Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2013, 5(12):763-767

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Research on experiment of *in-situ* pyrolysis of oil shale and production analysis

Yang Yang*, Shi-chang Liu, Qiang Li and You-hong Sun

College of Construction and Engineering, Jilin University, Changchun, China

---

ABSTRACT

As the shortage of energy increased, the extraction of oil shale resources got attention. Method of retorting was not applicable for oil shale resources in Jilin. To create a new method for in-situ oil shale mining was very necessary. The method of high voltage with power frequency electric heating in-situ pyrolysis of oil shale was proved to be feasible, which could generate the oil, gas and should be deeply studied. The production test result was complex, and the product showed the kerogen pyrolysis at this condition.

Key words: in-situ pyrolysis; oil shale; GC-MS test

INTRODUCTION

With the development of economy, energy became prerequisite and basis for human living, science development and social progress. According to the statistics, the coal resource of the world proven energy could only be exploited for 100 years, the petroleum would be 30-40 years, and the natural gas would be 50-60 years as the current mining level. Therefore, the primary task in the energy strategy was to find alternative sources of energy, and to take the energy sustainable development road. In recent years, the contradictions of supply shortage of petroleum were more and more prominent, which proved to be the bottleneck of Chinese economic development. According to the domestic oil resources and productive capacity, the gap between supply and demand would be rapid bigger in the future, the importing petroleum would continue to increase, and the risk with dependence on foreign countries would ever-aggravate, so that China was the biggest petroleum consumption country in the world[1]. In many ways of ensuring the supply of fuel, shale oil was a realistic resource which could take the place of petroleum. Thus, large-scale oil shale exploration and development had important significance to relieve the pressure of domestic oil and gas supply and demand.

Oil shale was a combustible organic sedimentary rock with high ash content. The shale oil could be obtained from it after low temperature coking, the oil content > 3.5%, and high organic matter content. Shale oil resource reserves were approximately 411 billion tons, equivalent to 3 times of the remaining recoverable reserves of crude oil and condensate oil that had been explored on the world. Oil shale resources in China were also very rich. According to results of the new round of national oil shale resource evaluation from 2003 to 2006, the oil shale in China distributed at the 47 basins of 20 provinces (city, area). The oil shale resource in China was huge at about 47.6 billion tons, equals to 1.5 times of the traditional petroleum resources, and banking fourth in the world [2].

THE METHODS OF IN-SITU MINING OF OIL SHALE

At present, the shale oil production was 400 thousand tons each year, and the exploitation scale was very small and the mining level in China was still at the initial excavation or roadway mining. The coefficient of mining was only about ten thousandth, the most oil resource verified were not able to be mined because of the lack of the exploitation technology. The oil shale rock was destructive distillated on the ground after the excavation. But this mining method had limitation of exploitation scales, and also many disadvantages as the low exploitation efficiency, environmental

pollution, groundwater pollution, more area and large amount of manpower [3]. Therefore, there was a big urgent need to develop the new technologies on the oil shale exploitation and utilization in order to increase the recoverable reserves of oil and gas resources. The in-situ exploitation of oil shale was an environmentally, efficiency way of mining, and had got much attention in recent years.

The in-situ exploitation methods were very few, such as American Shell in-situ conversion technology (ICP), Exxon Mobil split voltage technology, and Schlumberger critical flow of RF technology [4]. The domestic in-situ exploitation method was limited to the interior experiment stage, and also got some achievement. The oil shale resource in Jilin province was large, but thin reservoir and low oil content. The economy was poor by using the above technologies. To propose a new method of mining was in a favor of expanding the energy utilization.

THE MECHANISM OF HIGH VOLTAGE WITH POWER FREQUENCY ELECTRIC HEATING IN-SITU PYROLYSIS OF OIL SHALE

In the oil shale, the electrodes were set spaced, using high voltage-power frequency discharge, forming a class cylinder dendritic channel inside the shale. The temperature could reach thousands of degrees in the process, so that plasmas were formed on the channel surface. (Plasma, generated at high voltage and temperature, was substance of ionization which consisted of atoms without electronic with good conductivity). Continued to the power frequency, the movement of charged particles in the plasmas would cause the charges locally concentrated, generating an electric field; a current caused by charge directional movement, generating a magnetic field. The electric and magnetic fields affected other particles, and accompanied by strong heat radiation and heat conduction. So that the oil shale up to pyrolysis temperature [5-7].

In addition, under the instant high temperature conditions, the organic matter of the rock through high temperature would be graphitized. And the graphite had a strong conductivity and thermal capacity, also contributing to the heat conduction [8].

THE EXPERIMENT OF HIGH VOLTAGE WITH POWER FREQUENCY ELECTRIC HEATING IN-SITU PYROLYSIS OF OIL SHALE

The experiment was used to prove that the mechanism above was feasible. The Fig.1 showed the flow chart of the experiment equipment. It started with the transmitter and Composite heating apparatus, which could make the normal voltage much more. Then to the reactor (shown in Fig.2), which consisted the chamber cover, electrodes, feet, gas quick exhaust window and the observation window. The parameters of the reactor were shown in Table.1. The oil shale was put into the reactor, and it would product oil and gas at the pyrolysis temperature. Before collecting the gas, it would go through the cooler to make the gas oil cold and back to the oil collection [9-11].

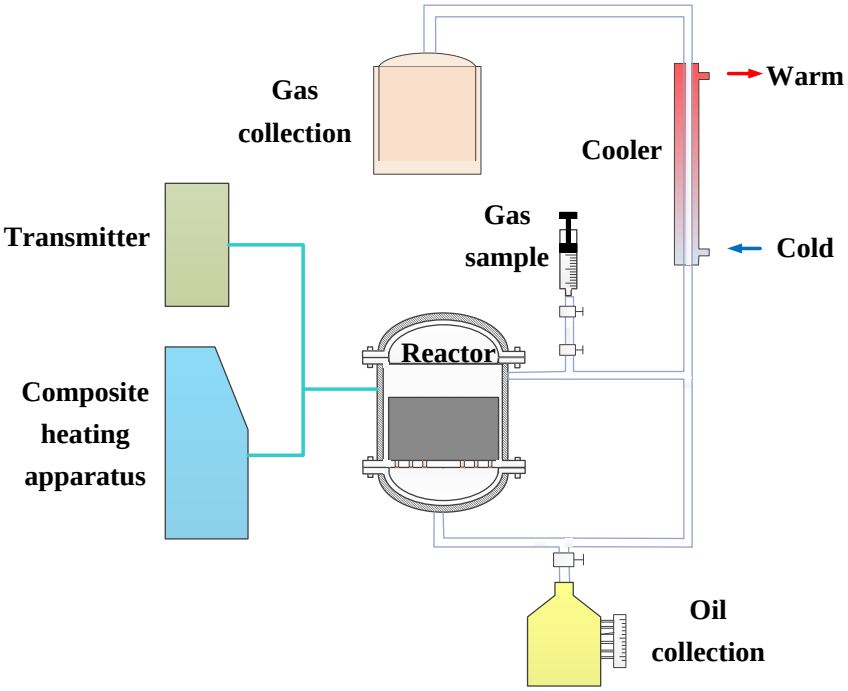

Fig.1: The flow chart of the experiment equipment

Fig.2: The design model of the reactor

The experiment started in Fig.3, the oil shale was put into the chamber, and the temperature sensors were set inside the rock. High voltage was used to break down the oil shale first. When the electric current increased suddenly, it proved that the electric current formed a channel inside the oil shale. Then the normal voltage was use to heat the oil shale through the channel. When the temperature of the oil shale rose to the pyrolysis temperature, the shale oil and gas could be collected. The gas and shale oil could both be ignited.

Table.1: Parameters of the reactor

Material	Stainless steel
Volume/m ^{3}	0.8
Height/m	1.2
Inside diameter/m	1.0
Outside diameter/m	1.4
Weight/kg	570
Sample weight/kg	500
Sample diameter/m	0.7
Temperature/℃	500
Pressure/MPa	1.0

Fig.3: The photo of oil shale in the experiment

Compared with the ICP technology, the electronic heaters were perpendicular to oil shale strata direction. While this method was to form channels parallel to the formation, the effective heat transfer area was much bigger than the ICP technology. And its material, shale slag will adhere on the heater, would result in the heater breakage for long, while this method could avoid the above case. The high voltage with power frequency electric heating in-situ pyrolysis of oil shale could successfully produce gas and shale oil, and also had its own advantage.

SHALE OIL PRODUCTION ANALYSIS

After the experiment, the shale oil was fully dissolved in hexane and then gas chromatographic tested by GC-MS, and the GC full scan spectra shown in Fig.4. The shale oil had a complex composition from the spectra, the system could recognized more than 200 peaks. The computer matched the mass peak of the spectra and the library, the first component separated were the alicyclic hydrocarbon of small molecular weight and some compounds containing hetero atom N, S and O, cyclic ketone, indene ketone, thiophene, phenol, and then aromatic compound like naphthalene, indene, quinoline. After the retention time is more than 15 min, the components were almost the larger molecular weight saturated alkane.

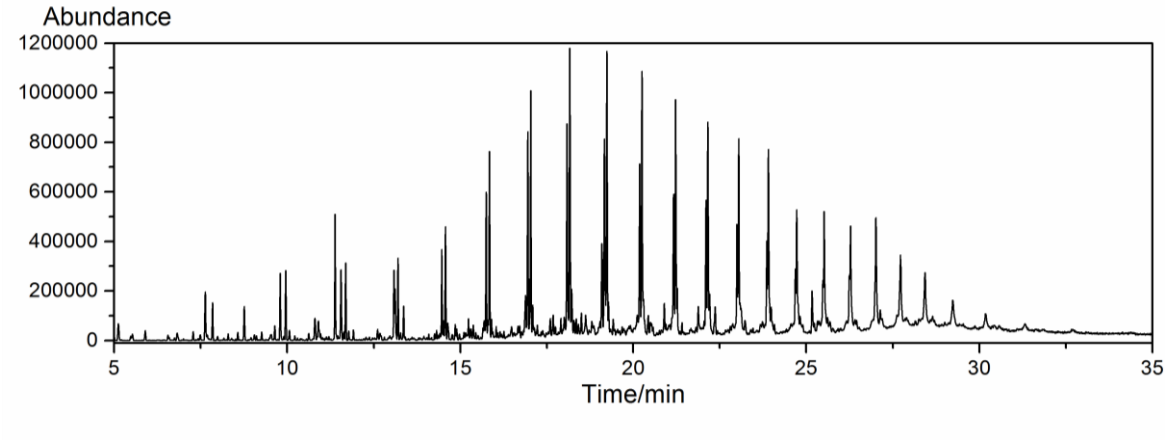

Fig.4: GC full scan spectra of shale oil

These components could be divided into three categories: aliphatic compounds, aromatic compounds and heteroatoms, and their relative contents could be calculated by gas chromatographic peak area normalization method. The highest content was aliphatic compounds, the accounts was about 71.81% of the total; the aromatic compounds was about 11.74%; heteroatomic compounds was about 16.45%.

The production could also prove that the oil shale could pyrolysis through high voltage with power frequency electric heating in-situ pyrolysis method.

CONCLUSION

1. The high voltage with power frequency electric heating in-situ pyrolysis method of oil shale could produce the shale oil and the gas. The underground equipment was simple, easy in-situ operations, was a promising method for in-situ oil shale pyrolysis.
2. The high voltage with power frequency electric heating in-situ pyrolysis method was more suitable than the ICP technology for the mining of oil shale resources in Jilin area, its mining channel was parallel to the oil shale layers.

Acknowledgements

This work is supported by the production- study-research-applying cooperative innovation national project on Chinese potential oil and gas resources (The exploration and utilization of oil shale).

REFERENCES

[1] Zhao-jun Liu, Qing-shui Dong, Song-qing Ye. *Journal of Jilin University(Earth Science Edition)*, **2006**, 36(6):869-876.
[2] Qun Lei, Hong-yan Wang, Qun Zhao. *Natural Gas Industry*, **2008**, 28(12):7-10.
[3] Sheng-ying Liu, Shi-hui Wang, Chun-rui Chen. Shell *Journal of Daqing Petroleum Institute*, **2007**, 31(6):53-55.
[4] Ji-hui Niu, Dian-yi Chen. *Journal of Jilin University (Earth Science Edition)*, **2006**, 36(6):1027-1030.
[5] Shu-yuan Li, Jia-lin Qian, Jian-qiu Wang. *Acta Petrolei Sinica*,**1990**,5(4):86-93
[6] Bai-zhong Sun, Qing Wang, Shao-hua Li. *Journal of Power Engineering*, 28（1）:163-167.
[7] Qing Wang, Qing-xian Jiang, Bai-zhong Sun. *Energy Engineering*, **2006**（2）:1-5.
[8] Zhi-qin Kang, Yang-sheng Zhao, Dong Yang. *Chinese Journal of Rock Mechanics and Engineering*, **2010**, 29(1):90-96.
[9] Qiao-rong Meng, Zhi-qin Kang, Yang-sheng Zhao. *Journal of China University of Petroleum*, 34（4）:89-98.
[10] Zhi-qin Kang, Zhao-xing Lv, Dong Yang, Guo-chao Yan,Yang-sheng Zhao. *Journal of Xi'an Shiyou University (Natural Science Edition)*, **2008**, 23（4）:30-34

[11] Qing-xian Jiang. Study on the Physical and chemical Characteristics of Huadian Oil Shale. [D]. *Northeast Dianli University*, **2006**.