双电机混动建模与仿真
Dual Motor DHT Modeling and Simulation

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2021-10-18

Dual Motor DHT Modeling and Simulation

1. Background
2. Energy consumption simulation of dual motor DHT
3. System performance analysis of dual motor DHT
4. Problem analysis and solution
5. Hybrid system simulation development process and benefits

1. Background

- The newly developed dual-motor DHT transmission needs to set reasonable development goals, control constraint boundaries, and optimally match the system;
- The focus is to realize the real-time optimal switching of working modes, find potential opportunities and directions for improvement, and finally realize the control and optimization of DHT hybrid system;
- Therefore, it is the most important how to make quick and efficient modeling and simulation;

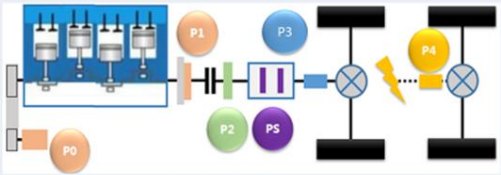
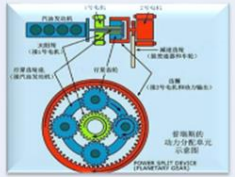
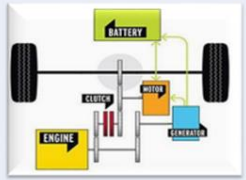
	Single motor				Dual motor		
Solution	发动机+DCT/AT_CVT+单电机				混动专用发动机DHE+双电机DHT		
Frame -work					 		
OEMs	**P0** 美系/德系/现代/吉利/长城	**P2** 德系/吉利/北汽	**P3** 比亚迪/上汽	**P4** 宝马/长城，多配合其他机构使用	**功率分流** 通用/丰田/福特	**串并联** 本田/长城/比亚迪/上汽/广汽/东风	**串联** 日产e-Power/东风
Feature	动力性提升5%-30%，节油率5%-25%，控制较复杂				节油率提升20-40%，动力性提升10%-20%，控制复杂		

Fig.1 Hybrid technical solution

2. How to build a simulation platform for hybrid system?

➢ Selection of simulation tools

— Development tool

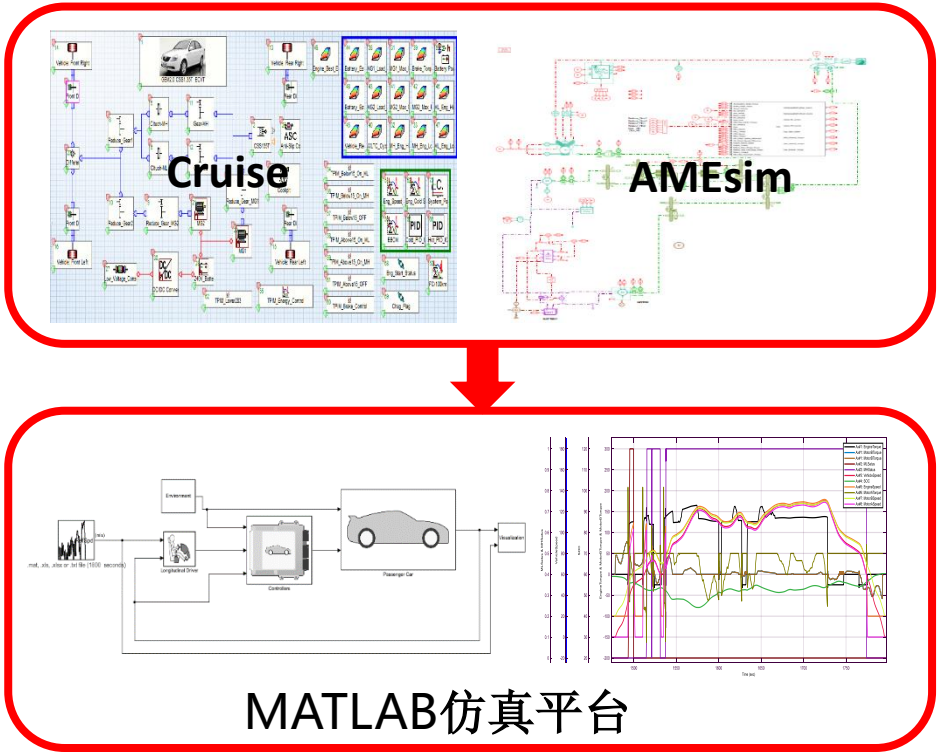
MATLAB /AMEsim/Cruise;

— Comparative analysis

Control accuracy\simulation efficiency \scalability;

— Definition

MATLAB can efficiently develop a hybrid system simulation platform.

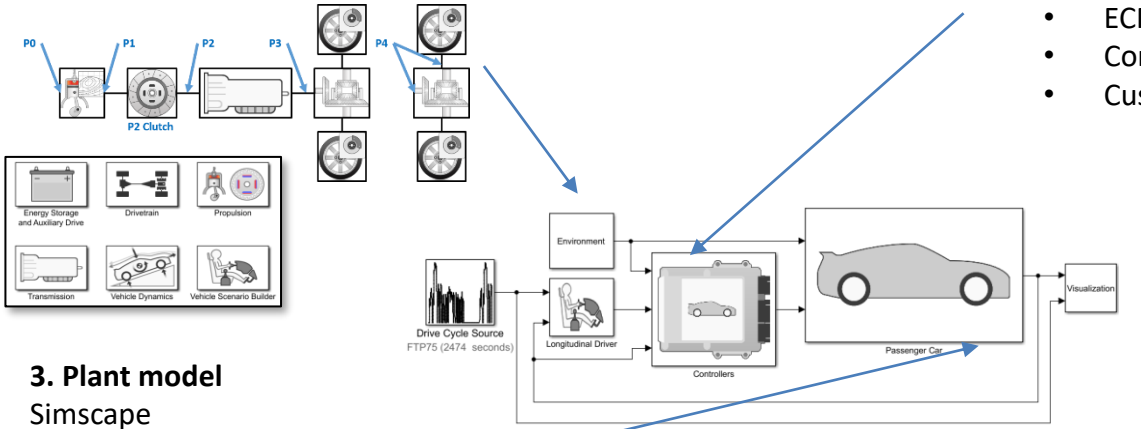


2. How to build a simulation platform for hybrid system?

1. Vehicle model frame

Powertrain Blockset: Reference Application

- HEV: P0, P1, P2, P3, P4

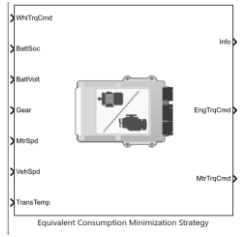


2. Control model

MATLAB/Simulink/Stateflow

Powertrain Blockset

- ECMS
- Controllers(HCU/ECU/TCU)
- Customize Controllers

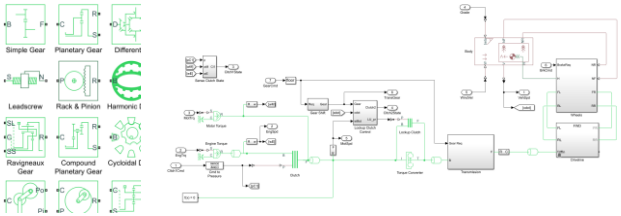


3. Plant model

Simscape

Simscape Driveline

- Drivetrain model
- Thermal management



4. Model parameterization and control parameter optimization

Model-Based Calibration Toolbox

Simulink Design Optimization Toolbox

- Parameterize
- Control parameter tunning

5. Create UI, report generation

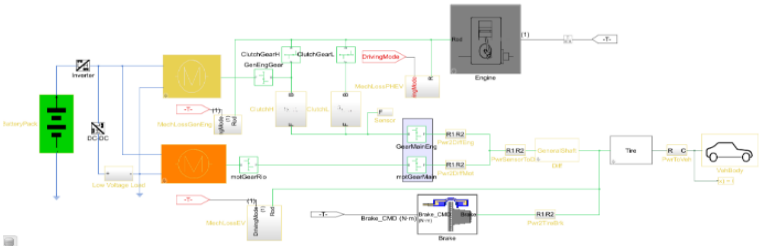
MATLAB/App designer/Report generator

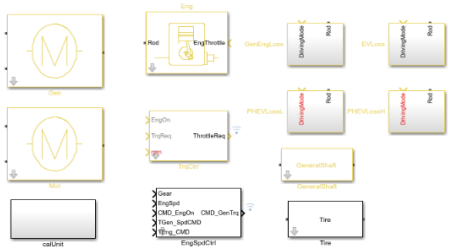
- GUI
- Automatic report generation

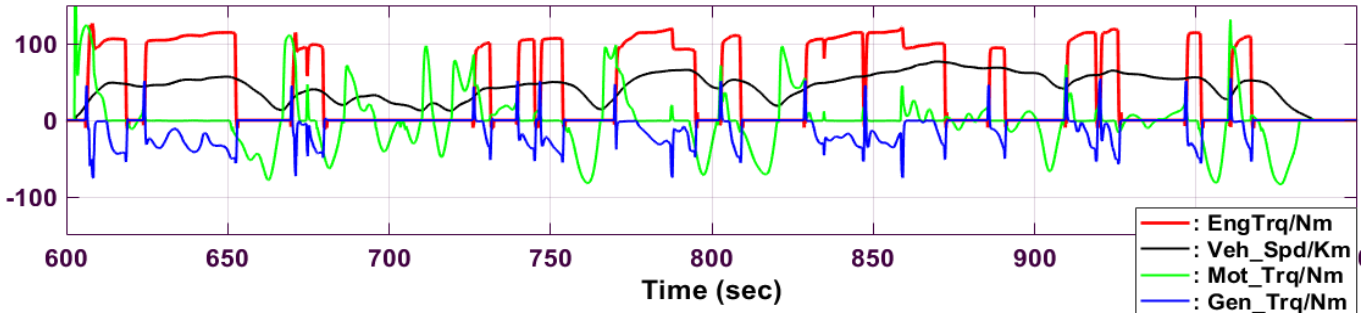
2. How to build a simulation platform for hybrid system?

➢ Subsystem dynamic response model (library)

The multi-power coupled hybrid system has sub-systems with different response characteristics such as engine, motor, battery and gearbox. Considering the dynamic response of each sub-system, a physical model library and documentation are established to achieve accurate and standardized modeling.





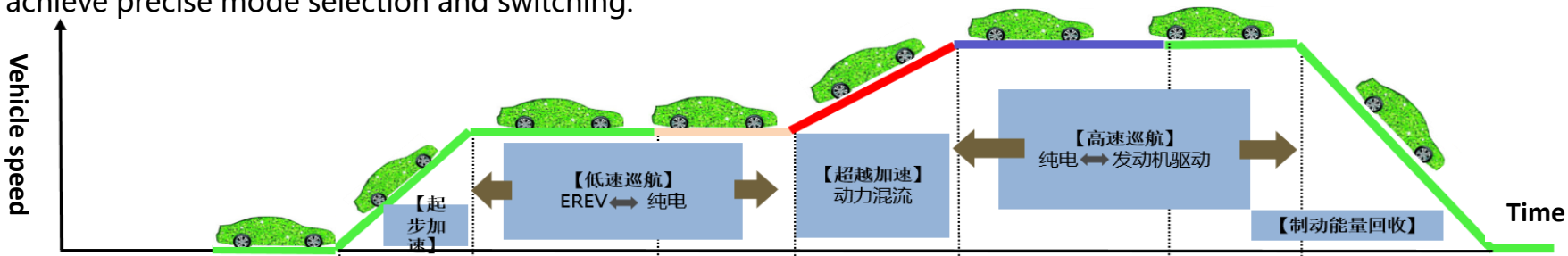


2. How to build a simulation platform for hybrid system?

➢ Vehicle drive mode and energy management control - mode decoupling

- **Working mode:** pure electric drive/series drive/parallel drive

- **17 kinds of dynamic switching modes:** different SOC and vehicle power requirement correspond to multiple possible working modes. It is necessary to evaluate the power performance and fuel consumption in each mode to achieve precise mode selection and switching.



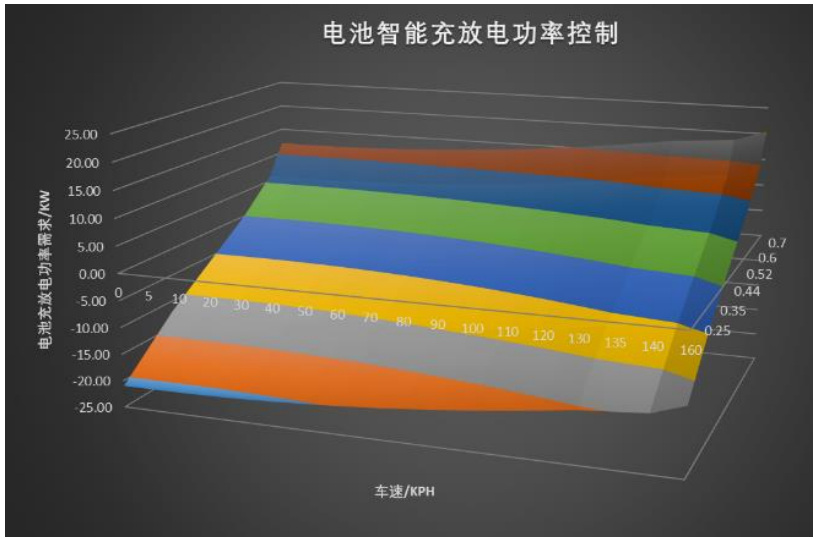
发动机	No Torque（可怠速发电）	No Torque（可行进中发电）		发电	驱动及发电	驱动或发电	No Torque	
MG1_发电	No Torque（可怠速发电）	No Torque（可行进中发电）		发电	发电	发电	No Torque	
MG2_驱动	No Torque	驱动		驱动	驱动	No Torque	驱动	制动能量回收
电池包管理	放电			充电	放电	充电	放电	充电
电池电量								
运行模式	停车（怠速充电）	EV	EV	EREV（行进中充电）	混合驱动（发动机助力）	发动机驱动（行进中充电）	EV	EV（制动能量回收）

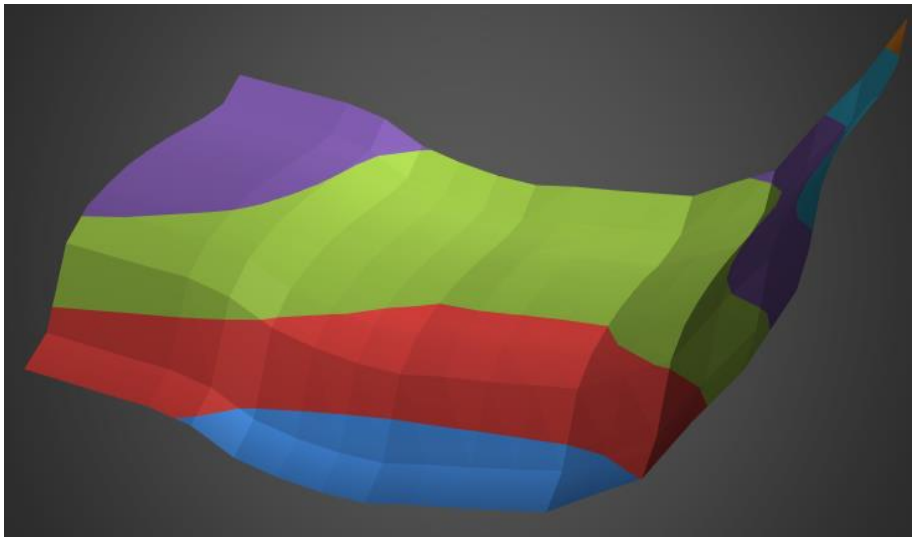
2. How to build a simulation platform for hybrid system?

➢ Vehicle drive mode and energy management control -- Power following

— **Battery charging and discharging:** the limits of energy flow, transfer efficiency, kinetic energy, real-time battery energy, charging and discharging are various in different working modes;

— **Engine start and stop:** The starting power needs to take into account vehicle demand power, battery charging power and 12V low-voltage load power to prevent frequent starting;





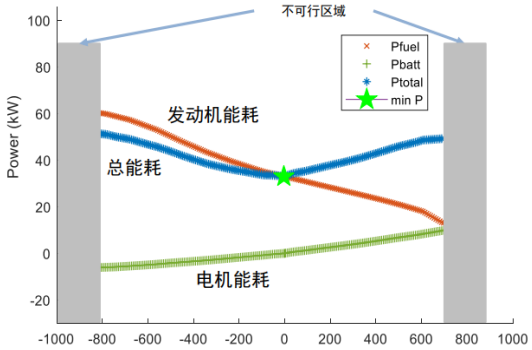
2. How to build a simulation platform for hybrid system?

➢ Vehicle drive mode and energy management control -- ECMS

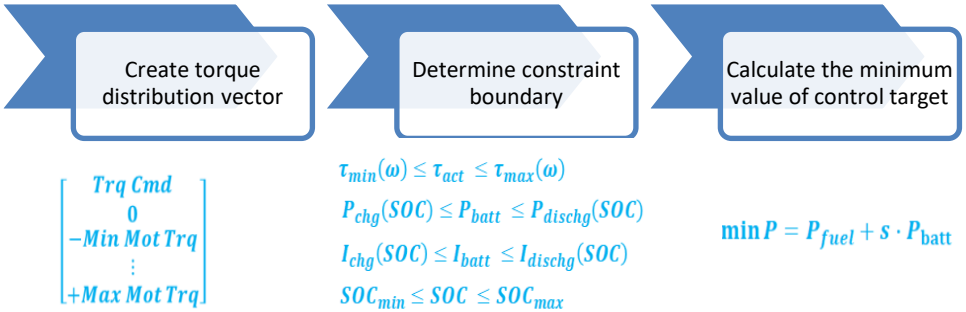
- **Control target:** The sum of instantaneous fuel consumed by engine and the equivalent fuel quantity of the consumed battery power is regarded as control target H for the optimization:

$$\mathrm{H} = \mathrm{P(fuel)} + \mathrm{S} * f(\mathrm{VehEnergEquReq}) + \mathrm{ConstraintPenaty}$$

- **Implementation steps:** According to control target H set by ECMS, each step of simulation will calculate all the energy distribution possibilities among engine, motor and battery in all modes, and optimize the distribution of driving power required by the vehicle between the engine and the motor in real time, in order to minimize the equivalent fuel consumption of the control target H;



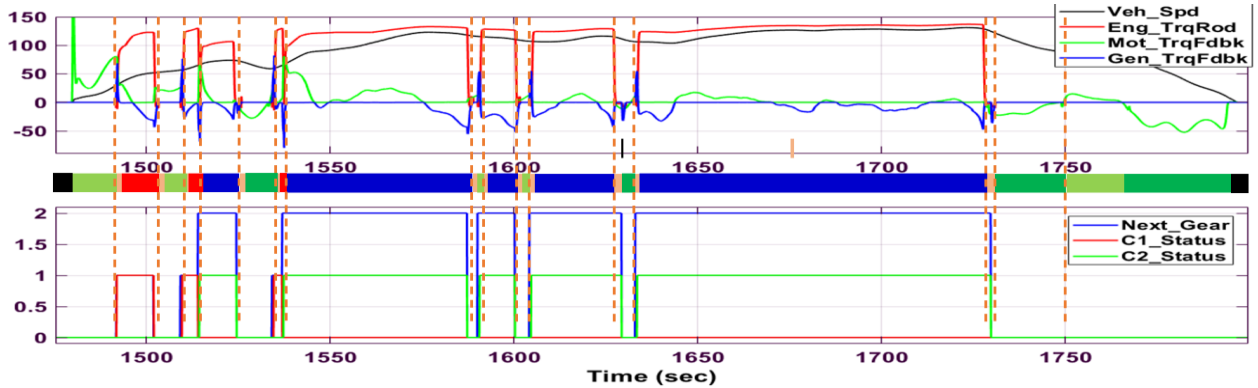
Control target

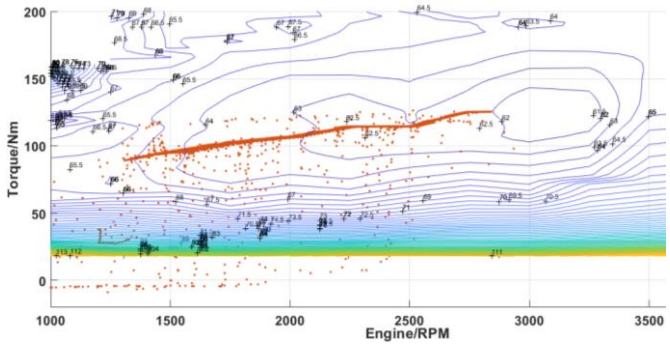


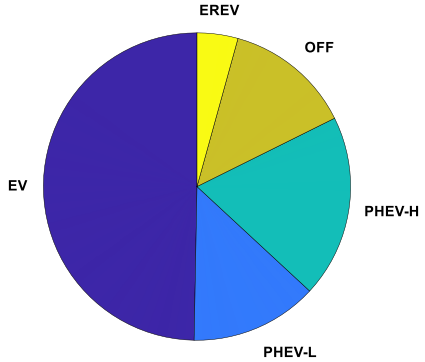
Implementation steps

2. How to build a simulation platform for hybrid system?

➢ WLTC simulation and analysis

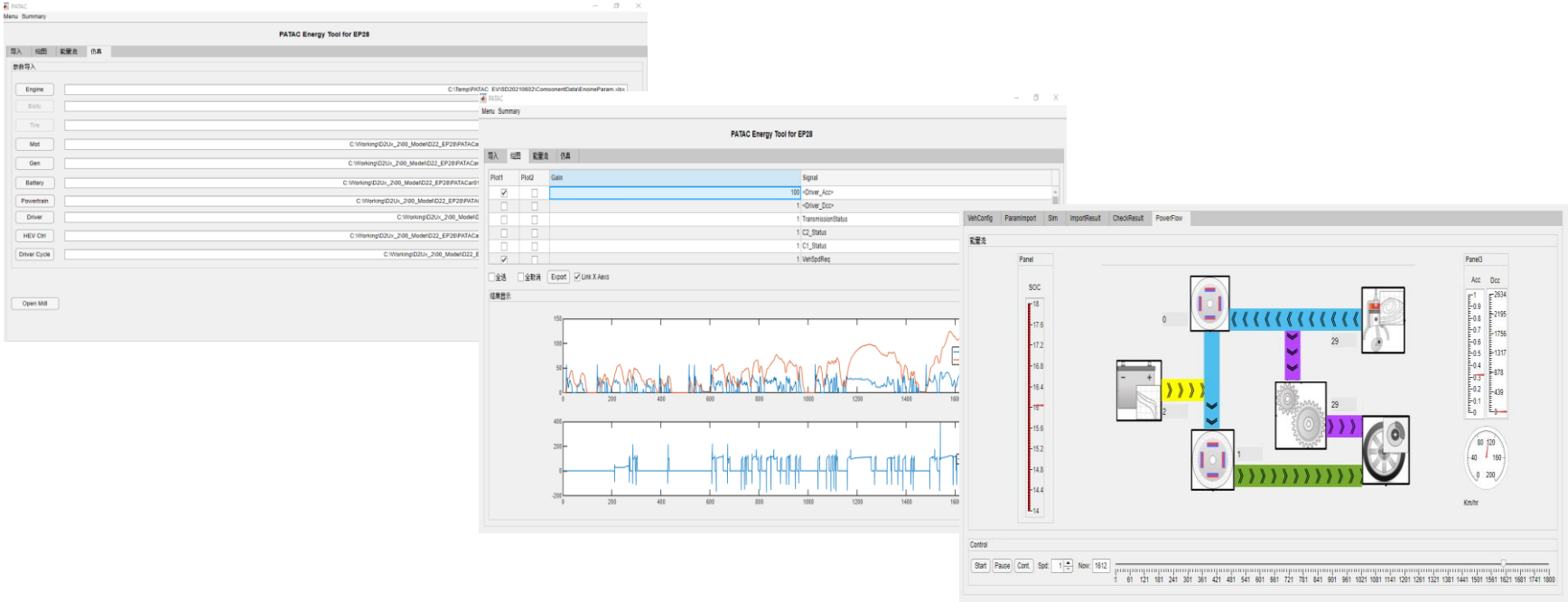






2. How to build a simulation platform for hybrid system?

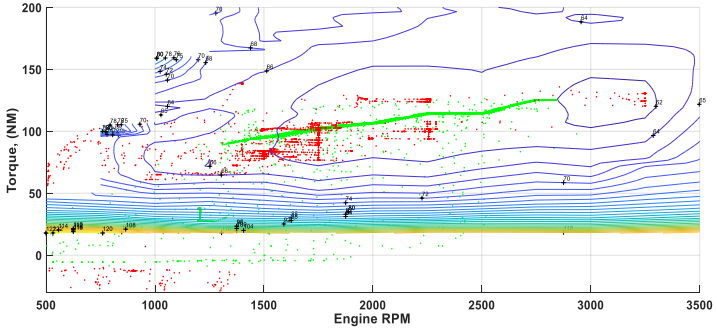
- **In order to realize the standardization and automation of input, control, output data and energy flow analysis, model data interaction interface, power flow analysis and simulation data analysis tools have been developed. It can quickly realize the simulation of energy consumption and performance at multiple driving modes, and the efficiency of data analysis is increased by 50%.**



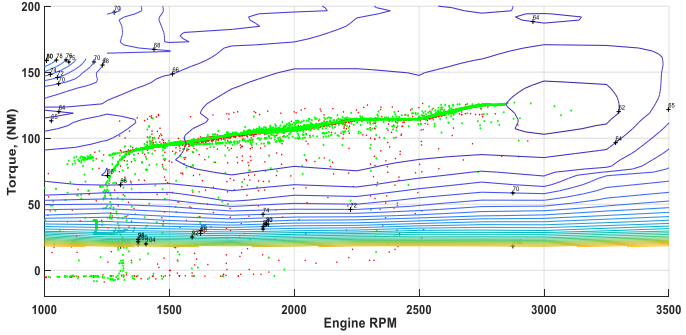
3. System performance analysis of dual motor DHT

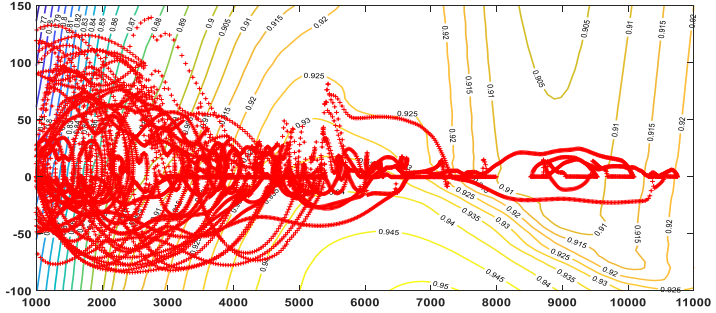
➢ System and control strategy development

Engine operating point

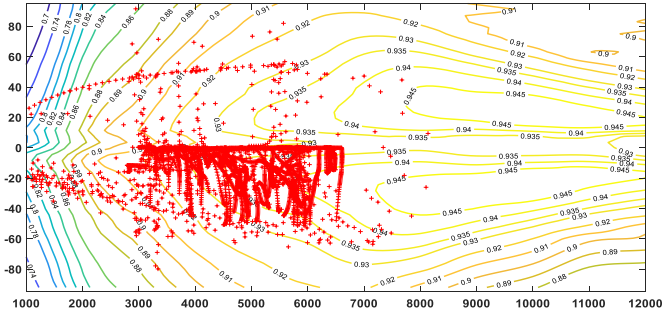


Engine operating point





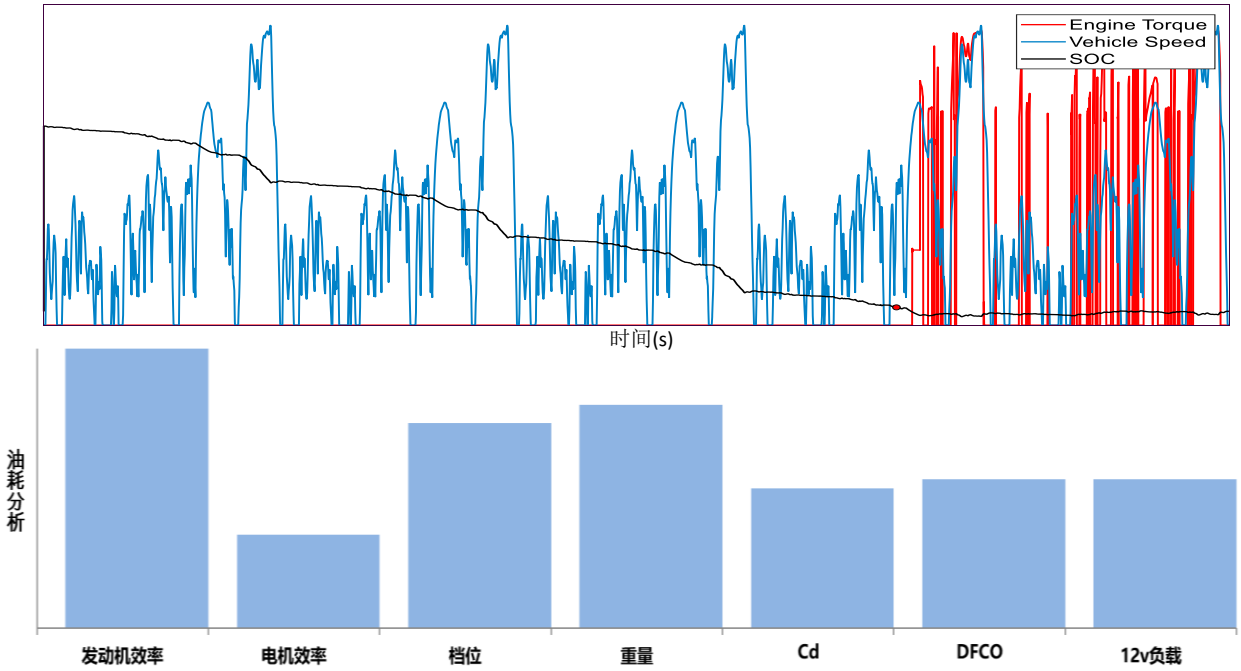
Motor-1



Motor-2

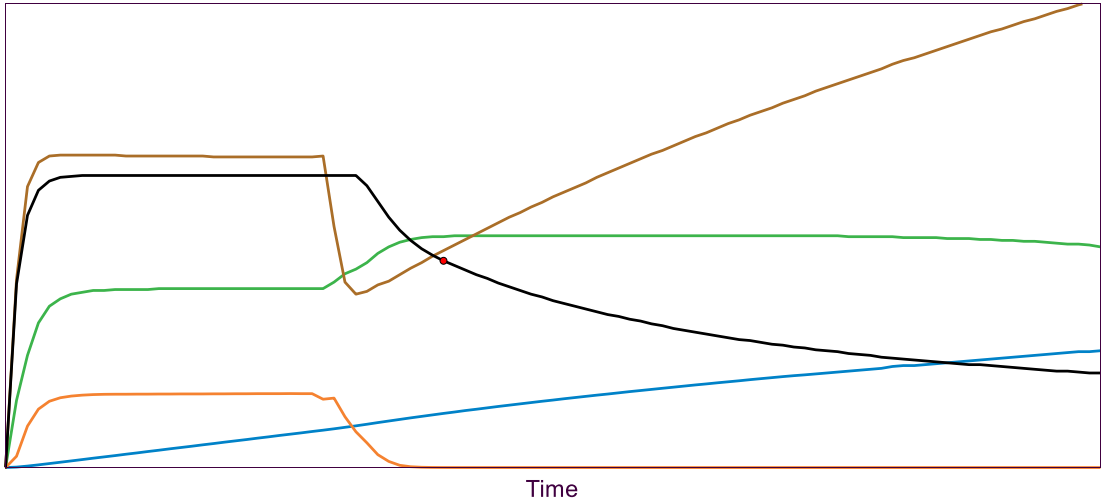
3. System performance analysis of dual motor DHT

➢ System and control strategy development



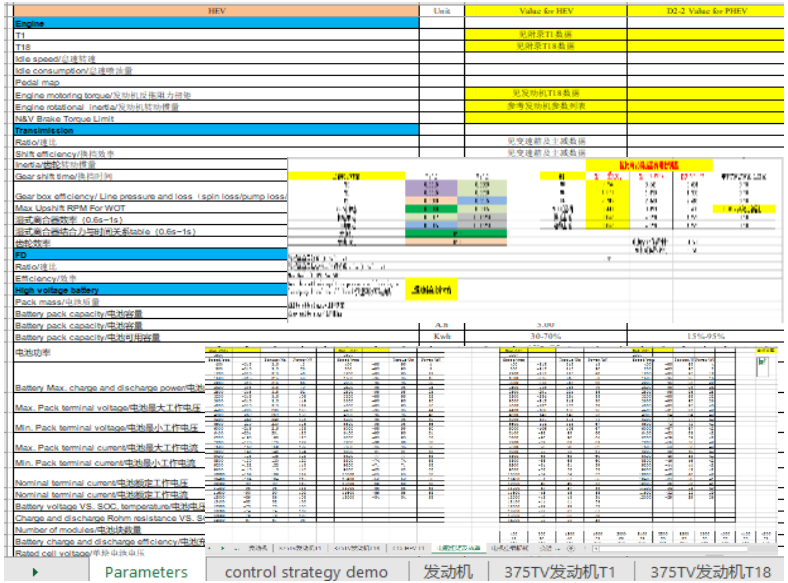
4. Problem analysis and solution

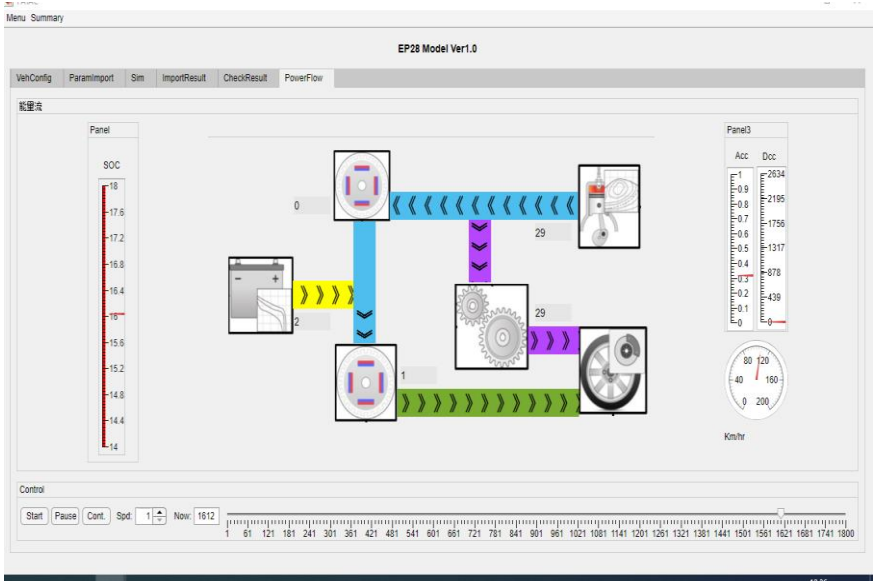
- **Problem: Shift process control**
- **Solutions：Multi-power source torque coordination, precise hydraulic control, improve shift control accuracy and shift quality;**



5. Hybrid system simulation development process and benefits

1. Data interaction standardization：unified input and output data template of system parameter;
2. Simulation model unification：unified input template of simulation model parameter, model data interactive interface one-click import and model generation;
3. Data processing automation: one-click export of simulation results to real-time energy flow and data analysis automation tools;





Thanks