

TRACTION BATTERY PROTECTION CONTROL METHOD AND SYSTEM, AND RAIL TRANSIT VEHICLE

Field of the Invention

The present invention relates to a control method of protecting traction battery and system, and a rail transit vehicle.

Background of the Invention

In a current locomotive or engineering vehicle equipped with a traction battery (see FIG. 1 for power electrical connection of the traction battery), the traction battery is subject to basic limitations of maximum current and minimum voltage during operation. The traction battery itself has different current discharge rates. When the discharge current increases, the voltage of the traction battery will be pulled down. When the traction battery is controlled, it often enters a voltage protection stage because its voltage is pulled down, a breaker actively breaks and the traction battery passively stops to achieve the purpose of protecting the traction battery and prevent the traction battery from being over-discharged. In practical work, it is common to encounter a situation where a traction battery still has capacity, but due to a sudden increase in power during operation, the current increases suddenly, the voltage decreases suddenly and is lower than a protection threshold value, the traction battery enters a protection state, and a locomotive stops running, which reduces the running efficiency of the locomotive.

Summary of the Invention

In response to the shortcomings of existing technologies, the technical problem to be solved by the present invention is to provide a traction battery protection control method, where on the premise that a traction battery is protected from being

over-discharged, the traction battery is fully used for discharging, thereby increasing the utilization rate of the traction battery and effectively improving the endurance capability of a traction battery locomotive or engineering vehicle.

A second objective of the present invention is to provide a rail transit vehicle using the foregoing traction battery.

To solve the above technical problems, the technical solution adopted by the present invention is as follows: A traction battery protection control method includes the following steps:

reducing traction power of a locomotive when the voltage of a traction battery is lower than a protection voltage and the discharge current of the traction battery is not 0; and stopping the locomotive when the voltage of the traction battery is lower than the protection voltage and the discharge current of the traction battery is 0.

In the present invention, when the voltage of the traction battery reaches or is lower than the protection voltage, the locomotive actively reduces the traction power. The purpose of reducing the discharge current is achieved by sacrificing part of the traction power of the whole vehicle. In this case, partial high-power traction limitation may occur, but current may still be discharged. When the discharge current is finally zero, the traction battery stops working. Therefore, in the present invention, the traction battery is fully used for discharging, thereby increasing the utilization rate of the traction battery, effectively improving the endurance capability of the traction battery locomotive or engineering vehicle, realizing maximization of energy utilization of the traction battery, reducing unnecessary energy consumption, and significantly improving the economy of the vehicle.

The protection voltage is calculated by a formula: $V = V1 + V2$, where $V1$ is a cut-off discharge voltage of the traction battery; and $V2$ is a safety margin voltage.

In the present invention, the safety margin voltage is set to minimize damage to the battery in charging and discharging processes.

In the present invention, the traction power is reduced by reducing traction current, which is easy to implement, with low cost and high reliability.

In the present invention, the safety margin voltage is set to 10 V to prevent voltage fluctuations at a critical value and to protect the traction battery from being over-discharged as much as possible. The safety margin voltage may alternatively be determined according to a voltage range of traction battery cells and a quantity of cells connected in series. For example, the voltage of some battery cells is 2 V or 24 V; and 400 or 100 battery cells are connected in series in some cases. The voltage of cells is 2 V, 400 cells are connected in series, and the safety margin voltage may be set to $0.02 * 400 = 8$ V; or the voltage of cells is 24 V, 100 cells are connected in series, and the safety margin voltage may be set to $0.24 * 100 = 24$ V. The safety margin voltage = the voltage of cells * 0.01 * the quantity of cells connected in series. The safety margin voltage may alternatively be adjusted according to actual applications.

A corresponding relationship between the reduction amplitude of the traction power and the magnitude of the discharge current of the traction battery is as follows:

if the traction power of the locomotive is half of the traction power of the whole vehicle, when the voltage of the traction battery drops below the protection voltage during its operation, the traction power of the locomotive is actively reduced to 45% of the traction power of the whole vehicle until the voltage of the traction battery recovers to above the protection voltage; and

if the traction power of the locomotive instantly increases from 0 to 100%, when the traction power of the locomotive increases and the voltage of the traction battery is lower than the protection voltage, the traction power of the locomotive is locked to M% of the traction power of the whole vehicle; if the voltage of the traction battery is still lower than the protection voltage, the traction power of the locomotive is reduced to N% of the traction power of the whole vehicle; if the voltage of the traction battery is still lower than the protection voltage, the traction power of the locomotive is reduced to K% of the traction power of the whole vehicle; and so on, until the voltage of the traction battery is greater than the protection voltage, where $M\% > N\% > K\%$.

In the present invention, the traction power of the locomotive refers to actual power that the locomotive needs to exert; and the traction power of the whole vehicle refers

to rated power or maximum power allowed under normal conditions. The traction power of the locomotive may be set to reduce by 5% each time, and the reduction amplitude may be further subdivided between 1% and 5% ($M - N = N - K = 1-5$) to further improve the utilization rate of the traction battery, thereby further improving the endurance capability of the traction battery locomotive or engineering vehicle.

In the present invention, M may be set to 80.

The present invention further provides a traction battery protection control system, including a computer device, where the computer device is configured or programmed to perform the steps of the method in the present invention.

Belonging to a single general inventive concept, a traction control system for a rail transit vehicle is further disclosed, where the traction control system is configured or programmed to perform the steps of the method in the present invention.

Belonging to a single general inventive concept, a rail transit vehicle using the control system described in the present invention is further disclosed.

Compared with the existing technologies, the beneficial effects of the present invention are as follows:

1. In the present invention, under the condition that the traction battery is protected from being over-discharged, the traction battery is fully used for discharging, thereby increasing the utilization rate of the traction battery, effectively improving the endurance capability of the traction battery locomotive or engineering vehicle, realizing maximization of energy utilization of the traction battery, reducing unnecessary energy consumption, and significantly improving the economy of the vehicle.
2. The present invention can further reduce the selection capacity of the traction battery to achieve the purpose of lowering costs, which is particularly obvious on lead-acid batteries (For example, on the same line, if the solution of the present invention is not adopted, a 480Ah traction lead-acid battery is required to meet basic requirements of line endurance. However, after the solution of the present invention is adopted, a 400Ah traction lead-acid battery can be used to complete basic functions. The reduction of the selection capacity can effectively lower costs).

Brief Description of the Drawings

FIG. 1 is a schematic diagram of power electrical connection of a traction battery; and FIG. 2 is a flowchart of an active power protection control method for a locomotive in the present invention.

Detailed Description of the Embodiments

A main implementation process of a method in Embodiment 1 of the present invention includes: a voltage value of a traction battery is monitored in real time; when the voltage of the traction battery reaches or is lower than a protection voltage, a locomotive actively reduces traction power, and the purpose of reducing the discharge current is achieved by sacrificing part of the traction power of the whole vehicle; in this case, partial high-power traction limitation may occur, but current may still be discharged. When the discharge current is finally zero, the traction battery stops working.

In the embodiment of the present invention, the amplitude of each reduction in the traction power of the locomotive is 5%, and the reduction amplitude may be further subdivided between 1% and 5%.

If the traction power of the locomotive is 50% of the traction power of the whole vehicle, the voltage of the traction battery is exactly near the protection voltage of the traction battery (for example, in the discharging process of the traction battery, as the discharge deepens, the voltage of the traction battery gradually decreases, therefore, there may be a situation where the voltage of the traction battery is near the protection voltage when the traction power of the locomotive is 50% of the traction power of the whole vehicle), and the traction continues. As the traction continues, the voltage of the traction battery gradually drops below the protection voltage. In this case, the traction power of the locomotive is actively reduced to 45% of the traction power of the whole vehicle, so that the voltage of the traction battery recovers to above the

protection voltage (that is, the voltage of the traction battery is greater than the protection voltage).

If the traction power of the locomotive instantly increases from 0 to 100%, as the traction power of the locomotive increases, the voltage of the traction battery is lower than the protection voltage. In this case, the traction power of the locomotive is locked, for example, the traction power of the locomotive is locked to 80% of the traction power of the whole vehicle. If the voltage of the traction battery is still lower than the protection voltage, the traction power of the locomotive is reduced to 75% of the traction power of the whole vehicle. If the voltage of the traction battery is still lower than the protection voltage, the traction power of the locomotive is reduced to 70% of the traction power of the whole vehicle until the voltage of the traction battery is above the protection voltage.

As shown in FIG. 2, the method of the present invention includes the following steps:

- 1) A protection voltage of a traction battery is obtained by calculation: the protection voltage is calculated by a formula: $V = V1 + V2$, where $V1$ is a cut-off discharge voltage of the traction battery; and $V2$ is a safety margin voltage (for example, set to 10 V).
- 2) The voltage of the traction battery is monitored in real time, and when the voltage of the traction battery is lower than the protection voltage and the discharge current of the traction battery is not 0, the traction power of a locomotive is actively reduced or limited to dynamically reduce the discharge current of the traction battery, so that the voltage of the traction battery is always greater than the protection voltage. When the voltage of the traction battery is higher than the protection voltage and the traction power of the locomotive is not limited or reduced, the traction battery is discharged normally. When the voltage of the traction battery is higher than the protection voltage (because the voltage of the traction battery increases after the discharge current of the traction battery is actively reduced, the voltage of the traction battery is higher than the protection voltage) but the traction power of the locomotive is limited, the power of the traction battery is reduced for discharging. When the discharge current of the traction battery reaches 0, the locomotive stops working.

Assuming that the release power of the traction battery required by the normal traction of the locomotive is 400 kW, the cut-off voltage of the traction battery is 580 V, and the safety margin is 20 V, the protection voltage of the traction battery is 600 V.

At the beginning, it is assumed that the static voltage of the traction battery is 900 V, and the voltage of the traction battery is pulled down to 850 V when discharged at the maximum power. In this case, the discharge requirement of the traction power of the locomotive is met, and the traction power of the locomotive does not need to be limited.

After gradual discharge, assuming that the static voltage of the traction battery decreases to 620 V and the low current discharge is 610 V, the locomotive can be discharged normally at low power. When the traction power of the locomotive is suddenly increased, the desired discharge current will increase. In this case, during the increase of the discharge current, if the voltage of the traction battery is less than 600 V, the increase of the discharge current will be limited (for example, the traction power of the locomotive is set to decrease by 5%, the traction current decreases by 8%, and the voltage of the traction battery may recover by 3%) to ensure that the voltage of the traction battery is not lower than the protection voltage. At this time, the locomotive is in a state of reduced power operation.

Limiting the discharge current is a dynamic automatic balancing process. The target value is the protection voltage, and limiting the discharge current is not just about limiting current increase. When the voltage of the traction battery is lower than the protection voltage, as the discharge further deepens, the discharge current may even gradually decrease.

After the maximum discharge current of the traction battery is 0, the locomotive stops working.

Embodiment 2 of the present invention provides a traction battery protection control system, including a computer device, where the computer device is configured or programmed to perform the steps of the method in Embodiment 1 of the present invention.

The computer device in Embodiment 2 of the present invention includes a processor and a memory, where the memory stores a program used for performing the steps of the method in Embodiment 1 of the present invention.

Embodiment 3 of the present invention provides a traction control system for a rail transit vehicle, where the traction control system is arranged in a vehicle and configured or programmed to perform the steps of the method in Embodiment 1 of the present invention.

A rail transit vehicle in Embodiment 4 of the present invention may use either the control system in Embodiment 2 or the control system in Embodiment 3.

Claims

1. A traction battery protection control method, characterized by comprising the following steps:

reducing traction power of a locomotive when the voltage of a traction battery is lower than a protection voltage and the discharge current of the traction battery is not 0; and stopping the locomotive when the voltage of the traction battery is lower than the protection voltage and the discharge current of the traction battery is 0.

2. The traction battery protection control method according to claim 1, characterized in that the protection voltage is calculated by a formula: $V = V_1 + V_2$, wherein V_1 is a cut-off discharge voltage of the traction battery; and V_2 is a safety margin voltage.

3. The traction battery protection control method according to claim 1, characterized in that the traction power is reduced by reducing traction current.

4. The traction battery protection control method according to claim 2, characterized in that the safety margin voltage = a voltage of battery cells * 0.01 * a quantity of battery cells connected in series; and preferably, the safety margin voltage is set to 10 V.

5. The traction battery protection control method according to one of claims 1-4, characterized in that a corresponding relationship between the reduction amplitude of the traction power of the locomotive and the magnitude of the discharge current of the traction battery is as follows:

if the traction power of the locomotive is half of the traction power of the whole vehicle, when the voltage of the traction battery drops below the protection voltage during its operation, the traction power of the locomotive is actively reduced to 45% of the traction power of the whole vehicle until the voltage of the traction battery recovers to above the protection voltage; and

if the traction power of the locomotive instantly increases from 0 to 100%, when the traction power of the locomotive increases and the voltage of the traction battery is lower than the protection voltage, the traction power of the locomotive is locked to M% of the traction power of the whole vehicle; if the voltage of the traction battery is still

lower than the protection voltage, the traction power of the locomotive is reduced to N% of the traction power of the whole vehicle; if the voltage of the traction battery is still lower than the protection voltage, the traction power of the locomotive is reduced to K% of the traction power of the whole vehicle; and so on, until the voltage of the traction battery is greater than the protection voltage, wherein $M\% > N\% > K\%$.

6. The traction battery protection control method according to claim 5, characterized in that $M = 80$.

7. The traction battery protection control method according to claim 5, characterized in that $M - N = N - K = 1-5$.

8. A traction battery protection control system, characterized by comprising a computer device, wherein the computer device is configured or programmed to perform the steps of the method according to one of claims 1-7.

9. A traction control system for a rail transit vehicle, characterized in that the traction control system is configured or programmed to perform the steps of the method according to one of claims 1-7.

10. A rail transit vehicle, characterized by using the control system according to claim 8 or 9.