1. Introduction

The current energy consumption structure in China is coal based.

China is a big developing country, it has large population and weak economic foundation due to its historical reasons. Its oil and natural gas resources are relatively short; it has been proven that the oil reserves accounted for only 2.4% of the world, and the natural gas accounted for 1.2%; while its coal accounted for about 14%. “Rich in coal, short of gas and oil” resource condition determines China’s energy structure being dominated by coal.

In China, the total energy production was 2.8 G tons of standard coal in 2009, while the coal accounted for 77.5%, the oil 9.4%, the natural gas only 3.8%, and other (hydropower, nuclear power, wind power) accounted for 9.3%. The total energy consumption in 2009 was 3.05 G tons of standard coal, including the coal 70%, the oil 17.8%, the natural gas 3.9%, the nuclear power 0.8%, the hydropower 6.7%, and other non fossil energy sources (wind, solar and biomass) 0.8%.

Above status indicates that there is a significant difference between China’s energy consumption structure and that of the world in average. In the consumption of primary energy consumption, the world average oil consumption level is 34.8%, China is only 17.8%; China’s natural gas consumption accounted for 3.9%, lower than the world average level by 20%; while the coal consumption in China is higher than the average level of the world by 40%; China’s nuclear power is only less than 1%, while the world average level reached 5.5%.

It is planned to adjust the energy consumption structure, the proportion of coal in primary energy consumption will be down to about 63% by 2015, the power consumption of natural gas, hydropower and nuclear power, and other non fossil energy (mainly wind, solar and biomass), will be risen to 8.3%, 9% and 2.6%, respectively.

The state’s plans give us more room to reform the energy resource utilization in various fields in China remain. It is a benefit to both oilfield and society to improve energy saving and environments.

**Keywords:** oilfield, wind heating, energy consumption, energy saving, emission reduction

PROSPECT OF WIND ENERGY APPLICATION IN CHINA’S OILFIELDS FOR HEATING

M. ZHENG, Y. TIAN, H. TENG, J. HU, F. WANG, Y. ZHAO, L. YU

Institute for Energy Transmission Technology and Application, School of Chemical Engineering, Northwest University, Xi’an, China, 710069

E-mail: mszheng2@yahoo.com, Tel./Fax: 8602988303216

In this paper, the wind energy resource in China’s oilfields is analyzed, the difference between China’s energy consumption structure and that of the world in average is analyzed as well, and the application prospect of wind heating technology in China’s oilfields is discussed as an example to reform China’s energy consumption structure. It shows that it is possible to use wind energy as an appropriate heat resource or supplementary heat source in some oilfields to supply heat energy for oil heating and living, more room to improve the energy resource utilization in various fields in China remain. It is a benefit to both oilfield and society to improve energy saving and environments.
2. Wind energy resource in China’s oilfields

Wind energy is one of the safe and clean energy resources [1, 2]. Meteorological data shows that there is an available wind energy resource of 253 GW at the altitude of 10 m in China’s land, the amount around the sea is 3 times of the land.

Wind electricity generation has become the main form of wind energy utilization presently; it attracted much more attention worldwide. The utilization of wind energy is of great significance from the viewpoint of energy saving and environmental pollution reducing, therefore it has become one of the most important directions of sustainable energy resource.

As compared to wind electricity generation and wind water pumping, etc, wind heating has the advantage of high energy conversion efficiency. Since thermal energy is the most elementary form of energy, the efficiency of conversion from any kind of energy into heat energy is 100% theoretically; therefore the use of wind heating is the most convenient and favorable. At present, the wind heating technology is still in demonstration trials.

The wind energy resource in China’s oilfields is plentiful. In Daqing oilfield, the annually average wind speed is 3.8 m/s [3]. The wind is season sensitive there, the speed of wind is larger in spring and autumn, and smaller in winter and summer. It has a clear monsoonal character, it is northwest wind in January (wind frequency 33.3%), mainly to southerly in July (wind frequency 36.9%), it is alternate significantly from summer to winter annually. The northwest wind possesses the maximum frequency of 11%, and the south of 9%, the east wind is the minimum frequency of only 2%, other direction is in 5–7%. The annual wind energy available time is about 4000 h in Daqing oilfield [3].

Gudong oil production plant of Shengli oilfield is located in Shandong province, which is a wind resource rich region. The wind speed in this area is more than 3 m/s, and the annual time is more than 6000 hours. In 2008, the factory used wind power to supply electricity to the oil well. At present, there are 20 wind power generators of 20 kW for the oil production.

Aershan oilfield is located in Xilinguole Meng, Inner Mongolia autonomous region; it is a wind energy resource rich area as well. The wind data cumulated in 10 years shows that its actually annual wind energy utilization is 4739.16 h.

Sansu gas plant 14–4 gathering station of Changqing oilfield is located in Wushenqi area, Inner Mongolia autonomous region, its wind data analysis shows that the annual average wind speed is 2.9 m/s statistically.

In Xinjiang autonomous region, the wind energy resource is plentiful as well, the annually effective wind energy density is 1500 kWh/m². In Karamay and Beita Mountains, the annual effective wind utilization is about 4000 h [4].

The Pen 18–17 of 6th oil factory well group of Changqing oilfield is located in Dingbian, Shaanxi province, its average annual wind speed is 3 m/s.

In summary, many of China’s oilfields have plentiful wind energy resources, rational utilization of the wind resource in these areas can contribute to energy saving and CO₂ emission reduction.

3. Utilization of heat energy in oilfields

Oil heating is one of the important technologies in oil exploration and development, especially in the eastern part of China, the oilfield has entered into the water – full stage and with the extracting of heavy oil, heating becomes more important. At present, the main methods of heating in China’s oilfields are electric eddy current heating, heating of oil and gas combustion, respectively.

The electric eddy current heating mode is mainly using electricity from electricity grid, various additional devices are employed. The heating through oil or gas combustion is consumption of primary energy; it exacerbates energy shortage and environmental pollution.

With the development of oil and gas exploring, the need of oil heating is increasing as well. According to statistics, in 2005 the number of heating furnace is 18460 in the oilfields of China National Petroleum Corporation (CNPC). Furnace energy consumption has become the major depletion source in oilfields, one oil furnace consumes about 1.70 million tons of fuel oil annually [5]. Therefore, it is important to improve heating technology in oilfield, and develop safe and reliable energy saving technology, so as to ensure the oil industry production.

Take Qin-Jing pipeline as an example [6], it is an underground pipeline to transport the oil from Qinhuangdao to Beijing Yanshan petrochemical refinery. It has six oil stations, whose task is to heat the crude oil so as to keep transportation of the crude oil flowing in the underground pipeline smoothly. The amount of the crude oil going through the station is 700–800 tons per hour. Even in summer, a large amount of fuel oil is combusted to heat the crude oil, it raises the temperature of crude oil by 8–9 °C. According to the statistical data of the fuel consumption, each station burns about 280 kg/h fuel on average in spring, summer and autumn. It burns 40 tons fuel oil per day for the 6 stations. More oil is combusted in winter [6].

In addition, paraffin-based oil contains more wax, it has high viscosity and condensation point. Condensation is the main problem of this oil during its transportation, which affects the flowing and production [7].
Daqing oilfield is located in the northeast part of China, it has a long and cold winter [8]. The oilfield produced paraffin base crude oil. In the production and transportation processes of such oil, the waxy crude oil condenses with the decreasing of temperature, which attaches to the wall of the pipeline, and results in the inner diameter of the pipeline to decrease. As a result, the production stops when the blockage in the pipe becomes so seriously. In order to relieve the condensation of paraffin oil in winter, crude oil is heated to a certain temperature.

The staff living in oilfield is another heating demand. For a housing estate with staff member of 200 people, if 30 kg hot water is needed for each person per day, the daily hot water amount is 6000 kg for such a housing estate. In addition, the warming in winter for these staffs addresses other issues. So the usage of heating for living in oilfield is also a very important part of the heat demands.

Figure 1 shows a typical usage of heating technology in oilfields.

It can be seen from the above discussion, that the demand of heating in oilfields is fairly common. According to wind resource in oilfields, it promises the use of wind energy as a heating source, it could contribute to energy saving in oilfields and reducing CO2 emission.

4. Envisage of wind heating technology

Considerable energy saving could be derived if the wind heating technology is employed in the long-distance pipeline transportation.

Liaohe oilfield is a major heavy oil production base in China [9]. Traditional heating technique is used in its oil production, gathering and other processes. The traditional heating technology includes electric heating and burner warming. Oil, coal, and natural gas burning cause a lot of energy consumption and serious environmental pollution. A large amount of gas and electricity transmission is consumed to meet the external heating demands annually. Energy saving in oilfield could be obtained if wind power is applied to the oil gathering and transportation links, external heat transmission systems, etc.

For a small oil well of Liaohe oilfield [9], the daily fluid is 100 m³, its water-containing content is 30%. Before entering the furnace, the temperature of the liquid is 40 °C, while the temperature of the outflow from the furnace is 60 °C, i.e., the temperature increases by 20 °C. Table 1 gives the basic physical parameters of the fluid.

| Medium     | Density (kg/m³) | Specific heat (kJ/kg·°C) |
|------------|----------------|-------------------------|
| Water      | 1000           | 4.174                   |
| Crude oil  | 884            | 2.582                   |

Table 1. Basic physical parameters of the fluid

From the data in Table 1, one could obtain the daily heat energy required for water and oil heating, respectively,

\[ Q_w = V_w \cdot C_p \cdot \rho_w \cdot \Delta t = 250.44 \times 10^4 \text{ (kJ)} \]

\[ Q_0 = V_0 \cdot C_0 \cdot \rho_0 \cdot \Delta t = 305.09 \times 10^4 \text{ (kJ)} \]

The total amount is

\[ Q_T = Q_w + Q_0 = 555.53 \times 10^4 \text{ (kJ)} \]

Therefore the power is

\[ P = \frac{Q_T}{T} = 64.3 \text{ kW} \]

where \( T \) is the daily heating tome, 24 × 3600 = 86 400 s.

According to the above data, a heater of 100 kW or at most 150 kW is needed to meet the demand of heating.

Table 2 gives the wind resource in Liaohe oilfield area [9].

\[ P = \frac{Q_T}{T} = 64.3 \text{ kW} \]

If the windmill tower is 50 m, and the wind turbine efficiency of 30%, a radius of about 27 m is required to meet the needs of the heating unit.

5. Status of wind heating technology in China

Currently, wind heating technology can be roughly divided into seven kinds, wind power-electric heating, liquid stirring, liquid extrusion, solid friction, mag-
netic vortex, wind heat pump and compressed air, etc. Except the “wind-electric heating” mode, the other modes are direct styles for wind energy to heat energy conversion, which has less conversion link, and thereby higher utilization efficiency. In the wind magnetic eddy heating process, the windmill gets wind energy and converts it into mechanical energy to promote magnetic eddy heating machine directly; in the wind heat pump process, the windmill promotes the heat pump and generates heat directly, it uses a small amount of energy to promote the machine to extract a large amount of energy from outside.

The United States is in a leading position in wind heating technology, Japan is the main country for wind heating in Asia; European countries, such as Finland and Denmark, develop wind heating technology and system as well.

In China, the research work has been undertaken in universities since the 1st wind heating seminar held in 1985. The research work has been conducted mainly in Xi’an Jiaotong University, Shenyang Technical University, Northwest University and Guangxi University. Xi’an Jiaotong University and Shenyang Technical University studied the hydraulic way, Northwest University carried out the magnetic vortex and heat pump modes, and Guangxi University conducted a vortex-induced heating topic [7–10].

Northwest University designed and manufactured wind driven permanent magnet eddy current heating equipment and heat pump system. Among them, the permanent magnet eddy current heating equipment has reached a 10 kW, and the heat pump heating device achieved 20 kW.

6. Conclusion

It gives us more room to reform the energy resource utilization in various fields in China. Wind energy heating technology has great potential in oilfields. For the oilfields with abundant wind energy resources, wind heating technology can be used as the heat source for crude oil and living heating or supplementary heat source for daily life, it could reduce the cost of oil extraction and pollution emission.

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