Research on the application of power battery in oil field equipment

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Abstract. In order to fundamentally solve the potential safety hazard caused by the need to connect the electrical equipment to the high-voltage transformer, the application research of the power battery in the oilfield electrical equipment is organized, and the electrical equipment based on the power battery is developed, which realizes that the wellhead transformer can meet the power load demand of the whole operation process. The field application proves that the power battery can be applied to the electric operation equipment to realize the intrinsic safety of the equipment, and has good energy-saving and environmental protection effect. The novel electrical equipment is easy to operate, simple to maintain, and can be generalized and applied in oilfield.

1. Introduction
In response to the national green and low-carbon development strategy, Sinopec Group puts forward the "blue water and blue sky" environmental protection plan. In the aspect of equipment technology progress, the oilfield also puts forward the project of "replacing oil with electricity" to promote the fuel structure adjustment of operation equipment, and develop and popularize the electric operation equipment. Compared with the traditional diesel powered workover rig, the electric workover rig has obvious advantages in energy saving, environmental protection and noise. Shengli Oilfield has taken the first step in the development and application of electric workover rig and drill. It is the first oilfield in China to use grid electric power instead of diesel power at the operation site. By the end of 2018, Shengli Oilfield had more than 80 sets of electric operation equipment.

At present, the main motor power of the winch of 40t electric workover rig is 90kw to 110kw, and the total supporting power is about 150KW. The power of the wellhead transformer is generally 30kVA or 50kVA, so in order to meet the load requirements of the electrical operation equipment, it is necessary to configure another high-voltage transformer to connect to the power grid. The construction period of oilfield minor repairing is short, and its house moving happens every three to five days. Frequently connection, disconnection and transportation of high-voltage transformer and cable will easily cause cable damage and has major safety risks. Professional high-voltage electricians are required to carry out high-voltage line work. It is very difficult to lay and overhead high-voltage cables in the operation well site. It is also difficult to guarantee the safety detection and repair of cables, which increases the usage and maintenance cost of high-voltage cables. Since the existing wellsite transformer load cannot meet the demand of network electrical operation equipment, additional high-voltage transformer is required which restricts the promotion and application of network electrical operation equipment. Applying power battery technology to oilfield network electrical operation equipment is one of the most effective methods to solve this technical problem.
2. Research and application of power battery in oil field equipment

With the rapid development of China's new energy industry, the power battery represented by lithium battery has the advantages of large capacity, instantaneous high power output, safety and reliability, which has been widely used in the field of electric vehicles and achieved good results. The research content of electric energy storage technology of oilfield operation equipment refers to using various electric energy storage devices which include battery and super capacitor. Reasonably using power electricity and power battery jointly could solve the high load electricity demand of grid electric workover operation equipment under large load and charge the battery when the well pad becomes redundant under low load. It can effectively utilize the energy feedback when the string is lowered. It realizes that only using the transformer at the wellhead of the pumping unit can meet the power load demand of the whole operation process, completely eliminates the potential safety hazard brought by the disassembly and assembly of the high-voltage transformer in each operation, and saves a lot of labor and operation costs.

2.1. The design of overall technical scheme of grid power priority

Shengli Oilfield produced the first grid electric well hoist based on power battery in 2015. Its electrical principle is shown in Figure 1, and advanced grid electricity priority control strategy is adopted. The power battery is connected to the DC bus of the inverter, and the load is large when lifting the string. At this time, the grid power should be used first to make the wellhead transformer work at the maximum load within the allowable range, and the power battery should be used for power supply when the transformer load is full. When lowering the string and other small load conditions, make the most of the surplus capacity of the grid power will be utilized to charge the battery in time. The reverse power generated in the process of lowering can also be recycled and used to charge the battery, giving full play to its advantages of energy saving.

![Figure 1. Schematic diagram of combined power supply of power battery and grid power](image)

2.2. Optimal selection of power battery

Domestic relatively mature electric energy storage devices include lead-acid battery, super capacitor and lithium battery, and the main technical indicators are shown in Table 1. Through the comprehensive analysis of all kinds of electric energy storage device materials, the prototype uses LFP battery considering the field working conditions and field environment. At present, super capacitor is also used as power compensation device for grid electrical workover operation equipment. However, the energy density of super capacitor is low, which cannot meet the operation demand when the power is cut off at the well site. Therefore, additional diesel generator is needed as standby power.
Table 1. Comparison of performance indexes of main electric energy storage devices.

| Comparison            | Super capacitor | LFP   | RELY  | LT    |
|-----------------------|-----------------|-------|-------|-------|
| Material price        | highest         | medium| higher| higher|
| Market application    | less            | widely| less  | less  |
| Energy density        | 5.64~7.29Wh/kg  | 100~135Wh/kg | 130Wh/kg | 60Wh/kg |
| Working temperature   | -40~+65 °C      | -30~+60 °C   | -45~+85 °C | -50~+60 °C |
| Cycle life            | million times   | 6000   | 5000  | 20000 |
| Cell capacity         | 9000F           | 40~300Ah | 40~10000Ah | 45~180Ah |

2.3. Battery management system (BMS) design

Battery management system (BMS) is an electronic device composed of battery electronic components and battery control unit. Its main function is to improve the utilization rate of battery, prevent over charging and over discharging of battery, extend the service life of battery, and monitor the status, fault diagnosis and protection of battery. The battery management system has the following main functions:

(i) detection and protection of cell voltage and total battery voltage;
(ii) battery current detection and protection, charge discharge balance control;
(iii) battery temperature detection and protection;
(iv) calculation and evaluation of SOC of battery pack;
(v) insulation monitoring and leakage protection.

2.4. Battery performance test

After one year's field application, in order to test the performance of the battery, a test scheme for the performance of the battery pack of the electric hoister with electric energy storage is developed. On September 14, 2018, the battery pack was tested on site. The test site is shown in Figure 2, and the results are shown in Table 2.

![Test of the electric hoister with electric energy storage](image)

Table 2. Test of battery performance of electric hoister with electric energy storage

| Item                        | Description                  |
|-----------------------------|------------------------------|
| power supply mode           | battery only                 |
| working condition           | lifting insulation pipe      |
| load                        | 207kN~276kN                  |
| number of string            | 37                           |
| cumulative power            | 46.89kWh                     |
3. Application effect and conclusion

From August 2018 to February 2019, after the successful development of electric hoist with power battery, it has completed 70 jobs, consumed 52202kwh in total, and consumed 745kwh in average for a single well. The energy-saving effect is significantly more than 60%, and it can meet the conditions of continuous operation and automatic walking without grid power. It is highly praised by the oil production plant and employees. Reliable and mature electric energy storage device can be further popularized and applied in grid electric workover rig and oil electric hybrid dual power operation equipment.

4. Next research direction and Conclusions

After more than one year's application, the electric hoister with power battery has achieved good application results. In order to further promote the application of electric energy storage technology in oilfield operation equipment, the following work is planned to be carried out:

(i) Establish technical specifications for selection of electric energy storage devices for different specifications of operation equipment, and guide the matching of electric energy storage devices for electric workover operation equipment;

(ii) The design of the integrated monitoring and protection scheme for the electric workover with electric energy storage system ensures the safe and reliable operation of the electric workover system;

(iii) Establish the inspection and evaluation standards of electric energy storage devices in oil fields, and realize the inspection and evaluation of electric workover rigs for newly purchased and in-service electric energy storage.

5. Acknowledgments

This work was financially supported by The Doctoral Startup Research Program in 2017 of the Binzhou University “Design of Electrical System for Oilfield Electric Operation Equipment with Electric Energy Storage” (2017Y02) and The Major Research Project in 2017 of the Binzhou University “Research on Key Technologies of Hybrid Power Supply of Power Battery and Power Grid” (2017ZDL04).

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