

Original Research Article

Electric vehicle power parameter matching and computer performance simulation research

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Abstract: This paper presents a preliminary method for matching the main powertrain parameters of a battery electric vehicle. A longitudinal dynamics model is used to calculate traction force, motor torque, motor speed, and motor-side power. For a 1500 kg case vehicle, the motor-side power demand at 120 km/h on a level road is about 23.2 kW. A design set including 45 kW continuous power, 90 kW peak power, 250 N·m peak torque, and 55 kWh battery energy is proposed for verification. The method is suitable for early design screening and teaching applications.

Keywords: battery electric vehicle; parameter matching; traction motor; battery sizing; longitudinal dynamics; performance simulation

1. Introduction

Battery electric vehicle (BEV) powertrain design requires a balance among performance, efficiency, cost, mass, and thermal capability. The motor, battery pack, inverter, and reduction gear are closely coupled. Undersized components may fail to meet acceleration, maximum-speed, or climbing targets, while oversized components increase cost and mass^[3-4].

Parameter matching is therefore an important step between vehicle target definition and detailed component design. A longitudinal model can estimate wheel force, motor torque, motor speed, power demand, and battery energy. Equation-based screening makes assumptions explicit and helps compare candidate schemes before prototype testing^[1-2].

This paper organizes the matching process into road-load calculation, motor operating constraint analysis, and battery energy estimation. A case vehicle is used to show the calculation route and support subsequent computer simulation.

2. Longitudinal vehicle model

2.1. Traction-force demand

For a vehicle traveling at speed v on a road with slope angle α , the required wheel traction force F_t is the sum of inertial, rolling, grade, and aerodynamic terms^[1-2]:

$$F_t = ma + mgf \cos\alpha + mg \sin\alpha + 0.5\rho C_d A v^2 \quad (1)$$

where m is vehicle mass, a is longitudinal acceleration, g is gravitational acceleration, f is rolling-resistance coefficient, ρ is air density, C_d is aerodynamic drag coefficient, and A is frontal area. In steady level-road driving, $a = 0$ and $\alpha = 0$.

2.2. Motor-side power demand

The mechanical power required from the traction motor is obtained from wheel power after considering driveline efficiency η_d :

$$P_m = F_t v / \eta_d \quad (2)$$

Here, P_m is motor-shaft mechanical power. This expression separates wheel power $F_t v$ from the upstream motor-side requirement. For acceleration and climbing conditions, the inertial and grade terms in Equation (1) should be retained.

3. Powertrain parameter matching

3.1. Motor torque and speed

The required motor torque T_m and motor speed n_m are determined by wheel radius r_w , gearbox ratio i_g , final-drive ratio i_0 , and transmission efficiency η_t [3,5]:

$$T_m = F_t r_w / (i_g i_0 \eta_t) \quad (3)$$

$$n_m = 60 v i_g i_0 / (2\pi r_w) \quad (4)$$

A feasible motor must satisfy torque and speed requirements at the same operating point. Maximum-speed performance constrains the motor speed range, while launch and gradeability generally constrain low-speed torque. Therefore, key operating points should be checked against the motor torque-speed envelope.

3.2. Continuous and peak power

Continuous motor power should support sustained cruising or climbing without exceeding thermal limits. Peak power is governed by the most demanding short-duration condition. A preliminary matching rule can be written as:

$$P_{\text{peak}} \geq \max(P_{\text{speed}}, P_{\text{acc}}, P_{\text{grade}}) \quad (5)$$

where P_{speed} , P_{acc} , and P_{grade} are evaluated under consistent vehicle and road assumptions. The peak value should also be checked with the required duration and inverter capability [3-4].

3.3. Battery energy and power

The nominal battery energy E_b can be estimated from target range S and average energy consumption e_c :

$$E_b \geq S e_c / (\text{DOD} \cdot \eta_b) \quad (6)$$

DOD is allowable depth of discharge and η_b is battery discharge efficiency. In detailed design, peak current, voltage sag, thermal behavior, aging, reserve energy, and auxiliary loads should also be considered [3-4, 6].

4. Simulation procedure and case-study inputs

At each simulation step, the model reads speed, acceleration, and road grade; calculates traction force from Equation (1); converts force demand to motor torque, speed, and power using Equations (2)-(4); and updates battery energy or state of charge. The structure can be implemented in MATLAB/Simulink, Python, or another numerical environment [3,5-6].

Table 1. Case-study parameters and model constants.

Parameter	Symbol	Value	Unit
Vehicle mass	m	1500	kg
Wheel radius	r_w	0.30	m
Rolling-resistance coefficient	f	0.012	-
Aerodynamic drag coefficient	C_d	0.30	-
Frontal area	A	2.2	m ²
Driveline efficiency	η_d	0.90	-
Maximum vehicle speed	v_{max}	120	km/h
Air density	ρ	1.225	kg/m ³
Gravitational acceleration	g	9.81	m/s ²

The calculation sequence is: Define targets and assumptions; calculate force, torque, speed, and power at maximum-speed, acceleration, and gradeability points; select motor, inverter, reduction ratio, and battery candidates; and verify them under representative drive cycles.

5. Results and discussion

5.1. Steady-speed power check

Using the inputs in **Table 1**, level road, still air, and $v = 120$ km/h (33.33 m/s), the rolling resistance is 176.6 N and the aerodynamic resistance is 449.2 N. The total road load is 625.8 N. Equation (2) gives

a motor-side mechanical power demand of approximately 23.2 kW. Therefore, a 45 kW continuous motor rating provides a reasonable margin before auxiliary loads and thermal derating are considered.

This result supports the continuous rating. Acceleration and gradeability can then be verified by specifying acceleration time, maximum road grade, climbing speed, total reduction ratio, adhesion limit, and allowable peak-power duration.

Table 2. Preliminary component ratings for system-level verification.

Item	Candidate value	Engineering interpretation
Motor continuous power	45 kW	Plausible from the 23.2 kW level-road check.
Motor peak power	90 kW	For acceleration and gradeability checks.
Maximum motor torque	250 N·m	Checked with ratio, wheel demand, and adhesion.
Battery nominal energy	55 kWh	Checked by range, DOD, reserve, and efficiency.
Voltage platform	350 V	Checked with current, safety, and efficiency.

5.2. Engineering implications

Equation (1) shows that mass mainly affects rolling, grade, and acceleration loads, whereas aerodynamic demand increases with the square of speed. Thus, high-speed energy use is sensitive to C_d , frontal area, and vehicle speed. In urban driving, acceleration demand and regenerative-braking limits become more influential^[1-2].

These relationships show that a single peak-power value is not a sufficient design criterion. The reduction ratio should place key operating points within the motor torque-speed envelope, and battery voltage and current limits should remain compatible with motor-inverter demand. Component matching is therefore an iterative system problem.

5.3. Model extension

The present study focuses on preliminary matching and steady-state performance estimation. For higher accuracy, the framework can be extended with drive-cycle time histories, efficiency maps, regenerative braking, auxiliary loads, battery equivalent-circuit parameters, and thermal constraints.

6. Conclusion

A transparent framework for preliminary BEV powertrain parameter matching has been presented. Longitudinal road loads are translated into motor torque, speed, and power constraints, and battery energy is estimated from range and usable-energy requirements. For the 1500 kg case vehicle, the level-road check gives a motor-side demand of about 23.2 kW at 120 km/h, making a 45 kW continuous rating a reasonable preliminary choice. The 90 kW peak power, 250 N·m torque, and 55 kWh battery are selected as preliminary matching results for subsequent system-level verification. Future work may include efficiency maps, regenerative braking, drive-cycle simulation, sensitivity analysis, and experimental validation.

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