Application of VPH Spectrometer in Gas Logging

In the process of oil or natural gas exploration and production, gas logging or mud logging is a very important detection method. On-line multi-component analysis of gases may help us analyse the location and reserves of oil and gas composition and its related content in the well.

Gas chromatography (GC) is often used to monitor and analyse multi-component gases, but it is also limited in some applications:

1, fast on-line detection, gas chromatograph requires a variety of auxiliary equipment, the gas path structure is also complex, and need trained operators, etc.

2, gas chromatography cannot distinguish between hydrocarbons and nonhydrocarbons simultaneously.

In recent years, Raman spectroscopy is introduced into this application. Compared with gas chromatography, Raman spectroscopy has many advantages: 1. Raman spectroscopy does not require pipelines, and the cost is not so high. There is also no need for specially trained operators, 2, the information of hydrocarbons and nonhydrocarbons can be obtained quickly at the same time.

The Transmission spectrometer is often used for gas logging detection. The main experimental process is as follows:

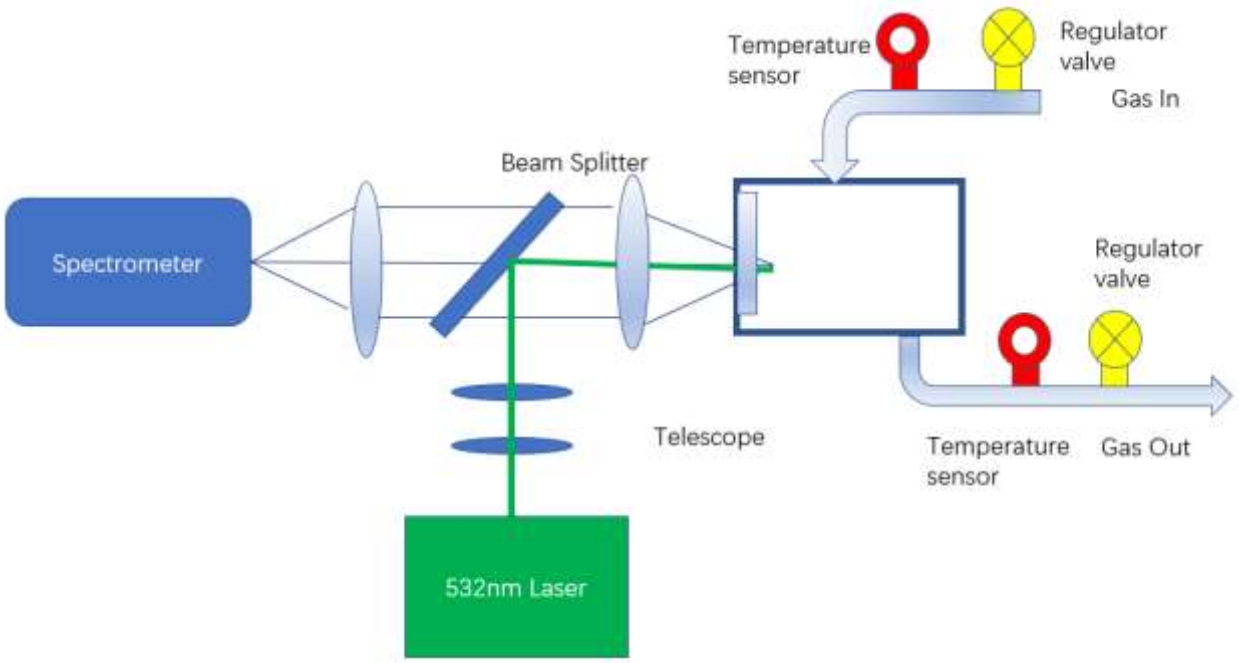

Fig.1: Schematic diagram of online gas Raman spectrometer

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In the above figure, the 532nm laser passes through the telescope system, and is reflected by the beam splitter and then focused into the sampling cavity through a window, and the Raman signal enters the spectrometer through the collection optical path. The inlet and outlet pipes are connected with temperature sensors and air flow valves, which can monitor the gas temperature in the detection chamber and control the flow rate of the gas to be measured.

Here is the internal structure of Transmission Spectrometer

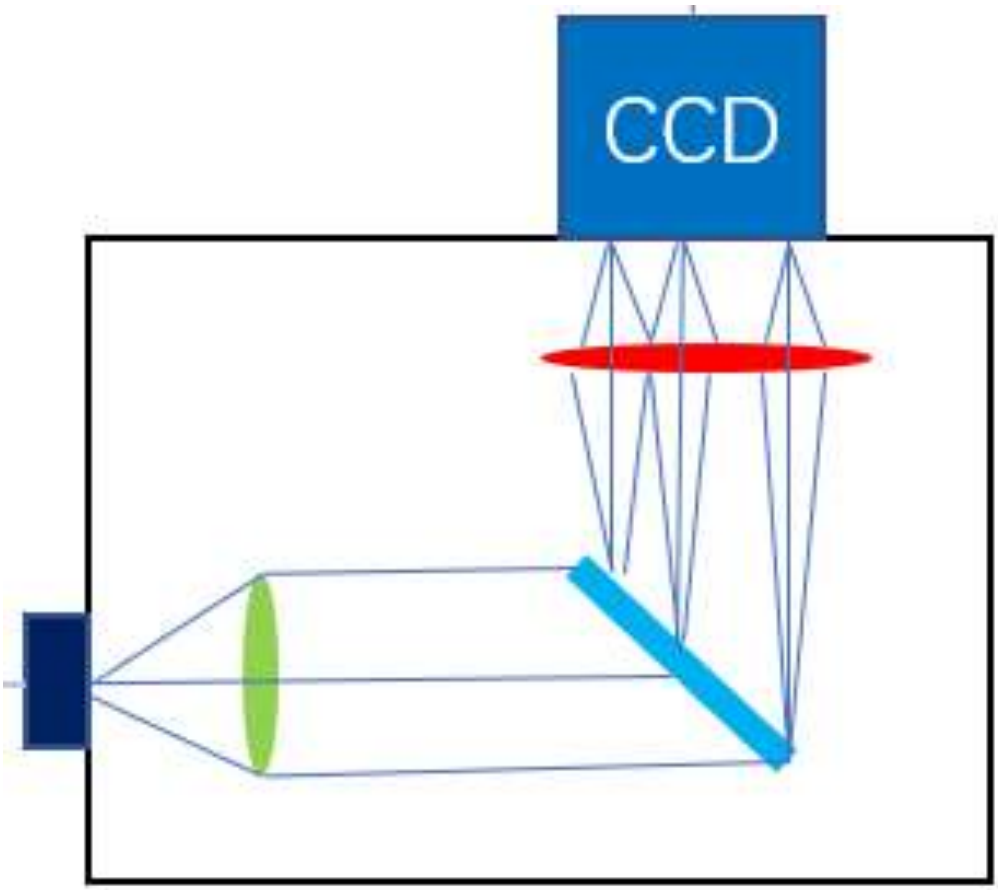

Fig.2：Schematic diagram of transmission grating spectrometer

The characteristics of this type of spectrometer are: 1. Compared with the reflective grating spectrometer, it has higher throughput, 2. The spectral range is also relatively wide in one shot. For example, when a 1800L/mm transmission grating is used in this kind of spectrometer, if the sensor width of the camera is about 30mm , the range of one shot can be over 4200cm^{-1}, and the resolution can be below 10cm^{-1}. Each gas has its own Raman peak, and such fingerprint characteristics can help us analyse a wide range from low wave numbers (hundreds of wave numbers) to more than 4,000 wave numbers and displays simultaneously.

During the mud logging analysis, the Raman spectrum of the mixed gas will be complicated, and there are often many overlapping bands. Scientists therefore developed new chemometric analysis that can deconvolve the superimposed spectra and ignore background and matrix effects. One of them is called data driven Raman spectroscopy (DDRS). This method is an application of partial least squares analysis (PLS). For Raman spectroscopic analysis of mud logging, it is not based on matching a single peak to analyse the spectrum, DDRS

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help to separate the most useful and relevant Raman spectrum for related components in a complex multi-component gas mixture for analysis. So, this method can not only judge the gas composition qualitatively, but also make quantitative analysis, which makes the mud logging exploration more efficient.

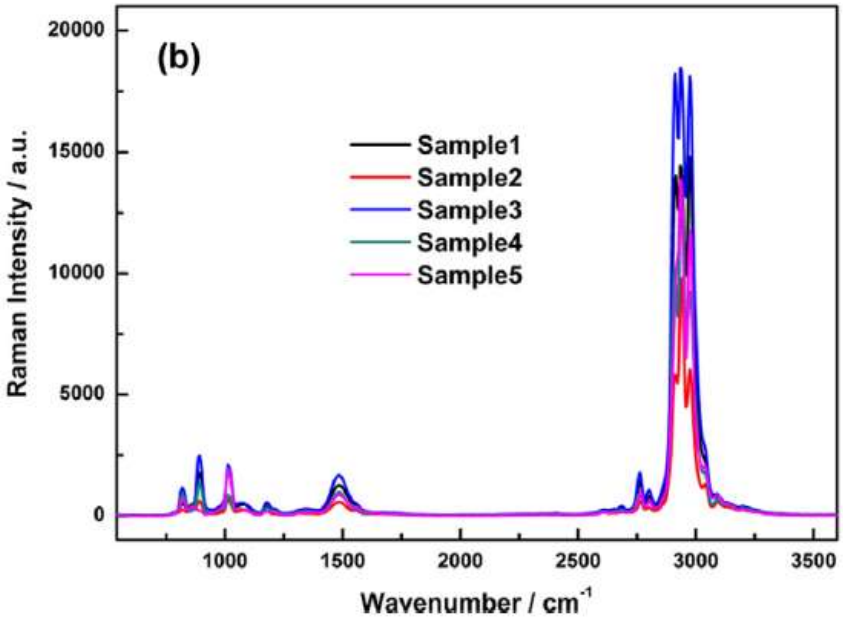

Fig.3：Raman Spectra of Various Hydrocarbon Gas Mixtures at Different Concentrations（From[1]）

Zolix has also developed a kind of transmission grating spectrometer in recent years, the VPH series spectrometer.

Fig.4：VPH Spectrometer

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Main technical features:

1. Ultra-high Throughput

F/number: F/2.3, Fiber coupling: 100% collection of optical signals with fiber, NA 0.22

2. Ultra-high light collection efficiency

The high transmission VPH grating ensures high diffraction efficiency, and the AR-coated lens ensures the maximum light transmission efficiency, thus achieving the maximum light transmission in the visible or near-infrared

3. Very low stray light

VPH grating - extremely low stray light due to smooth diffraction efficiency curve

4. Perfect spectral imaging quality

5. Compact design

6. High spectral resolution

Model Omni-iSpecT532A1, 5cm-1@585nm, 50um slit

Model Omni-iSpecT785A1, 3cm-1@912nm, 50um slit

Reference：

Xi Han a, Zhi-xuan Huang, Xiao-dong Chen, Qi-feng Li,Ke-xin Xu, Da Chen, Fuel, 207, 143 (2017).

KONG Andong，YANG Dewang，GUO Jinjia，WU Lulu，YAN Aoshuang，ZHOU Faju，WAN Yaqi，Optics and Precision Engineering，30(10)，1151（2022）

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