detection system designed by this method have high feasibility, high practicality and obviously effective to monitor coal. But it also has some disadvantages and must be improved further.*

Keywords *. casing damage, Distribution, Fiber Bragg Grating, real time monitoring, sensors*

I. INTRODUCTION

In well drilling and extracting oil process, the main function of casing is wellbore protection, shaft strengthening and cementing complex formations. With the unceasing exploitation of gas fields and continuously adjust the gas field development plan, which cause casing working condition becomes bad, even damage, which seriously affecting the oil field regular production. In order to maintain the level of predetermined production plan, production unit have to invest a lot of money in drilling new wells to replace those abandoned well. Frequent casing damage will disturb the normal production plan. When the number of casing damage Wells reaches a certain amount, which will destroyed the injection-production pattern system and the oil well can only production in the unreasonable state. This will cause the waste of oil and gas resources and influence on the improving economic benefit of oil well[1]. Therefore, real-time casing damage monitoring work is very important.

At present, our current detecting casing damage methods such as supersonic imaging logging, multi-arm caliper tool, hawk eye TV well logging, eight arm caliper logging, magnetic weight well logging, ultrasonic casing imaging tool, downhole TV well logging technology[2-5], but all these methods still remains in the well structure has been broken and the production process is unnormal. It is not difficult to find that this kind of measurement method has the following disadvantages:

The interval of measurement large, so it can not guarantee for the measurement time is the best opportunity that diagnosis and solve the problem of casing damage, and can not describe dynamic variation characteristics of casing accurately.

Construction difficulty is big in ocean and remove areas, we can not collect data in wicked condition such as wicked weather.

The well need to be closed when working, so it affect the normal production, and expand the unnecessary cost. Because of these factors, the study and develop of "The undergrpund permanent senser"become the hot spot in casing damage filed at present[6]. The undergrpund permanent senser need to provide data continuous according to required, so we can identify problem and solve it in time . 20th, the develop of optical fiber sensor in military an industry cause the attention of people. Compared with conventional electronic equipment, optical fiber has the superiority. Mainly includes:

transmission signal is light, the influence of electromagnetic field is small, so it suitable for long-term on-line monitor.after armour treatment, optical fiber sensor can work as usual underground under the condition of hight temperature and pressure.length unit of measurement is wavelength, with nano for orders of magnitude, precision is high.volume is small, easy of installation, technical progress fast, cost-effective. more kinds, thereinto distributed optical fiber sensor can do continuous monitoring of spatial distribution. Because of these advantages, optical fiber sensor becomes consummate underground permanent sensor.

II. THE BASIC PRINCIPLE OF FIBER BRAGG GRATING

The basic principle of fiber Bragg grating that interference fringe of uv laser irradiate the photosensitivity optical in within limits, and the refractive index of fiber core occur permanent and periodic change, so fiber Bragg grating was formed. In essence, fiber bragg grating equivalent to a narrow band filter, when incident light that include certain spectrum range transfer to fiber Bragg grating, grating will reflect

incident light that meet Bragg reflection condition and was modulated by external condition such as temperature, pressure, stress, flow etc, according to demodulation of reflection spectrum, we can attain information that we required, formation as shown in figure 1.

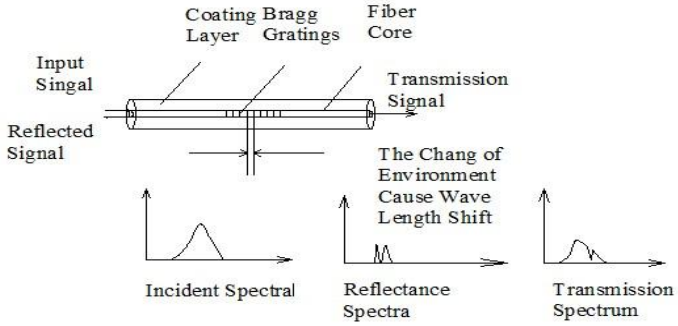

Fig. 1 Fiber Bragg grating structure diagram

Fiber Bragg grating meets the Bragg reflection condition:

$$\lambda_B = 2n_{eff} \cdot \Lambda$$

λ_B the Bragg grating reflection wavelength, n_{eff} the Effective refractive index of optical fiber core, Λ the period of grating[9].

As for fiber grating measured physical quantity (such as temperature, pressure, flow rate, stress, radiation intensity) changes, n_{eff} and Λ change correspondingly, thereby the Fiber Bragg grating center reflection wavelength λ_B changes. In return, by detecting the change of λ_B, the change of measured physical quantity can be inferred[8-12].

III. DISTRIBUTED OPTICAL FIBER BRAGG SENSORS

When the bushing works normally, it is damaged by various internal or external causes. for examples, temperature changes lead to the change of soil around the pipeline, so the pipeline is deformed and even damaged; the pipe wall is wore by the sediment of the crude oil unavoidable and corroded by other chemical components in crude oil quickly, so that cause the damage of pipeline. Distributed optical fiber Bragg sensors can detect the defects with small corrosion area (dozens of square centimeters) and about 50% corrosion depth. The measurement range break the previous limitations and reach hundreds of kilometers, which can continuously collect bushing damage data along the entire length of well completion , and then monitor all bushing of the entire well and provides the qualitative and quantitative information of downhole damaged bushing parameter changes. The traditional measurement tools only measure a given point parameters at any given time. In order to test the full range parameters, point type sensor can only be achieved by back and forth movement in the well, which impact the balance of downhole environment inevitably. Strengths of the distributed optical fiber Bragg sensor is that the optical fiber wasn't moved in surveyed area. This can ensure the equilibrium state was unaffected. The optical fiber is placed in capillary tubing, so the distributed optical fiber Bragg sensor is used for testing in the place where capillary tubing can reached. The distributed optical fiber Bragg sensor technology can real-time monitoring the integrity of long distance pipeline in this field[13-16].

The most allowed loss of a distributed optical fiber Bragg sensor monitoring system is limited. So the total loss of distributed optical fiber Bragg grating monitoring system must be estimated before site installation to ensure it in the permissible range. If not, the system can't work normally. When optical fiber is working, loss would increase greatly with increasing distance. The adaptors, splicing and wellhead equipment docking would generate loss. The most allowed loss of system need to be increased with using transmission fiber of low loss and reducing the adaptors and the splicing to apply the optical fiber Bragg sensing system for best.

The installing for optical fiber real-time monitoring system on oil and gas well

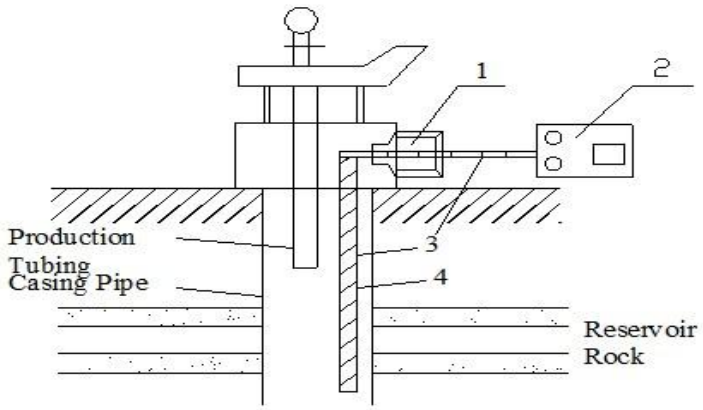

fig.2 The optical fiber real-time monitoring system installation schematic

1-the wellhead equipment; 2- ground instrument section;

3- sensing cable; 4- the distributed optical fiber Bragg sensor

Such as graph, this monitoring system consists of 3 sections: the underground sensing section, the wellhead equipment and ground instrument section system[17].

Optical cable which consist of distributed optical fiber sensor, armored protection ventricular and fiber was installed in the annular space between casing and production tubing, and then injected into well. This makes the sensors easy to install and change. The function of the wellhead equipment is to bear the weight of all sensing cables underground, and guarantee the smooth docking of the underground cable and aboveground cable. It is noteworthy that the exit position must be sealed absolutely. The ground equipment system is used for the acquisition, processing and interpretation of the data, as well as the subsequent network transmission.

IV. DATA PROCESSING

In the traditional control method, operation staffs supervise the production at operation station, enterprise administrators can't understand the practical running situation if they don't pay a personal visit, let alone implement the decision. At the end of 20th century, thanks to the rapid development of sensor, mobile communication, computer and internet, the realization of the dynamic monitoring of casing had the technical basis, and the industrial remote control can come true. Not only the technicians but also the managers can understand the field condition and make decisions through computers and mobile devices. The concrete processing is showed in Figure 3.

The environment temperature and pressure which downhole casing in, stress imposing on casing and so on can be measured by sensor. Then these data will be collated and transmitted to database server. After compared these data and the previous data, visualization charts of contrast result can be obtained. These charted will be sent to web server and then published on the internet. Managers and technicians can supervise these data anywhere through internet. At the same time, alarm procedures was set in database server, and they can sent alarm information to the binding mobile through GPRS Modem when data anomaly [18].

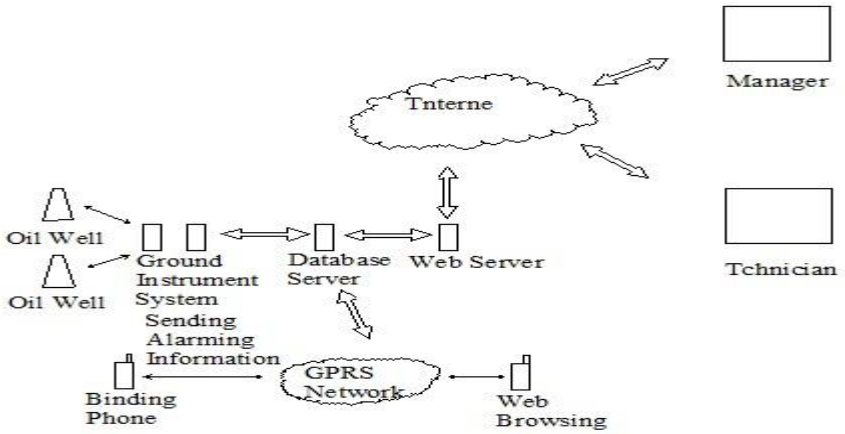

Fig.3 Diagram of data processing network

Problems about fiber Bragg grating

A . high cost

At present，although the optical fiber Bragg grating research made a certain progress，confirmed that optical fiber grating sensor is effective, reliable and advanced technology of sensor, but its cost especially optical fiber grating demodulation devices cost is still high, in China widespread use conditions are not ripe, which requires increased research efforts to develop more cost-effective practical optical fiber equipment.

B. Installation success rate need to further improve

Sensors in installation will be a lot of damage，the survival rate is low. In order to avoid direct impact of optical fiber Bragg grating sensor about casing wall or bottom hole, design a sensor array protection room, improve sensor encapsulation technology is necessary. Different packaging technology to improve the performance of the sensor has played an active role.

C. The durability of the sensor

The lifetime about a well normally have for years, or even decades, as the sensor's long-term stability and durability directly affects its service during the period of the condition monitoring. If fiber Bragg grating used in actual production casing of monitoring, its durability must be further tested[19].

D. manufacture of sensor is difficult

Because the casing will be in the condition with high temperature and high pressure under the well in a long time, it is difficult to make the casing adapt to this condition. The sensor will not work normally in a short time when it contacted with the fluid under the well, so, the sensor need to be sealed by the protection ventricular, but this skill in our country can't satisfied with the need. The skill to make fiber grating sensor is very skilled in a long time, but the production is very expensive and the shape of the fiber grating sensor and the style to install it can't adapt to the condition in our country.

V. CONCLUSIONS

With the development of the oil and gas field, the damage of the casing becomes more and more worse, in order to prevent and manage early; we should get the accurate information of the casing in time. Distributed optical fiber Bragg grating sensor system can carry on the dynamic monitoring; also, it can work in a high temperature and can't be disturbed by the electromagnetic and it can transfer much information. It attracted more and more attention from the director. According to the high price and low success rate in installing, we should increase the research efforts and input more manpower and material resources to develop the fiber with low price and better performance. Now, dynamic monitoring become more and more important, distributed optical fiber grating sensor is better than traditional sensor, it will have a wide prospect.

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