The Feasible Research of Electric Vehicle by Using Two-gear Transmission

Yang Guanlong[a], Su ling[b], Li ZhongHua[c], Liu jie, Tian Xueyong

Chongqing Changan New Energy Automobile Co. Ltd, Chongqing 401120, China;

[a]yanggl@ changan.com.cn, [b]suling@ changan.com.cn, [c]lizh@changan.com.cn

Keywords: electric vehicle; two-gear Transmission; economy; dynamic; vehicle control unit

Abstract. In this paper, the two-gear transmission electric vehicle was studied. First, the transmission ratio was optimized by use of genetic arithmetic, which can increase the drive mileage. Second, the dynamic performance of electric vehicle was analyzed, including maximum velocity, acceleration time and maximum grade ability. Third, the driving mileage was researched for ECE drive cycle on the MATLAB/SIMULINK platform. The results indicate that two-gear electric vehicle can improve motor efficiency and increase the driving mileage. But the cost of vehicle will increase. Meanwhile, the vehicle control unit becomes relatively complex.

1. Introduction

The electric vehicles(EV) get attention deeply by different countries, car enterprise and scientific research structure, because of they have the advantage of high efficiency and zero emission. Two-gear transmission can improve the economy and dynamic of the electric vehicles, which gradually become a hot topic.

Reasonable matching two-gear transmission has important effect for vehicle consumption economy[1]. The transmission ratio optimization can design gear paramers, which can obtain best energy consumption economy [2], [3], [4]. Genetic arithmetic can fulfill best matching transmission ratio for electric vehicle based on the optimization theory[5], [6].

The paper is organized as follows. In the next section, we optimize the transmission ratio by using genetic arithmetic in this paper, and some parameters are given. In Section 2, the dynamic performance is analyzed. Section 3 analyzes the driving mileage about ECE drive cycle based on MATLAB -SIMULINK platform. Finally, we conclude our paper in section 4.

2. The optimizing analysis of transmission ratio

In order to improve the performance of the electric vehicle, the transmission ratio should be selected rationale. The climbing ability of vehicle become more stronger with the increase of the first-gear ratio. The highest velocity is higher because of the second-gear ratio is smaller.

The first-gear ratio should be fulfilled specially condition based on motor capacity,which is described in equation (1).

$$i_1 \geq \frac{(mg \cos(\alpha_{max}) f_r + mg \sin(\alpha_{max}))r}{T_{m max} \eta_t i_0} \tag{1}$$

where, i_1 is first-gear ratio, m is the vehicle mass, g is the acceleration of gravity, f_r is the coefficient of rolling resistance, r is the vehicle radius, $T_{m max}$ is the maxmium motor torque, η_t is the transmission efficiency, i_0 is the main retader ratio.

The second-gear ratio should be fulfilled specially condition based on maximum motor speed, which is described in equation (2).

$$i_2 \leq 0.377 \frac{r \cdot \omega_{n max}}{v_{max} i_0} \tag{2}$$

where, i_2 is second -gear ratio, $\omega_{n max}$ is the motor maximum speed, v_{max} is the maxmium velocity.

Futhermore, the transsimion ratio has effect on the driving mileage of electric vehicle. Accordingly, the design of transsimion ratio make the electric vehicle drive longer on the base of meeting dynamic performance for ECE driving cycle. In this paper, the genetic arithmetic is adopted to optimize the transsimion ratio. The optimize model is shown in Fig.1. The parameter values and specifications for electric vehicle model are provided in Table 1.
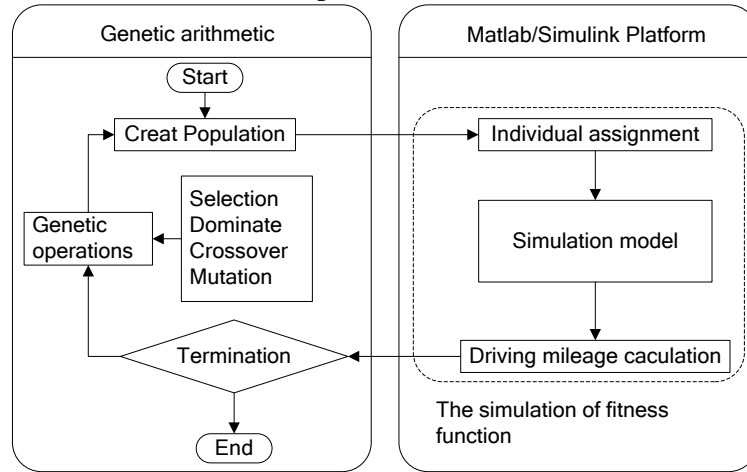

Fig.1 The optimal model of transmission ratio

The maximum of evolution algebra is 80. The population size is 50. The crossover probability is 0.7. The mutation probability is 0.1. The optimize result is shown in Fig.2. It can be seen that the first-gear and second-gear optimize ratio is 13.4 and 6.99 respectively, when the evolution algebra get to 69 generation.

Table 1 The power-train parameters of EV

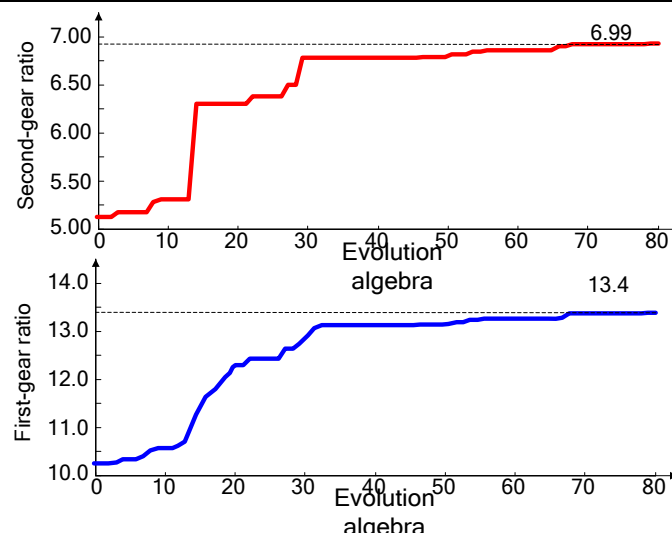| Component	Characteristic	Data/Values
Vehicle	Mass	1575 kg
	Frontal area	2.28 m^2
	Aerodynamic drag coefficient	0.357
	Wheel radius	0.318 m
	Rolling resistance coefficient	0.0083
Motor	Peak value power	55 kW
	Peak value torque	≥190 Nm
	Maximum speed	9000 rpm
Battery	Energy storage	≥25 kW·h
	Rated voltage	320 V

Fig.2 The optimal results of transmission ratio

3. Dynamic performance analysis

The dynamic performance indicators contain maximum velocity, acceleration time and maximum gradeability. The results are shown in Table 2.

Tab 2.5 The simulation result of dynamic performances

Dynamic indicators	Simulation results	
	Two-gear	Prototype
0～50km/h acceleration time（s）	5.759	6.08
0～80km/h acceleration time（s）	8.359	8.394
Maximum gradeability（%）	30.54%	26.25%
Maximum velocity（km/h）	118	92

It can be seen that the acceleration time from 0 to 50 kilometers per hour is 5.759 seconds, which improves 5.3 percent repect to prototype vehicle. The acceleration time from 0 to 80 kilometers per hour is 8.359 seconds, which improves 0.4 percent repect to prototype vehicle. The maximum gradeability is 30.54 percent, which improves 16.3 percent repect to prototype vehicle. The maximum velocity is 118 kilometers per hour, which improves 28.3 percent repect to prototype vehicle.

4. Driving Mileage analysis

The motor effciency effects the driving mileage of electric vehicle. The two-gear electric vehicle can adjust the motor effciency and incease the driving mileage to some extent. The the driving mileage is 108 kilometers, which improves 4.8 percent repect to prototype vehicle. The motor operating points are shown in Fig.3.
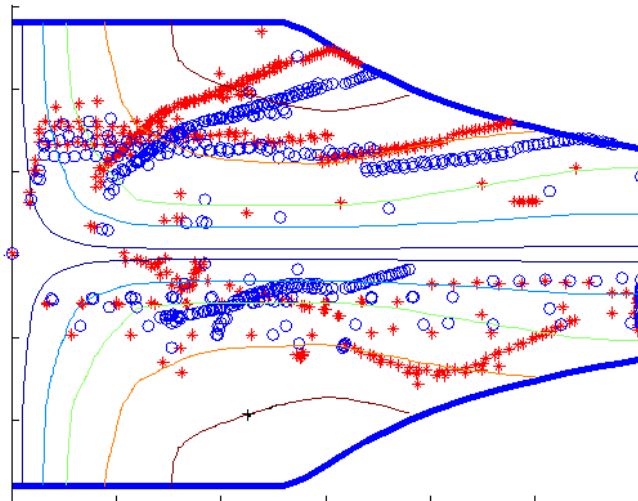

Fig.3 The operating points of motor

It can be seen that the motor operating points mostly distribute in high effciency area when the electric vehicle matchs two-gear transmission.

5. Conclusions

In the paper, the simulating calculation of dynamic and economy performance for electric vehicle is fulfilled on the matlab/simulink platform. The results demonstrate that two-gear electric vehicle can improve motor efficiency and increase the driving mileage. But the cost of vehicle will increase. Meanwhile, the vehicle control unit becomes relatively complex.

Acknowledgements

References

[1] Qin Da-tong, Zhou Bao-hua, Hu Ming-hui, et al. Powr train parameter design for the electric vehicle with two-speed transmission [J].Journal of Chongqing University, 2011, 34(1):1-6.

[2] He Ren, Wang Jiang-feng. Interval optimization of automobile transmission parameters. [J]. SAE, 1999-01-0733

[3] Zhang Bo, Zheng He-yue, Wang Cheng. Plug-in hybrid electric vehicle energy management strategy [J].Journal of Mechanical Engineering, 2011. 47(6):113-119.

[4] Delphine S, Gregory R, Yohan M. Design optimization and optimal control for hybrid vehicles [J]. Optimization and Engineering, 2011, 12(1): 199-213

[5] Cabral H, Melo M. Using genetic algorithms for device modeling [J]. IEEE Transactions on Magn etics, 2011, 47(5):1322-1325.

[6] Zhu Zheng-li, Yin Cheng-liang, Zhang Jian-wu. Genetic algorithm based optimization of electric vehicle powertrain parameters[J]. Journal of Shanghai Jiaotong University，2004，38 (11):1907-1912.