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Simulation Research on Battery Energy Management Strategy of Extended Program Based on Cruise

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Abstract: *As a new energy vehicle, range-extended electric tractor have the advantages of long driving range and low pollutant emissions. However, at present, most extended battery have problems of insufficient energy management and high consumption.Therefore, it is necessary to study the energy management strategy of the extended-range electric vehicle battery. The additional battery provides power and power for the whole vehicle, realizes on-board charging through the expansion field, provides charging function when parking, and can be connected to the power grid; High voltage power supply safety management function; High voltage battery charger, high voltage power supply device, high voltage circuit current detection function, manual maintenance switch, battery system thermal management system, monitoring system operation status detection function.In order to construct the advanced energy management strategy and carry out the effective simulation analysis, based on the Cruise platform, this paper studies the power system matching and energy management control strategy of the extended battery, and completes the power system matching according to the vehicle dynamic parameters and the basic parameters of the vehicle. In this paper, a Cruise vehicle model of an extended-range extended battery is established on the Cruise professional simulation software platform, and joint simulation experiments are performed based on the energy management strategy model built in Matlab / Simulink. Simulation results show that the control algorithm designed in this paper satisfies the vehicle's driving needs,improves the economy of the vehicle by 6.84%, better controls the change of battery SOC. So as to verify the dynamics and economics of the power system and to evaluate the advantages and disadvantages of using this energy management strategy in different operating conditions, this paper studies the dynamics and economics under different cycling conditions. The vehicle power system matching and energy management strategies designed in this article have better economic characteristics when driving in this cycle.*

Keywords: *Cruise Platform, Energy Management Strategy, Extended Electric, Battery SOC, Cruise Vehicle Model, Power System Matching*

1. Introduction

As a new type of electric vehicle, the extended battery with additional program can overcome the limitation of charging time of traditional extended battery by adding internal combustion engine, and also can effectively improve the problem of short range of pure extended battery. With the remaining battery power drops to the set minimum threshold, the extended range can be extended by starting the extended range device to run in the extended range mode. Moreover, the vehicle with this structure has low requirements for batteries, and can use batteries with smaller capacity, which not only reduces the volume and weight of the battery of the extended battery, but also reduces the cost of the extended battery. The vehicle can be operated in pure electric mode, extended range mode or hybrid electric vehicle mode (HEV) as required. In the extended range mode, with the increase of battery capacity, the fuel-saving rate of pure electric vehicles is close to infinite. This is a smooth transition mode for pure electric vehicles. The low-speed torque is large, the high-speed driving is stable, the braking energy recovery efficiency is high, the structure is simple, and the maintenance is convenient. It is a pure electric passenger car especially suitable for urban public transportation and long-distance electric bicycle users.

At present, many experts have invested a lot of time and energy in the research of energy management strategies. In [1], the author puts forward a part-time hybrid energy management strategy based on energy prediction, designs two energy prediction algorithms based on moving average and emergency state respectively by using the principle of decision tree algorithm, and then tests the characteristics of the two prediction algorithms. In [2], the author proposed a novel four-wheel-drive electric vehicle layout. The results show that more advanced controllers can significantly reduce energy consumption at constant speeds and different driving cycles. In [3-5], the authors proposed a microgrid energy management strategy based on the coordination of heat pump air conditioning system (HPACS) and hybrid energy storage system (HESS). In [6], the author introduced the structure of the hybrid power system and the operating characteristics of the tram, and then proposed an energy management strategy based on the system's operating mode [7-8]. In [9], the authors proposed an energy management control method based on a dynamic factor strategy. The experimental results show that the strategy can better maintain the state of charge of the battery and maintain the changing trend of SOC compared with the equivalent consumption minimization strategy (ECMS). In [10], this paper proposes an intelligent energy management strategy for hybrid hydraulic electric vehicles to minimize their total energy consumption. This article also presents an intelligent controller that shows its improvement in overall vehicle energy efficiency. In [11], the author proposes a new method to determine the optimal charging / discharging schedule of EES units in the distribution system by adopting the multi-objective optimization method, which will effectively reduce the operating cost and enhance the security of the distribution network. In [12], in order to improve the control performance of the traditional equivalent minimum fuel consumption strategy (ECMS) under actual complex road conditions, the authors propose an adaptive equivalent fuel consumption minimum strategy (A- ECMS), can adjust the equivalent fuel consumption minimum strategy [13]. In [14], the authors established a state-multiple-input-multiple-output dynamic power exchange model to transform this energy management problem into an optimization problem, reducing the complexity of the algorithm and avoiding the effects of mode switching.

The key technologies for electric vehicle research are mainly focused on vehicle controllers, energy management strategies, motor drive control technologies, and battery-related technologies, but there are still many methodological problems and difficulties. The current range of pure electric vehicles currently on the market is about 300 kilometers on a single charge, and the range usually requires the vehicle to maintain an appropriate speed during the driving process and the vehicle has a good battery management system. The optimal service life of a battery is up to 4 years, and due to different battery types, its life and cost are also greatly different. Some batteries are not only costly, but also have poor recyclability.

Many research teams at home and abroad have conducted in-depth research on Cruise platform and related technologies. In [15], the authors studied a vehicle string traveling in a single lane, where the vehicle uses a connected Cruise control system to adjust its longitudinal movement based on data received from other vehicles via wireless car-to-car communication. In [16], the author studied Cruise control of high-speed train motion. Unlike most researches on centralized control or decentralized control, this paper proposes a distributed control mechanism based on graph theory. In [17], the author designed a human automated interaction system. This article uses a universal model of full-speed range adaptive Cruise control to illustrate the applicability of this method and demonstrates the potential of this collaborative method in human-computer interaction. In [18-19], the authors proposed a longitudinal Cruise strategy to enable vehicles to run adaptive cruise control and collision avoidance functions. In [20], based on the specific power of the vehicle, the authors evaluated the impact of the adaptive Cruise Control (ACC) system on improving fuel efficiency. The results of this study provide useful information for connected vehicle and autonomous vehicle manufacturers to improve fuel efficiency on the road [21].The number of vehicles with automatic gap control (AGC) has increased. AGC mainly helps relieve driver fatigue on highways [22]. In [23-25], the author introduced the concept of reaction forward and adopted a single control algorithm to implement adaptive cruise control (ACC). The results show that even if the information of the preceding vehicle changes suddenly, or the speed of the preceding vehicle exceeds the set speed of the target diver, the system can effectively process complex traffic information and realize safe and comfortable driving. In [26], the author proposed an algorithm for a three-arm robot based on Kinect motion sensing, and used Kinect to collect depth images, thereby achieving inefficient use.

In order to construct the advanced energy management strategy and carry out the effective simulation analysis, based on the cruise platform, this paper studies the power system matching and energy management control strategy of the extended battery, and completes the power system matching according to the vehicle dynamic parameters and the basic parameters of the vehicle. In this paper, the Cruise vehicle model of the extended battery with increased program is established on the Cruise professional simulation software platform. In order to verify the power and economy of the power system, and to evaluate the advantages and disadvantages of the energy management strategy in

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different conditions, this paper studies the power and economy in different cycle conditions.

2. Method

2.1 Energy Management Design of Extended Battery

(1) Battery parameter selection

Assume that the energy of the battery pack is W(kwh); the operating voltage is U(V); Under this condition, the car mainly overcomes rolling resistance and air resistance, so the work to overcome the resistance is:

$$W_{total} = \left(F_f + F_w\right)\cdot S = \left(fmg\cos\alpha + \frac{1}{2}C_D A\rho v_r^2 \right)\cdot S = 19.01kwh \tag{1}$$

The energy source of a pure extended battery is a lithium battery, so there are: $W \geq W_{total}$

The battery energy calculation formula is: $W = U \cdot Q_{total} / 1000$

Combining the above conditions and formulas, the battery selection requirements are: $W \geq 19.01kwh, Q_{total} \geq 56.6Ah$

(2) Motor parameter selection

The choice of motor power will have an important impact on the power and economics of extended battery. The choice of motor power for pure extended battery need to consider the vehicle's power performance goals. The motor power Pm must meet:

$$P_{\mathrm{m}}\eta_t \geq P_{\mathrm{t}} \tag{2}$$

Which is: $P_m \geq \dfrac{\left(fmg\cos\alpha + \frac{1}{2}C_D A\rho v_r^2 + mg\sin\alpha + \delta m\frac{dv_r}{dt} \right)\cdot v_r}{3600\eta_l}$

Take different speed and gradient values and calculate:

$$\begin{aligned} v_r &= 70km/h, i = 4\%, P_{m2} \geq 24.06kw \\ v_r &= 40km/h, i = 12\%, P_{m2} \geq 27.91kw \\ v_r &= 20km/h, i = 20\%, P_{m2} \geq 21.83kw \end{aligned} \tag{3}$$

(3) Input and output

Motor torque first depends on the driver's operating commands, and is also affected by the current state of the battery and motor. The value of the battery SOC directly restricts the output power of the motor and is expressed as *T(SOC(t))*; and the maximum output torque of the motor is also expressed as $T_{(\omega m(t))}$ at different speeds, so Have:

$$\begin{gathered} T_{acc} = \gamma_{acc} \times T_{\max}, \quad T_{brake} = \gamma_{bmke} \times T_{\max} \\ T_{SOC\_\max} = T(SOC(t)), \quad T_{\omega\_\max} = T\left(\omega_m(t)\right) \end{gathered} \tag{4}$$

Among them, γ_{acc} is the percentage of the accelerator pedal stroke, and γ_{brake} is the percentage of the brake pedal stroke. *SOC(t)* is the current SOC of the battery, which determines the maximum allowed motor torque T_{SOC_max}. *ωm(t)* and T_{act} are the current actual speed and torque of the motor, T_{ω_max} is the maximum torque of the motor at the current speed, and T_{max} is the maximum torque of the motor.

2.2 Matching the Power System of Range-Extended Extended Battery

The maximum speed is usually used as an important item in the dynamic index, which reflects the acceleration performance and climbing ability of the tractor. According to the maximum speed of the vehicle, the sum of rolling resistance power P_f and air resistance power P_w is used to estimate the maximum required power of the vehicle. As shown in the formula.

$$P_1 = P_f + P_w = \frac{1}{3600\eta_t}\left(Mgr_{v+} \frac{C_D A}{21.15} v^3 \right) \tag{5}$$

In the formula, P_1 is the total power of the vehicle at the highest speed, *kW*; *A* is the windward area of the tractor, m^2; *f* is the rolling resistance coefficient of the tractor; η_t is the mechanical efficiency of the tractor drive train; *M* is the tractor's full load mass, *kg*; *g* is gravitational acceleration, m/s^2; *v* is vehicle speed, *km/h*.

(1) In order to ensure that the designed vehicle meets the requirements of tractor climbing performance indicators, the required power of the vehicle also needs to consider the climbing resistance P_i of the vehicle.

$$P_2 = P_f + P_v + P_i = \frac{1}{3600\eta_t}\left(M\cos\theta gfv + \frac{C_J^A}{21.15} v^3 + Mg\sin\theta fv \right) \tag{6}$$

Where P_2 is the total power of the vehicle when driving at a certain speed on a certain slope, *kW*; θ is the road slope angle.

(2) As the extended range extended battery directly provides the required power from the drive motor, the output characteristic curve of the motor is an equal power curve. When deriving the tractor acceleration curve, it is also necessary to assume that the rolling resistance and air resistance of the vehicle during the low-speed acceleration driving are zero, so according to the tractor's dynamic balance equation, that is, the formula is shown.

$$Fv = P \tag{7}$$

Then it can be concluded that the acceleration curve relationship during the tractor acceleration process is:

$$a = \frac{F}{M} = \frac{dv}{dt}, \int_0^t = \frac{P}{M} dt = \int_0^{v_n} v dv, \quad v = v_m \left(\frac{t}{t_m} \right)^x \tag{8}$$

In the formula, *x* is the fitting coefficient; t_m is the time of the acceleration process, *s*; v_m is the acceleration speed of the acceleration process, *km/h*; *t* is time, *s*; *v* is the current vehicle speed at time *t*, *km/h* ; *F* is the driving force, *N*; *M* is the full load mass of the vehicle, *kg*.

2.3 Allocation and Modeling of Energy Management Strategy

The goal of energy control strategy is to distribute the driver's demand torque reasonably, so that on the basis of meeting the vehicle's power demand, the comprehensive fuel effect of the whole vehicle is the best. The target working mode is determined according to the working mode switching control algorithm by collecting the state information of the whole vehicle and each power component, and the corresponding working mode is executed after the working mode of the whole vehicle is determined. power integrated motor can be determined according to the above calculated driver demand torque and output.The target torque is modified. In order to prevent the output torque from changing too much, which will cause the vehicle to be unstable and improve the driver's driving experience, the vehicle energy distribution rules are as follows.

(1) Pure electric drive

The engine does not start, and the power demand is provided by the front and rear motors. It is often used for starting or driving at low speed. The specific torque distribution of each component is as follows:

$$\begin{cases} T_{BBg} = 0 \\ T_{ISG1} = T_{req} / 2 \\ T_{ISG_2} = T_{req} / 2 \\ T_{BSG} = 0 \end{cases} \tag{9}$$

ISSN 2706-655X Vol.3, Issue 6: 89-101, DOI: 10.25236/IJFET.2021.030610

In the formula, T_{Eng} is the target torque of the engine *(N m)*; T_{ISG1} is the target torque of the front-drive motor *(N m)*; T_{ISG2} is the target torque of the rear-drive motor *(N m)*; T_{BSG} is the target torque *(N m)* of the starter / generator integrated motor; T_{req} is the driver's required torque *(N m)*.

(2) Tandem drive

The engine starts, the clutch is disconnected, and the starter / generator integrated motor is charged to the power battery, and then discharged to the front and rear motors to continue driving the vehicle. The specific torque distribution of each component is as follows:

$$\begin{aligned} T_{Bng} &= T_{BSG\_gr} \\ T_{ISG_1} &= T_{req} / 2 \\ T_{ISG_2} &= T_{req} / 2 \\ T_{BSG} &= -T_{BSG\_gr} \end{aligned} \tag{10}$$

Where T_{BSG_gr} is the generator torque *(N m)*.

(3) Parallel drive

The engine starts, the clutch closes, drives the front axle to drive, and drives the starter / generator integrated motor to charge the power battery.And the rear axle is still driven by the rear motor. It is often used for high-speed driving when the battery is insufficient. The torque distribution of each component is as follows:

$$\begin{cases} T_{Bng} = T_{e\_opt} \\ T_{ISG1} = 0 \\ T_{ISG_2} = T_{req} - Min\left(0.9T_{e\_opt}, 0.3T_{req}\right) \\ T_{BSG} = T_{e\_opt} - Min\left(0.9T_{e\_opt}, 0.3T_{req}\right) \end{cases} \tag{11}$$

Where T_{e_opt} is the optimal torque of the engine *(N m)*.

(4) Regenerative braking

When the brake pedal is pressed, if the regenerative braking conditions are met, the regenerative braking energy recovery mode is entered, and the front and rear motors provide braking torque. The specific torque distribution of each component is as follows:

$$\begin{cases} T_{Bng} = 0 \\ T_{ISG1} = Min\left(T_{req} - T_{ISG2\_\max\_gr}, 0\right) \\ T_{ISG2} = Max\left(T_{req}, T_{ISG2\_\max\_gr}\right) \\ T_{BSG} = 0 \end{cases} \tag{12}$$

Where $T_{ISG2\_\max\_gr}$ is the maximum torque *(N m)* that the rear drive motor can provide.

3. Experiment

3.1 Data Source

For extended-range extended battery, the extended-range engine and generator are coaxially mechanically connected, and are not directly mechanically connected to the drive structure. Therefore, the speed at which the engine operates is the operating speed of the generator. Therefore, the following principles should be followed when matching the parameters of the range extender generator: Firstly, there is little difference between the rated power of the range extender generator and the rated power of the engine; Secondly, the motor speed range of the range extender generator is roughly the same as the engine speed range; Third, the speed of the generator's high efficiency zone should be in the same area . Based on the above selection and parameter matching, the range-extended extended battery studied in this paper selected an inline three-cylinder engine designed by a certain factory. Its parameters are shown in Table 1.

ISSN 2706-655X Vol.3, Issue 6: 89-101, DOI: 10.25236/IJFET.2021.030610

Table 1. Parameter values of extended range extended battery engine

Project name	Parameter value	Project name	Parameter value
Engine type	Inline three cylinder	Fuel tank capacity	20L
Peak power	40kW	Displacement	1.0L
Speed	6000rpm		

Table 2.Range extender generator parameters

Project name	Parameter value	Project name	Parameter value
Types	Permanent magnet synchronous generator	Speed	4000rpm
Rated power	35kW	Peak torque	135N m
Motor rated speed	2000rpm		

Based on the above calculations, the basic parameter values of the battery can be obtained as shown in Table 3. 100 cells are connected in series to form a battery pack with a capacity of 10 Ah, and 5 battery cells are connected in parallel to form a battery pack with a total capacity of 50 Ah.

Table 3. Parameter values of power battery

Project name	Parameter value	Project name	Parameter value
Type of battery	Lithium Ion Battery	Total battery energy	57.6kj
Rated voltage	320V	Total battery capacity	50Ah
Cell voltage	3.2V	Battery range	100-20%

3.2 Cruise-Based Energy Management Strategy Design Process

First, according to the battery SOC and the driver's shifting operation, the driving mode of the vehicle is divided into a passive parking mode, a normal driving mode, a reverse mode, and a parking mode, as shown in FIG.

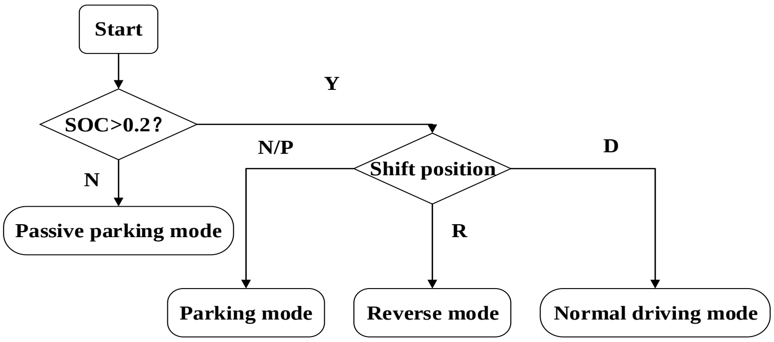


Figure 1: Driving mode selection of extended battery

The battery is fully charged and the vehicle enters this mode when the shift mechanism is in D position. The motor torque in this mode is determined by the state of the accelerator pedal, brake pedal, and battery motor. To ensure the safety of the entire vehicle, the driver's brake pedal is given priority in the normal driving mode. On the one hand, the vehicle is classified into a non-energy recovery mode and an energy recovery mode based on the state of the entire vehicle; on the other hand, the mechanical brake pressure of the wheel brake needs to be calculated based on the state of the motor and brake pedal. The energy management strategy under normal driving mode is shown in Figure 2.

ISSN 2706-655X Vol.3, Issue 6: 89-101, DOI: 10.25236/IJFET.2021.030610

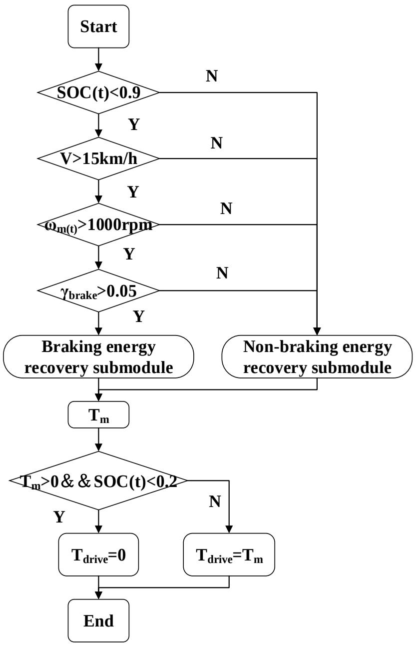


Figure 2: Energy management strategy for normal driving

The flow chart of motor torque calculation under braking energy recovery is shown in Figure 3. The brake pedal stroke is linearly proportional to the driver's required braking torque, and the motor speed also affects the motor torque. In addition, because the energy generated by the electric motor of this pure extended battery is stored in a lithium battery, the current generated by the motor cannot exceed the peak charging current of the battery.

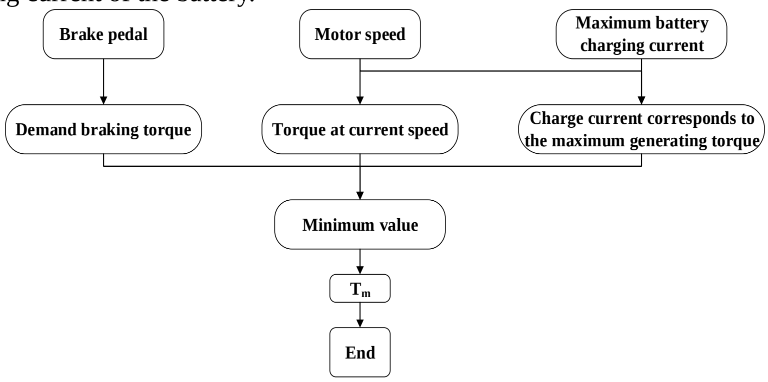


Figure 3: Energy management strategy under braking energy recovery conditions

The flow chart of the motor torque calculation under non-braking energy recovery condition is shown in Fig. 4. In this condition, if the brake pedal is depressed, the motor torque is directly set to zero. Only when the brake pedal is not depressed, the accelerator pedal is considered. Its torque is also affected by the accelerator pedal stroke and the motor speed. In addition, the battery SOC and the maximum discharge current directly limit its output power to the motor.

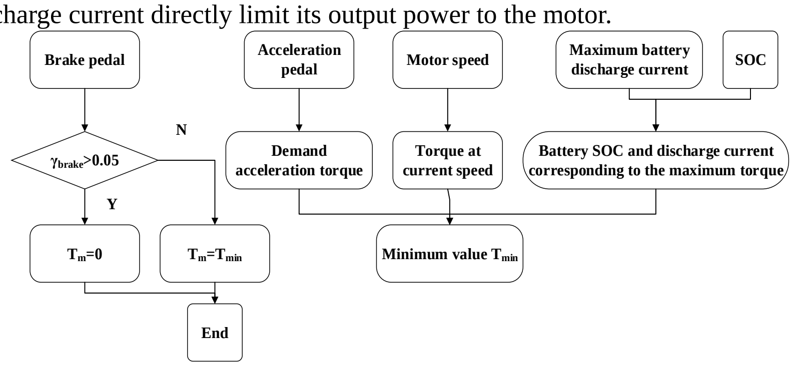


Figure 4: Energy management strategy under non-braking energy recovery

ISSN 2706-655X Vol.3, Issue 6: 89-101, DOI: 10.25236/IJFET.2021.030610

3.3 Construction of An Extended Vehicle Extended Battery Model Based on Cruise

The direction of the signal and energy flow during the entire forward simulation is the same as the direction of the power flow when the vehicle is actually running. After analysis by the controller, the operating states of the range extender and the power battery are adjusted, and the output power is transmitted to the wheels through the mechanical transmission system to change the current actual vehicle speed. The actual vehicle speed is then fed back to the driver module for control of the next cycle. The forward simulation diagram is shown in Figure 5:

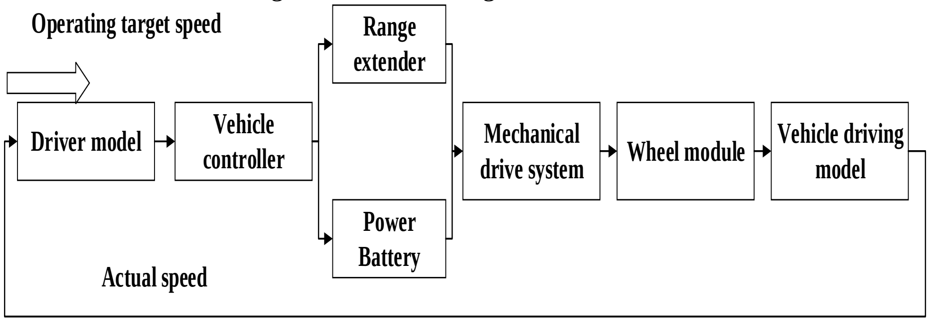


Figure 5: Schematic diagram of forward simulation

There is no driver module in the backward simulation. It is based on the system requirements. It is assumed that the vehicle runs in a specified cycle in advance. Its information flow direction is opposite to the power flow direction in the actual operation of the vehicle. Firstly, the power demand that satisfies the working condition is reversely calculated according to the driving conditions, and then the total power demand is calculated and analyzed by the vehicle controller and reasonably allocated between the range extender and the power battery. The working state of each main component under the fixed working conditions, the process of backward simulation is shown in Figure 6.

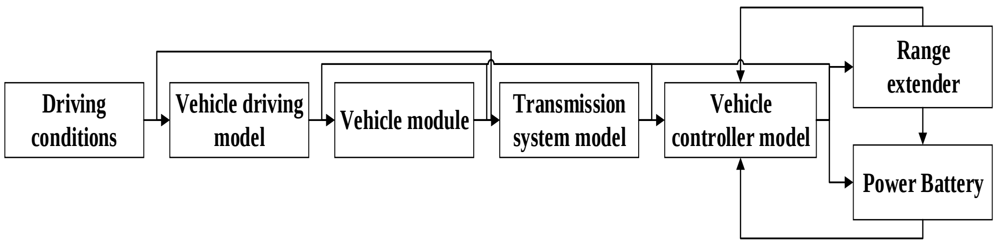


Figure 6: Schematic diagram of backward simulation

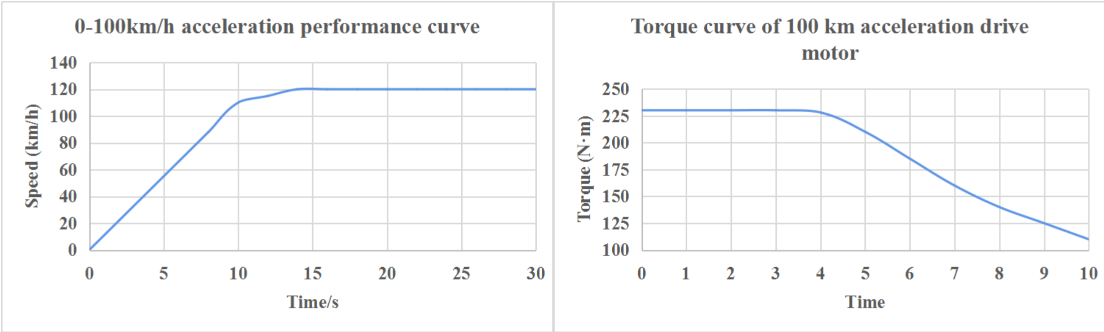
4.Results and Discussions

4.1 Analysis of Vehicle Characteristics Based on Cruise

(1) Dynamic calculation analysis

The curve shown in Figure 7 (a) is the "time-vehicle speed" curve corresponding to the 0-100km / h acceleration test. As can be seen from the figure, the vehicle model built in this paper has a 0-100km / h acceleration time of 8.82s. Compared with the initial design index of the vehicle design, which is less than or equal to 12s, the vehicle power equipment is verified to some extent. Both the model and the vehicle control strategy model can meet the vehicle design acceleration performance index of 100 kilometers, and at the same time, the measures for improving vehicle performance can be further studied from another angle. At the same time, it can be concluded from the curve in Fig. 7 (b) that the motor outputs a constant peak torque at the initial stage of acceleration, which increases the demand for a larger torque required for vehicle acceleration. When the vehicle accelerates to 3.98 seconds, the motor enters the constant power area, after which the motor outputs constant power.

ISSN 2706-655X Vol.3, Issue 6: 89-101, DOI: 10.25236/IJFET.2021.030610



(a) 0-100km / h acceleration performance curve (b) 0-100km / h acceleration drive motor torque curve

Figure 7: 0-100km / h acceleration performance curve

Next, the maximum speed test is performed. FIG. 8 shows the “time-power” curve of the driving motor. During the simulation of the maximum speed, the motor cannot work for a long time at the peak power, so a time limit is imposed on the output power of the motor in the simulation model. When the motor runs at peak power for 13.94s and switches to the rated power, the maximum vehicle speed is calculated to be 122.1km/h.

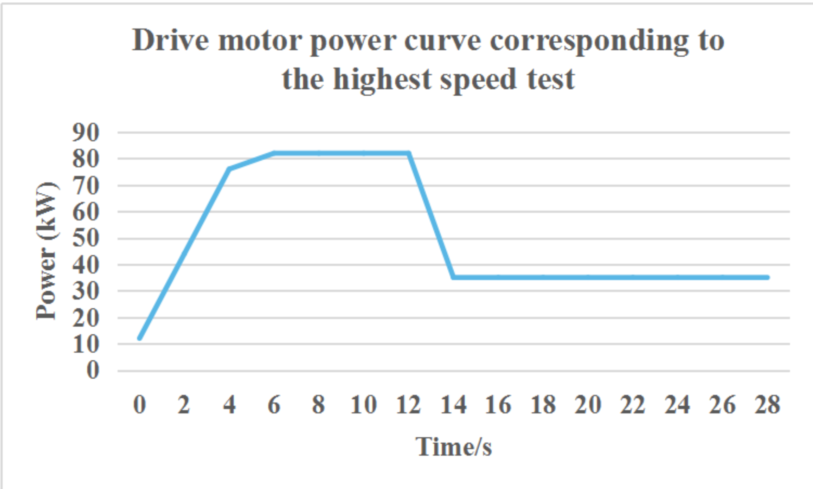
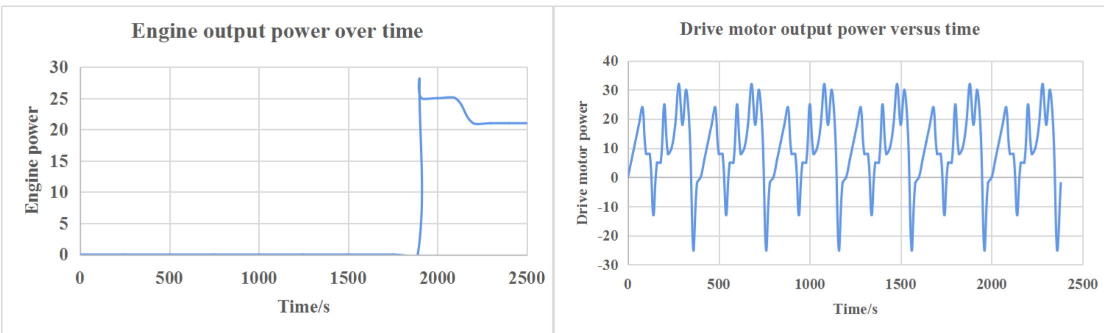


Figure 8: Power curve of driving motor corresponding to the highest speed test

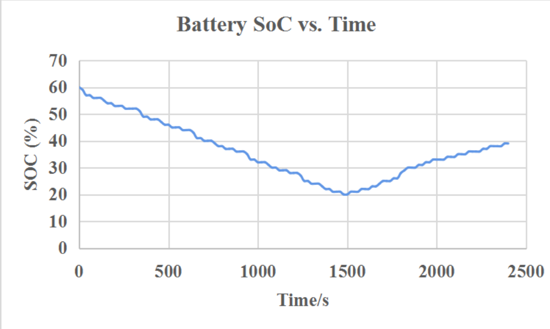
(2) Simulation calculation

On the premise that the vehicle meets the dynamic performance requirements, the vehicle needs to be tested and calculated for the cycling conditions during the driving process. This can comprehensively verify the rationality of the vehicle model and the setting of the vehicle controller, and also provides a more direct method for finding technology to improve vehicle performance. Figure 9 shows the simulation results.

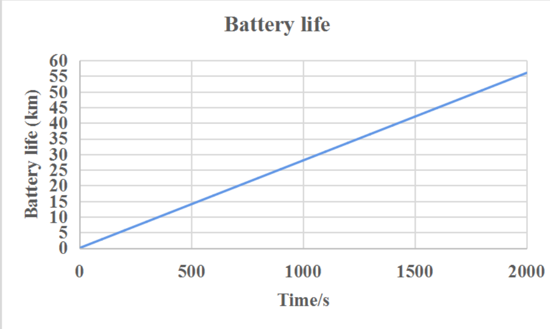


(a) Engine output power (b) Drive motor output power

ISSN 2706-655X Vol.3, Issue 6: 89-101, DOI: 10.25236/IJFET.2021.030610



(c) Battery SOC



(d) Battery life

Figure 9: Simulation results during driving

From the analysis in FIG. 9, it can be known that the current driving speed of the vehicle and the target road condition are within a range allowed by the speed tolerance band, and the vehicle speed can well follow the change of the working condition. It can be seen that the maximum speed of the vehicle is 72.1km / h, and the average speed is 35.72km / h. Because of the higher requirements for vehicle speed in this cycle, the power battery is used as a power source to provide energy to the drive motor, and the drive motor drives the wheels to drive the vehicle. From the start of operation to the 1940s, the engine was started, and the entire vehicle began to run in extended range mode, and operated at a constant power of 25.4kW to meet the vehicle's required power. At this stage, the SOC of the power battery continued to drop from 60% to 30%, the ΔSOC (that is, the initial SOC-the final SOC) is 21.48%. When the vehicle speed is low, in order to reduce the engine's emissions, the engine runs at a lower output power. The excess energy is supplemented by the generator to generate power for the power battery. The pure electric range is 55.6km. It can be seen that there are more operating points distributed in the area where the fuel consumption rate of the engine is large, which also means that the fuel consumption of the engine is large under this control strategy.

4.2 Simulation Analysis of Power and Economy of Extended Range Extended Battery

In order to verify the power and economy of the power system, and to evaluate the advantages and disadvantages of using this energy management strategy in different operating conditions, this paper calculates the vehicle's dynamics and economics using six cycle operating conditions "NEDC, EUDC, FTP75, WLTC, HIGHWAY, JAPAN_08". The above six types of cycling conditions represent different road conditions, so the dynamics and economy of different cycling conditions are studied.

Figure 10 shows the relationship of the ΔSOC of the power battery under six cycle conditions. It can be seen from the figure that this control strategy is not suitable for use under EUDC cycle conditions. The main reason is that under EUDC cycle conditions, the power battery continues to discharge and the peak power of the power source is large. The battery is very unfavorable, affecting the service life of the battery, which in turn affects the performance of the vehicle.

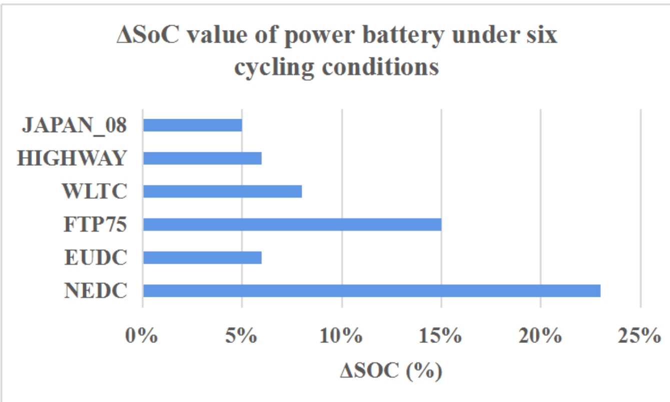
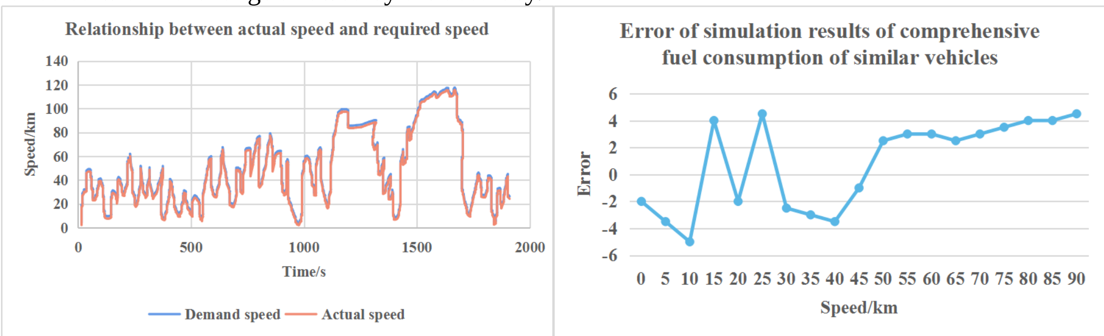


Figure 10: ΔSOC value of power battery under six cycling conditions

From Figure 11 (a), we can know that the actual vehicle speed in the current period of the vehicle simulation process can better follow the required vehicle speed. Although there are errors, they are all within ±5%, and other cycle conditions also meet the error tolerance range. Figure 11 (b) shows the

ISSN 2706-655X Vol.3, Issue 6: 89-101, DOI: 10.25236/IJFET.2021.030610

error comparison between the comprehensive fuel consumption simulation and the actual test results of similar vehicles. The error is also controlled within ± 5%. From the above analysis, it can be known that the validity of the vehicle simulation calculation model has been verified, and the simulation calculation results obtained by this method are credible, that is, the true situation of the vehicle can be reflected within the range allowed by the accuracy.



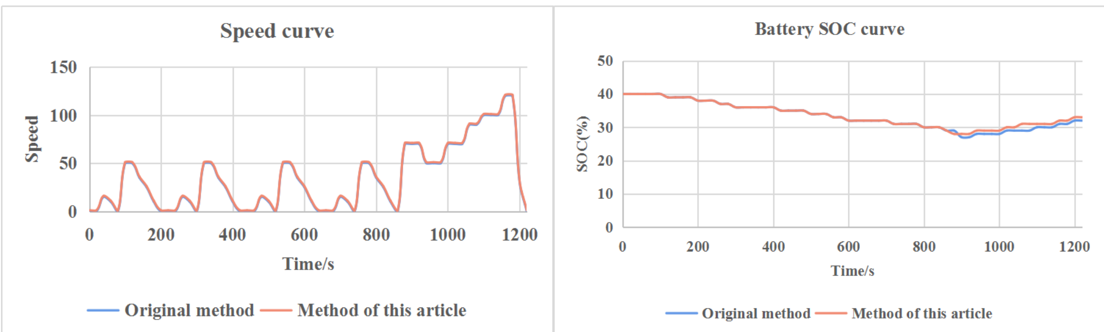
(a) Relationship between actual vehicle speed and required vehicle speed (b) Error in simulation results of comprehensive fuel consumption of similar vehicles

Figure 11: Simulation analysis under WLTC cycling conditions

In the WLTC cycle, the total running time of the vehicle is 10800s, the maximum speed is 78.28km / h, and the average speed is 36.41km / h. From the figure above, it can be concluded that the vehicle power system matching and energy management strategy designed in this article has better economic characteristics when driving in this cycle. The operating point of the engine is almost within the range of 3500r / min and fuel consumption of 258g / kWh. The pure electric range is 75.2km, and the comprehensive fuel efficiency of the extended range extended battery has been greatly improved. For the driving motor, its operating point is also distributed in the high efficiency section of the motor. In addition, although the power battery has a larger charge and discharge peak power, the battery ΔSOC is 4.663%. In this way, regardless of the engine, the drive motor, and even the power battery, it maintains a good characteristic operation, so the vehicle runs more efficiently in this mode.

4.3 Comparison and Analysis of Simulation Results of Energy Management Strategies

The management strategy outlined in this document directly affects the position of the engine operating point in the distribution of the overall characteristic curve and then affects the fuel consumption of the entire vehicle. further compare the differences between the original method and the optimal management on this paper, taking as an example the initial value of the SOC battery up to 40, analyze the results before and after the optimization. The vehicle speed curve after the NEDC is shown in Figure 12 (a) below.The two designed energy management strategies can better meet the requirements of the driving conditions. The actual driving speed of the original method and the method on this paper are substantially consistent with the target speed of the working condition. speed error is significantly reduced and the tach response rate is faster after the introduction of the fuzzy controller, which shows that the energy management strategy based on fuzzy optimal control has a better control effect.



(a) Car speed following change curve (b) Battery SOC change curve

Figure 12: Simulation results of energy management strategy

Figure 12 (b) shows the comparison of battery SOC changes based on the original method and fuzzy optimization control. The battery SOC change trend is the same when driven by pure electric

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power. After the engine is started, the fuzzy control strategy optimizes the target torque of the engine in real time so that the operating point of the engine always works near the optimal curve. When the total required torque is constant, the change in strategy causes different torque distributions, which in turn affects different trends in fuel consumption and electricity. It can be seen that the battery SOC optimized and controlled in this paper is more stable, lowered more slowly, and consumes less power during driving under the same operating conditions, which is conducive to increasing mileage and extending battery life.

5. Conclusions

Based on Cruise platform, this paper deeply studies the power system matching and energy management control strategy of range-extended extended battery, and completes the power system matching based on the vehicle's dynamic parameter index and the vehicle's basic parameters. In the matching process, this paper proposes a method for calculating the required power based on the acceleration time. Through research, it is found that it is more concise and accurate than the traditional required power determined based on the gradient and the maximum speed, because the calculation results show that the entire vehicle is accelerating. The power requirement is greater than the power requirement to meet the climbability and maximum speed.

In this paper, a complete vehicle model of a range-extended extended battery is established on the Cruise professional simulation software platform, and joint simulation experiments are performed on the energy management strategy model based on Matlab / Simulink. During the simulation, different initial values of battery SOC were selected, and NEDC was used as the simulation condition. In order to verify the dynamics and economics of the power system and to evaluate the advantages and disadvantages of using this energy management strategy in different operating conditions, this paper studies the dynamics and economics under different cycling conditions. In the WLTC cycle, the total running time of the vehicle is 10800s, the maximum speed is 78.28km / h, and the average speed is 36.41km / h. The vehicle power system matching and energy management strategies designed in this article have better economic characteristics when driving in this cycle.The optimization of the battery can better help us provide energy and protect our environment more environmentally friendly.The battery capacity is larger, and it can travel longer distances in a pure electric state (the range extender is not working), which should be the biggest advantage. Generally speaking, the battery capacity of extended-range car is around 40 degrees. At high speeds, extended-range cars are definitely more fuel-intensive. Electric motor drive and engine drive, due to the different working principles, the economic speed of the two is different. In urban conditions, electric drives will be more fuel-efficient, and at high speeds, due to the absence of a transmission and the increase in vehicle weight (increased power battery capacity), the energy consumption performance at high speeds will definitely not be good. At the same time, no matter how energy-saving the extended-range vehicle is, it still cannot change the nature of fuel-burning. In the long run, the country's original intention of vigorously developing new energy vehicles is still violated.

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