

Research on Energy Saving and Reconstruction of Lithium Battery in RTG Container Crane

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Abstract. With the development of lithium battery energy storage system, energy saving and emission reduction of RTG becomes possible by using hybrid power technology. In this paper, the principle, advantages and disadvantages of the three main types of such technology used in the market are analyzed. According to the research, high-power water-cooling lithium battery RTG technology shows better energy efficiency and stability in the operation. Its safety and service life time have been greatly improved, and the cost of reconstruction and maintenance is reduced, which make it possible for wider application and promotion, which produces great economic and environmental benefits.

1. Introduction

In recent years, china's port container throughput has become the first in the world for many years. Rubber tyre gantry crane (RTG) has become the main loading and unloading equipment of the container port depot in China [1]. Due to flexible mobile operation requirements, the traditional RTG is generally powered by a diesel engine with large energy consumption, high cost of oil and gas emissions. It inevitably produced a large number of nitrogen (NO_x), sulfide (SO_x), carbide (CO_x) mixed flue gas in the process of operation, which has been the main pollution source of container ports[2]. In order to reduce the energy consumption and greenhouse gas emissions, the technology such as combination of a diesel-electric unit or an LNG generator unit and a storage unit (such as a super capacitor or a lithium battery) and recovery of RTG potential energy regeneration with storage energy unit is used for energy saving reconstruction of RTG, which has become a research hotspot in recent years[1, 3-9]. According to the composition of power, it is divided into three kinds of hybrid power forms, namely, the diesel-electric unit, the super capacitor, the li-ion battery and the LNG generator unit. The effect of energy saving and emission reduction of diesel-electric unit-super capacitor hybrid RTG technology is not the highest (about 30%). The reduction effect of a super capacitor hybrid RTG in LNG generator set is obvious. However, LNG is used as a driving force, especially when the RTG is suddenly loaded. LNG as a power, especially suddenly loaded, is not very convenient. The lithium battery has a large storage capacity, stable discharge current, no pollution and good safety performance, which is an ideal energy savings unit of RTG[1, 4]. Lithium battery - diesel-electric unit hybrid RTG has an outstanding effect on energy saving and emission reduction (about 60%), but it is expensive to upgrade lithium batteries.



In this paper, hybrid power RTG schemes of li-ion battery are analyzed, and their advantages and disadvantages are discussed. The research is conducive to improve and apply the energy saving technology of RTG lithium battery.

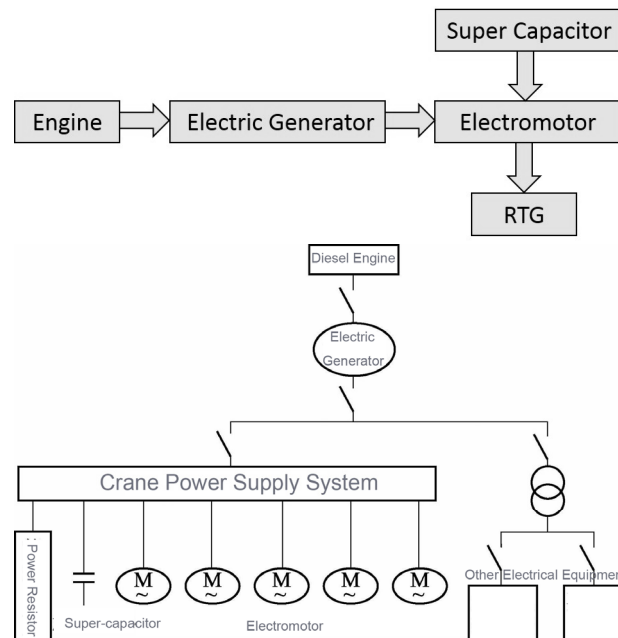


Figure 1. Operating principle of RTG using super-capacitor as auxiliary power source

2. RTG using light lithium battery as auxiliary power source

2.1 Operating principle

Hybrid RTG schemes use lithium battery instead of super capacitor as auxiliary power source. Compared to super capacitors, lithium battery has the advantages of large storage capacity, stable discharge current, no pollution and good safety performance. Charge discharge controller (DC/DC converter) controls the charge and discharge of the energy saving unit. It could automatically adjust the output power of the energy saving unit according to the energy required for lifting motor. The diesel generators could carry only a small percentage of the load current, even at maximum load. The output power of the generator set can still be maintained, which could significantly reduce the power of the diesel engine. It could automatically adjust the output power of the energy saving unit based on the energy required to lift the motor. Which could make the diesel generator carry a small load of current. Even at maximum load, the output power of the generator set could still be maintained, which could greatly reduce the power of the diesel engine. It is as shown in Figure. 2.

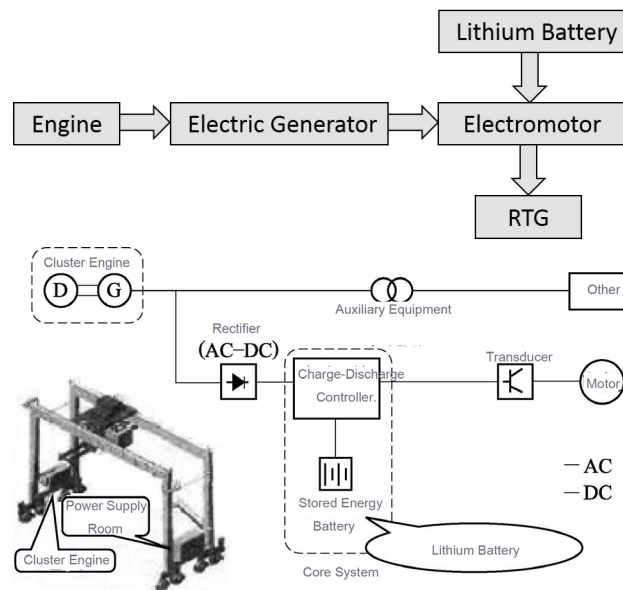


Figure 2. Operating principle of RTG using light lithium battery as auxiliary power source

2.2 Technology assessment

RTG using light lithium battery as an auxiliary power source did not get rid of traditional RTG using diesel engine as the main source. Lithium-ion batteries are used only for auxiliary power and energy recovery devices, which requires two large DC/DC converters to control the flow of energy. Increasing cost of transformation and maintenance. Because lithium batteries could recycle some energy, the energy consumption of RTG could be increased by 50% compared with that of conventional diesel. Although the speed regulating and frequency conversion could improve the energy consumption of the diesel engine, but the diesel engine as power source must work in the whole process of continuous running, which couldn't fundamentally reduce the fundamental problem of standby energy loss in the process.

3. RTG using large capacity lithium battery as main power source

3.1 Operating principle

Large capacity lithium battery hybrid RTG uses power battery as the main power, and small diesel engine as auxiliary charging power supply. For a hybrid power system with low power lithium batteries, a large capacity lithium battery pack is used as the active power source in the hybrid power system. The charge and discharge process of the large capacity lithium battery is basically stable. The voltage and power level fully meet the needs of the grid, and provide the working power directly to the frequency conversion drive system. The power of diesel generating set is further reduced, and the diesel engine is only used as an auxiliary power source for charging. The system composition is as shown in the following chart. Small power diesel generators do not work directly in normal operation, and RTG is driven directly by power batteries. When the battery power is reduced to a certain range (50%), the lithium battery is powered by a 50 kW diesel generator or an external power supply, and the potential energy is also fed back to the lithium battery group: It means not only satisfy the peak power demand and the power demand of steady operation, but also fully absorb the potential energy feedback.

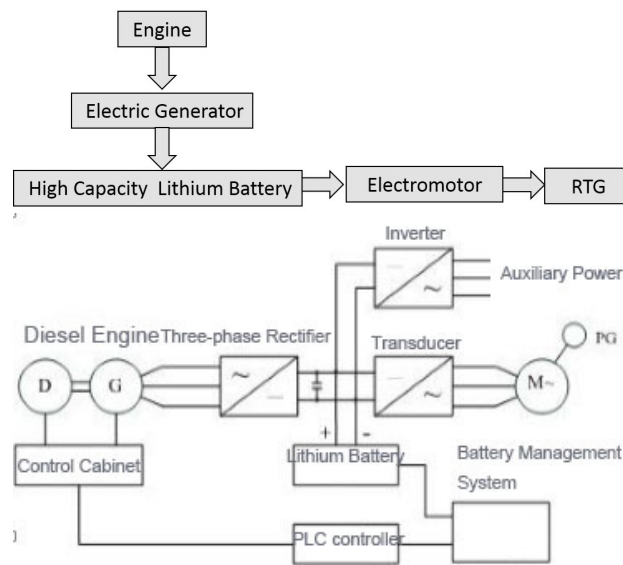


Figure 3. Operating principle of RTG using large capacity lithium battery as main power source

3.2 Technology assessment

The running time of the traditional RTG less than 20% load accounts for 75% to 80%, and its average power is only 60~80 kW. While Lithium battery could be employed as an active power source to recover potential energy, and it can also stop output power during the RTG pause. The energy saving effect is obvious, and it can reach about 65%. However, the charging current of the self cooled lithium battery cannot be too high and the life of the lithium battery is affected by the temperature. A possible method is to reduce the charging current. It is necessary to use a large capacity battery to meet the continuous operation of the RTG 2H. At the same time, the use of self cooled lithium battery technology can not adjust the temperature of different electric core accurately, the overall temperature of the battery is relatively high, the temperature difference of the core is larger, the termination life of the core is not uniform, resulting in the decline of the life of the whole lithium battery. Moreover, if the electric core is abnormal, it will cause the local temperature to increase rapidly. The self cooling system is difficult to discharge the heat in time. And the larger battery capacity may cause the greater accident risk. Due to the adoption of large capacity lithium battery for transformation, the cost of alteration and subsequent replacement is relatively large.

4. RTG using lithium batteries cooled by water as main power source

4.1 Operating principle

By installing the water cooling pipe in the inner pole of the battery group which is connected with the external water cooling system, the water cooled lithium battery system has the function of constant temperature, which can both make heat and refrigerate. This makes it suitable for different regional environment. The water cooling system reads the temperature state of each battery group through the communication protocol. The liquid temperature keeps the battery pack at the best working temperature 25~30 °C by liquid circulation. The hybrid power RTG of high power water cooled lithium battery is hereby replaced by a high power low capacity water cooled lithium battery group and a small power diesel generator set (charging) instead of the high power diesel engine set on the traditional tire. The battery pack provides the power supply to the DC bus bar directly on the inverter. The auxiliary equipment is powered by a DC/AC inverter and its working voltage range is available. Under normal operation condition, the small power diesel generating set does not work and the RTG is driven directly by the water cooled lithium battery pack. Managed by the intelligent battery management system, the state (voltage, temperature) of each group of batteries is monitored and

controlled in real time. After collecting data from PLC, the small diesel engine is controlled to start and stop and the battery is compensated properly. During the action of lifting, declining and braking, the electricity generated will be returned to the lithium battery pack, which will better save energy and reduce consumption.

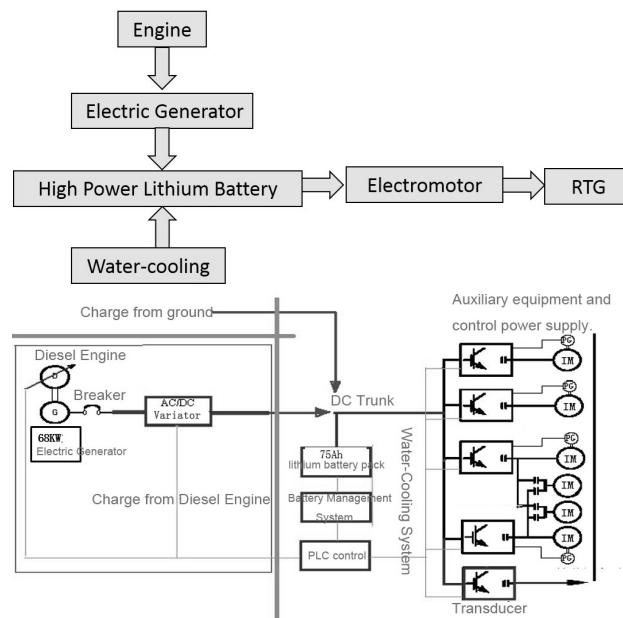


Figure 4 Operating principle of RTG using lithium batteries cooled by water as main power source

4.2 Technology assessment

The hybrid power RTG of high power water cooled lithium battery is similar to hybrid power RTG of large capacity self cooled lithium battery for employing the lithium battery as the main power source and using the diesel engine as the auxiliary charging power, which has the advantages of the large capacity lithium battery RTG. It can store the potential energy and reduce the power loss during the non working period, and the energy saving effect is remarkable reach nearly 62%. In addition, because of the obvious heat dissipation effect of the water cooled lithium battery technology, the water cooling system can control the maximum temperature of the core under 35 °C lower 10 °C than the self cooling system, and the temperature difference of the core can be controlled at 2-3 °C when the water cooled battery system works. The same problem, prolonging the life of the battery For the heat generated by the abnormal electric core can be taken away by the water cooling system, and the temperature of the abnormal electric core is controlled to avoid the heat control, and the security of the system is improved, and the hidden danger of the RTG of the large capacity self cooled lithium battery is eliminated. Due to good temperature control performance, the temperature can be controlled at about 30 C even under the condition of high current, the battery life is relatively long, the use of small capacity lithium battery can also meet the actual work of RTG, greatly reducing the cost of transformation and later maintenance.

5. Conclusion

In this paper, three kinds of RTG lithium battery transformation technology have been studied systematically. The research shows that the technology of high power water cooled lithium battery is the best applicable technology of RTG energy saving transformation at present. It has the advantages of large capacity self cooled lithium battery RTG, and its lithium battery pack capacity is smaller. The operation life is longer, and the safety level is higher. Therefore, large power water cooled lithium

battery RTG will become the mainstream technology of the RTG all lithium battery transformation in the future.

Reference

- [1] X.X. Huang, F. Wang, Y.M. Zhao, Y. Wang, Sci. Technol. Por, **2** (2014)
- [2] M.G. Gu, Energy Conserv. Environ. Prot., **61** (2012)
- [3] P. He, Equip. Manuf. Technol., **157** (2017)
- [4] T. Huang, L. Xu, X.X. Huang, W.Q. Wang, Chin. J. Power Sources, **1399** (2016)
- [5] M. Liu, W.Q. Wang, J. Wu, Comput. Meas. Contr., **182** (2017)
- [6] J. Wu, W.Q. Niu, M. Liu. Comput. Meas. Contr., **79** (2017)
- [7] W. Wang, J.Y. Zhou, J.X. Qiu, J. Gong, Sci. Technol. Por, **2** (2012)
- [8] J.X. Zhu, W.G. Fu, D.Z. Pu, Technological innovation and development of three decades in logistics engineering. **2** (2014)
- [9] X.Y. Zhu, X.M. Zeng, Hoisting and Conveying Machinery., **4** (2015)