Improvements on EVSIML

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Abstract

A computer simulation software named EVSIML has been developed and is being brought to perfection all along. It has combined the MATLAB and Visual C++ programming languages and the Object-Oriented programming technology. The software of EVSIML (Electric Vehicle SIMuLator) is developed by MATALB and Visual C++ (VC) programming languages with Object-Oriented technology on the basis of the drivetrain model of the EV. It makes features of programming of MATALB and Visual C++ with Object-Oriented technology. EVSIML is mainly used to simulate the power performances and fuel economics of EV originally and now its functions have been expanded in order to deal with much computation and analysis about engineering including system match and control analysis. At the same time, as a complicated simulation software, excellent Graphical User Interfaces (GUI), high efficiency, quickly execute speed, good reusability, good maintainability and good expandability are also absolutely necessary. The paper will present the latest improvement on EVSIML and the new features of it in detail.

In order to maintain the energy security of China, improve the air quality and enhance the competition of automobile industry of China in the world, the national science ministry of China has especially founded the special important EV project in the national "tenth-five" and "863" program, plan to emphasize particularly on the industrialization of the EV, exert to gain a significant breakthrough in the key cell technology, the system integration technology and the whole vehicle technology of the EV. The EV is a complex system that integrates a number of subsystems such as the vehicle body, electric propulsion, and energy source and energy management. The technologies involved are diversified and multidisciplinary, including electrical and electronic engineering, mechanical and automotive engineering, and chemical engineering. Because of these multidisciplinary and fast-changing EV technologies, the design process of the EV should be flexible, prompt and economical. Computer simulation not only facilitates this design process, but also enhances the system optimisation of the EV.

Keywords
electric vehicle, simulation, software, improvement

1. INTRODUCTION

Computer simulation technology is of great importance to the design of electric vehicles (EV). In this research project, based on the drivetrain model of the EV, the software of EVSIML (Electric Vehicle Simulator) is developed, which is developed by MATALB and VC with Object-Oriented technology.

1.1 Merits of the interface programming of MATALB and visual C++ with object-oriented technology

EVSIML is mainly used to simulate the power performances and fuel economics of EV, accordingly much computation and analysis about engineering must be dealt with, and many figures also need to be output. Simultaneously, as complicated simulation software, excellent Graphical User Interfaces (GUI), high efficiency, quick execution speed, good reusability, good maintainability and good expandability are also very crucial.

MATLAB is an integrated technical computing environment that combines numeric computation, advanced graphics and visualization, and a high-level programming language. VC is a strong IDE for creating Microsoft Windows-based applications, which provide a powerful debugging function. Software developed with VC has good GUI, high efficiency and other merits. Besides, c++ language sustains the Object-Oriented technology, software programmed with which has good reusability, maintainability and expandability. Accordingly, these technologies are adopted in EVSIML.

1.2 Methods of blending programming with MATLAB and VC

There are several methods of blending programming with MATLAB and VC: (1) Use the function library. MATLAB contains a mathematic function library, which owns abundant contents, at the same time, it provides the mathematic function interface of C and C++ languages which can be called conveniently in the IDE environment of VC. The demerit of this method is that the abundant graph handling function can't be used. (2) Translate the .m file into CPP code and compile into

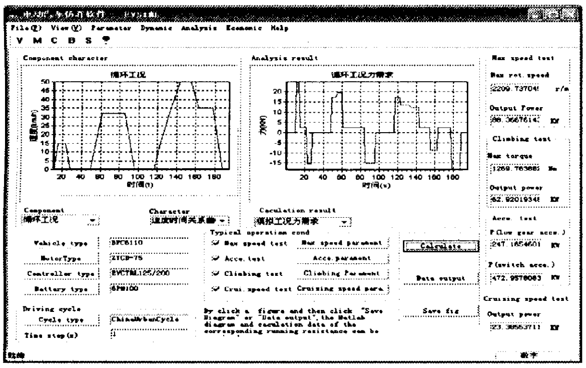
EXE or DLL file. The readability of the code compiled by this method is not ideal. (3) Write the statement with MATLAB language under the IDE environment of VC, according to the syntax of Matcom. This method combines the powerful mathematical computerization ability and the excellent Graphical User Interfaces (GUI) of VC. The software developed by this blending programming method adopted in the development and expansion of EVSIML has high efficiency, quick execution speed, good reusability, good maintainability and good expandability.

1.3 Feature of EVSIML

1.3.1 The drivetrain parameters input module

In the EVSIML, all data input modules have the function of examining, modifying, deleting and adding data. All the drivetrain parameters are stored in the data base system, which is linked to the VC with the ODBC.

In main, there are vehicle body parameters inputting module, motor parameters inputting module, battery parameters inputting module, driving cycle parameters inputting module and controller parameters inputting module. Figure 1 shows the driving cycle parameters inputting interface.



Component: 循环工况

Character: 速度时间关系曲线

Caculation result: 模拟工况力需求

Vehicle type: BFC6110

MotorType: ZYCB-75

Controller type: EVCTRL125/200

Battery type: 6PM100

Driving cycle

Cycle type: ChinaUrbanCycle

Time step(s): 1

☑ Max speed test

☑ Acce. test

☑ Climbing test

☑ Crui. speed test

By click a figure and then click "Save Diagram" or "Data output", the Matlab diagram and caculation data of the corresponding running resistance can be

Max rot. speed: 2209.737046 r/m

Output Power: 88.3667614 KW

Max torque: 1269.763682 Nm

Output power: 62.92019348 KW

F(low gear acce.): 247.1654601 KW

F(switch acce.): 472.9578083 KW

Output power: 23.38553711 KW

就绪

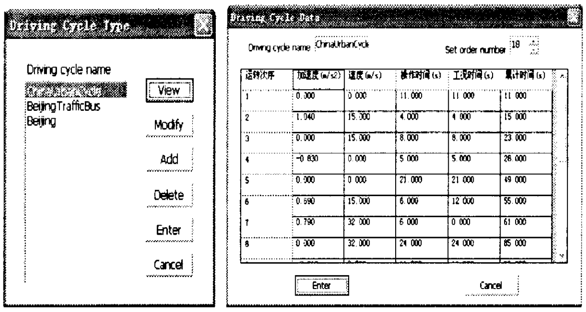
Fig. 1 The driving cycle parameters inputting interface

1.3.2 The simulation modules of EVSIML

EVSIML mainly include the running resistance simulation module, power performances simulation module, status analysis module and fuel economics simulation module. The main function of these modules is as follows:

1. The running resistance, power performance, status analysis results and fuel economics can be simulated with corresponding drivetrain parameters, which can be obtained through the data base files in EVSIML.
2. The simulation results can be figured out or displayed in data type.

Figure 2 shows the status analysis module interface.



BeijingTrafficBus

Beijing

Driving cycle name: ChinaUrbanCycle

Set order number: 18

运转次序	加速度(m/s2)	速度(m/s)	操作时间(s)	工况时间(s)	累计时间(s)
1	0.000	0.000	11.000	11.000	11.000
2	1.040	15.000	4.000	4.000	15.000
3	0.000	15.000	8.000	8.000	23.000
4	-0.830	0.000	5.000	5.000	28.000
5	0.000	0.000	21.000	21.000	49.000
6	0.690	15.000	6.000	12.000	55.000
7	0.790	32.000	6.000	0.000	61.000
8	0.000	32.000	24.000	24.000	85.000

Fig. 2 The status analysis module interface

2. THE SIMPLIFIED MODEL OF AC MOTOR

When the AC motor runs steadily, the input power from voltage is:

$$P_1 = 3 \cdot V_1 \cdot I_1 \cdot \cos\Phi_1$$

Hereinto:

V_1 - Line voltage of three-phase power supply

I_1 - Line current of three-phase power supply

$\cos\Phi_1$ - Power factor

The output power from the output shaft of the AC motor:

$$P_2 = P_1 - P_{Cu1} - P_{Fe} - P_{Cu2} - P_m - P_s$$

Hereinto:

P_{Cu2} - Copper loss of the rotor winding

P_{Fe} - Iron loss the AC motor

P_m - Mechanical loss against the friction

Torque of the bearing and wind resistance

P_s - Additional loss

The output torque of AC motor

$$T2 = \frac{9550 \cdot P_2}{n}$$

The external characteristic curve of a kind of AC motor can be seen from Figure 3.

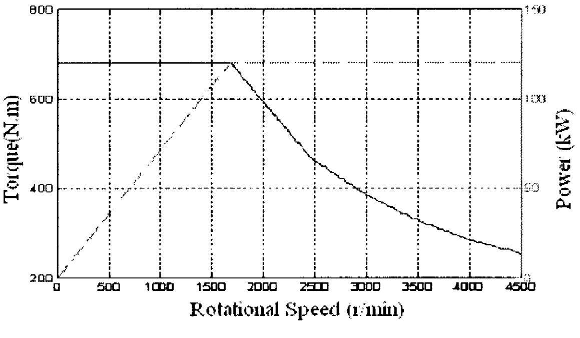


Fig. 3 External characteristic curve of AC motor (120KW)

3. THE DEFINITION OF SOC OF LITHIUM BATTERY

The factors which influence the charged status mainly include structure and usage. In the process of actual application, the charged status of the battery is mainly influenced by usage (discharging current and discharging temperature).

A standard current method can be used to determine the charged status at constant temperature of a battery. Standard current method determines the SOC of a battery by the equivalence of discharging capacity Q at different discharging currents and discharging capacity Q' at a standard current I_{ref}. It can be known from experiments that the capacity at discharging current I_0 ($I_0 \neq I_{ref}$) is not equal to the capacity at discharging current I_{ref}. By using the weighted coefficient $\alpha(i)$, the equivalent discharging capacity in the period of 0-T can be obtained, then the residual capacity C_r at the current of I_{ref} can be determined.

$$C_r = C_n - \int_0^T \alpha(i) i(t) dt$$

So the SOC of battery is:

$$SOC = \frac{C_r}{C_n} \times 100\%$$

The nodus of this method is how to compute the weighted coefficient $\alpha(i)$. It can be solved by the relational graph between discharging capacity and discharging current. For example, at a temperature of 25℃, by making experiments of lithium battery whose discharge rate in three hours is 100Ah, the discharging capacity C at different discharging current I can be obtained, which can be seen form Figure 4.

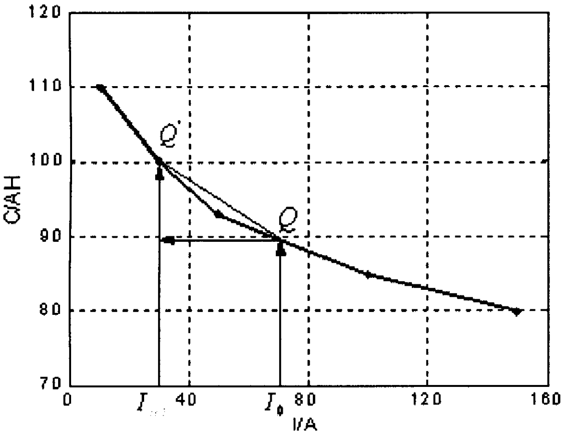


Fig. 4 Battery capacities at different current

If the fluctuation of capacity caused by completely discharging at current I_0 is C_{I_0}, then the quantity of electricity Q when partly discharging at current I_0 can be equivalent to the quantity of electricity Q' when discharging at current I_{ref}.

$$Q' = Q / C_{I_0} * (C_n - C_{I_0}) + Q = Q * C_n / C_{I_0} \tag{2-74}$$

Then the weighted coefficient $\alpha(i)$ can be expressed by:

$$\alpha(I_0) = \frac{C_n}{C_{I_0}}$$

The selection of reference current I_{ref} can also influence the validity of the standard current method. In the above example, the current at nominal capacity is taken as the reference current. But in the actual application, the reference current is selected from the average current in the running process of EV. If reference current is greatly different from actual current, the computation validity will be reduced.

4. SIMULATE THE BFC6110-EV WITH EVSIML

4.1 The main design parameters of BFC6100-EV

The main design parameters of BFC6110-EV are shown as Table 1.

Table 1 The main design parameters of BFC6110-EV

Length×Width×Height(mm) Wheelbase (mm) Tread front/back (mm)	10660×2500×3560 5050 2099/1824
Curb quality (kg)/Maximum total quality (kg)	2420/3190
PMDC motor with enhanced-magnetism windings Rated power/Maximum power (KW) Rated rotated speed/Maximum rotated speed (rpm) Maximum Torque (Nm)	75/125 2000/2500 1050(Operating in five minutes)
Controller Maximum output (A) Controller Size (mm)/Weight (kg)	640 660×380×240/25
Sealed and free maintenance lead-acid battery Rated Voltage (v)	12V/100Ah 12(v)×32×3group

4.2 Power performance simulation result

According to the drivetrain parameters of BFC6110-EV, the power performance of BFC6110-EV is simulated with EVSIML. The simulation results are shown as the Figure 5 to Figure 8.

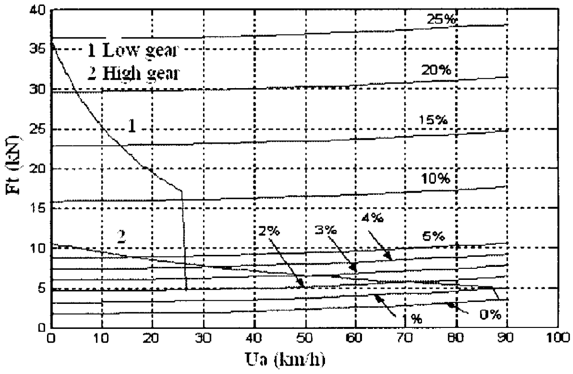


Fig. 5 Balance figure of the drive

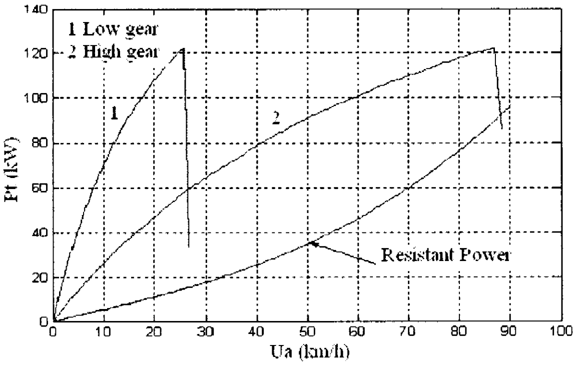


Fig. 6 Balance figure of drive power

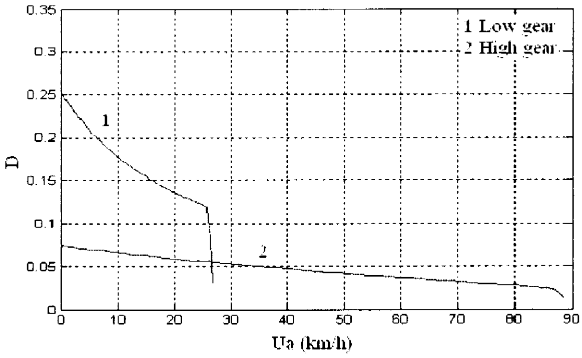


Fig. 7 Acceleration time

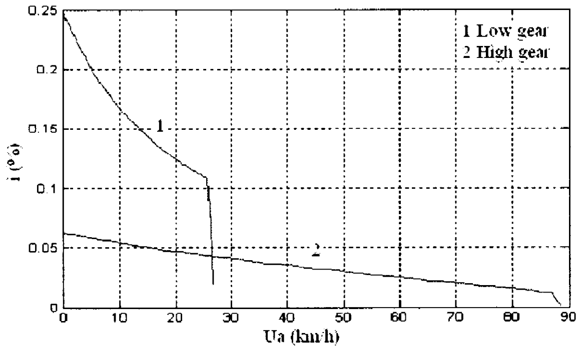


Fig. 8 Grade ability

4.3 Fuel economy simulation result

The speed-time figure of the fourth cycle status of a Chinese bus is shown as Figure 4 (a). The total time is 129s and the total range is 0.7048km.

Based on this status, the driving range and the operation status of the battery are simulated with EVSIML. The results are shown as Figure 9 to Figure 12 and Table 2. In order to check clearly the change condition, the original four-cycle statuses are computed.

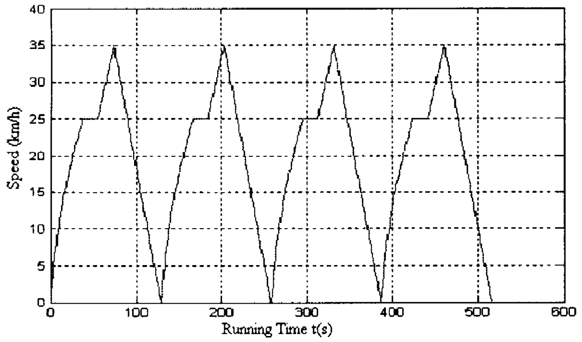


Fig. 9 The cycle status

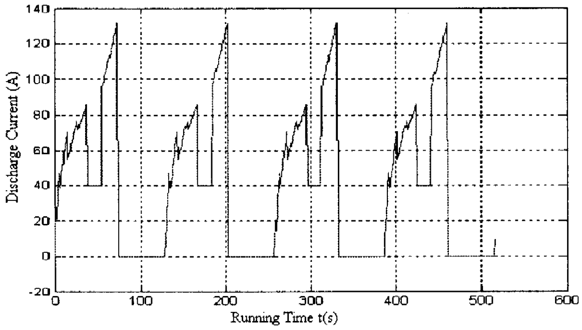


Fig. 10 The discharge current of the battery

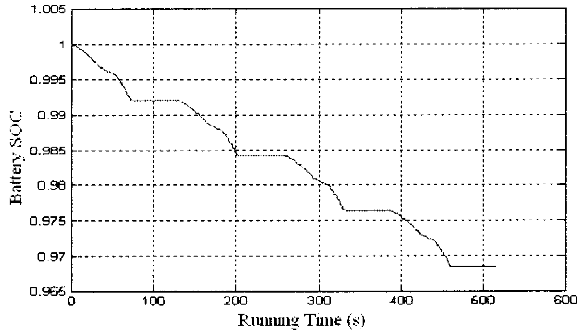


Fig. 11 The SOC of the battery

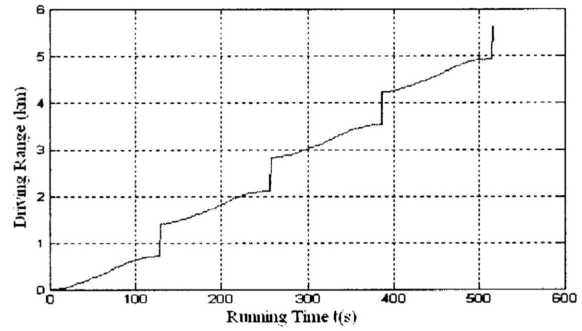


Fig. 12 The driving range

Table 2 The driving range and battery operation status

Time and range parameters		
Total time (h)	Number of cycle status	Driving range (Km)
3.63	101.2	142.53
Battery operation status		
The remain capacity (Ah)	The terminal DOD	The terminal voltage (v)
63.04	0.8	348.9

4.4 Comparison between the test data and simulation results

Table 3 Comparison of test and simulation results of BFC6100-EV

Item			simulation	Test
Power Perfor-mance	Maximum speed (Km/h)		88.7	81.3
	Acc.Time (s) (0-60Km/h)	High shift	45.68	51.0
		Start and shift	55.4	45.6
	Gradability (%)		20.02	20
40Km/h Range	Range (Km)		348.9	306
	Capacity consumption rate (Ah/km)		1.7739	1.536
	Power consumption rate (kWh/km)		0.6514	0.556

4.5 Analysis of simulation results

The simulation results are close to those acquired from tests, which proves that the simulation models of the components of BFC6110-EV are correct and the means by which the power performance and economic performance are calculated are feasible. Temperature and road conditions and the selection of coefficient of road resistance and efficiency of mechanic system caused small differences between the results of calculation and tests. The temperature and the coincidence performance greatly influence the range. The approval test shows that the technical parameters and basic performance fully meet the requirements of national standards. The performance of BFC6110-EV is suitable for public transportation in Beijing City.

5. CONCLUSION

In this paper, the EV simulation software called EVSIML is introduced, and has been expanded by adding the modules of an AC motor and a lithium battery. The blending methods are introduced. EVSIML has great significance in the system analysis, the parameter selecting and the consummating of the unbuilt vehicle. Also, the dynamic performance and driving range simulation of BFC6110-EV is performed, the result is important to the system optimizing and matching of BFC6110-EV. This paper can be used as reference for the practical operation and control of the EV.

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