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Optimization Analysis of Collaborative Thermal Management Parameters of Electric Vehicle Power System

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Abstract: Firstly, through the reading and summarization of domestic and foreign literatures, this paper studies and analyzes the cooling methods of battery packs and motors, and finds the solutions for the cooperative thermal management of electric vehicle power systems and their existing problems. Secondly, the structure of the electric vehicle parallel cooling system was studied and analyzed, and the parallel liquid cooling scheme was confirmed. The model of the parallel cooling system was established by using GT-SUITE simulation software. The parallel cooling system model motor is located on the main branch road. When the system starts running, the coolant will flow through the motor to cool it, and the battery is located in the secondary branch. On the road, an event controller controls the battery temperature to be in the range of 25 ° C to 30 ° C. When the battery temperature is not within this range, the event controller will cause the coolant to flow through the battery, so that the battery temperature returns to 25-30 ° C.

Keywords:electric vehicle; temperature control; thermal management system; simulation analysis;battery temperature

1. RESEARCH ON THERMAL MANAGEMENT OF ELECTRIC VEHICLES

The function of the cooling system of the electric vehicle is to ensure that the temperature of the battery pack and the power motor of the electric vehicle can be kept within the normal temperature range under any working conditions[1]. The cooling system should not only ensure that the temperature of battery and power motor of electric vehicle can be reduced to the normal working temperature of battery pack and power motor in high temperature environment, but also ensure that the temperature of battery pack and power motor is too low in external low temperature environment. The multi-thermal system of electric vehicle includes motor thermal management system, battery thermal management system and electric air conditioning system, and the three systems are closely related and interrelated when running. Aiming at the thermal management of battery pack and power motor, in recent years, major electric vehicle brands and related research institutes have carried out a lot of research work and achieved many research results[2].

In the battery thermal management system, considering the relationship between the heat dissipation mode of the battery and the external environment, the battery thermal management system can be divided into active cooling system and passive cooling system. The working condition of the active cooling system is not affected by the external environment, and the working state is adjusted in time according to the detected calorific value of the battery to ensure that the battery runs in the normal working environment. Passive cooling system can be affected by the external environment, and the detection of battery temperature is not very accurate, so it can not accurately manage the thermal of the battery pack, and is generally used for low-power electric vehicles.

2. THERMAL MANAGEMENT THEORY AND MODEL ESTABLISHMENT OF ELECTRIC VEHICLE POWER SYSTEM

2.1 Overview Of Power Motor

Motor is an important part of the power output of electric vehicle. If the motor temperature is too high or too low, it will affect the work of the power motor and reduce the service life of the power motor, thus affecting the use of electric vehicles. With the continuous development of electric vehicle technology, the power requirements of electric vehicles are gradually improved, so the power of the motor is constantly increasing, and the temperature of the motor will also increase with the increase of power, so better cooling system and cooling method are needed for the motor cooling. At present, according to the different cooling media at home and abroad, the motor thermal management system is divided into two cooling modes: airflow cooling and liquid cooling[3].

2.2 Design And Establishment Of Parallel Thermal Management System

2.2.1 Software introduction

GT-SUITE is a highly integrated engine+powertrain+vehicle simulation platform developed by GAMMA Company, and all its modules share the same pre-and post-processing interface. Its operation is simple, the interface is friendly and easy to use, multi-level model management, and the real machine assembly modeling concept[4]. Its own template library is very rich, covering: fluid, mechanical, electrical, magnetic, thermal and control components. For the same physical phenomenon, GT-SUITE usually provides different levels of physical models, and users can build models with different complexity according to their needs [5].

2.2.2 Model design and establishment

Select parallel automobile thermal management model to establish, and the schematic diagram of the model is shown in Figure1.

Through the analysis of the structure of Figure 1, Figure 2-1 is improved, and the parallel thermal cycle model of electric vehicle thermal management is made by GT-SUITE software, as shown in Figure 2.

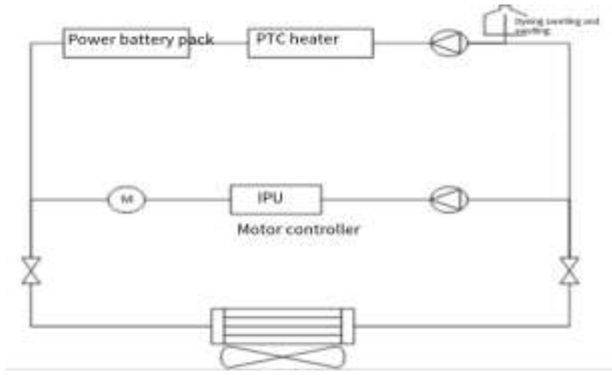

Figure. 1 General structure of parallel model

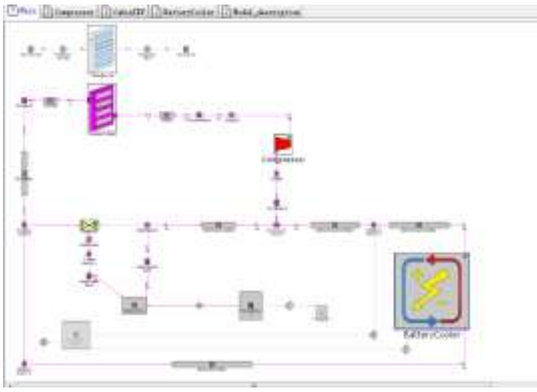

Figure. 2 Parallel model established by GT-SUITE

2.2.3 Functions and parameters of main components of the model

Compressor: The "ComPosDispRefrig" template is used for modeling, because the input of this template is relatively small, and the compressor can be modeled quickly. In the simulation process, the pid controller on the compressor will keep the outlet temperature of the evaporator at 3°C, which is also the reason why the battery cooling branch is opened and closed. In this model, the reference speed of the compressor is set to 1000RPM. The compressor model and its parameters are shown in Figure3 and Figure 4.

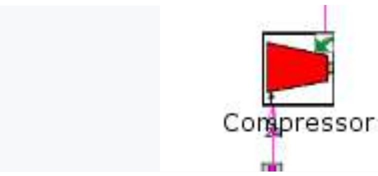

Figure.3 Compressor Model

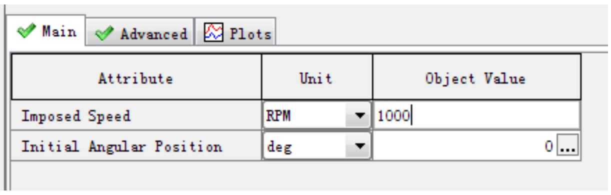

Figure.4 Compressor parameter setting

Expansion valve: The expansion valve changes the mass flow of the refrigerant by expanding or contracting the refrigerant, so as to adjust the superheat of the evaporator outlet and make the superheat within the normal range. The TXVSimpleTargetSH template is used to represent the thermal expansion valve of the cabin evaporator with the drive valve opening. The expansion valve model is shown in Figure 5.

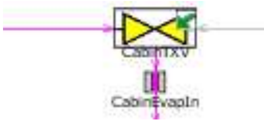

Figure.5 Expansion valve model

Condenser: The condenser is a kind of heat exchanger, which is used to discharge the heat of the air conditioning system to the outdoor air. In this structure, the refrigerant enters in the form of hot steam and is discharged in the form of cold liquid. Set the reference air flow rate to 0.7 kg/s. The condenser model and its parameters are shown in Figures 6 and 7.

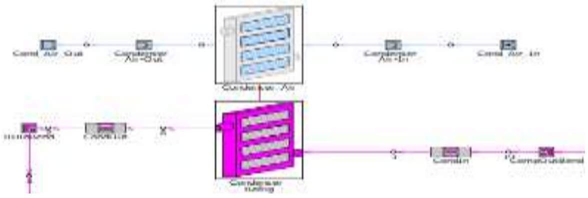

Figure.6 Condenser model

Figure.7 Condenser parameter setting

Battery: The battery cooler is modeled by a simple method, in which the thermal mass represents the total mass of the battery. It is connected to a heat pipe representing a heat exchanger. In this case, the direct evaporation of refrigerant is modeled. This allows rapid system simulation to evaluate the influence of battery cooling on the refrigerant system and its response. The heat loss of the battery is modeled by the battery template, which releases heat to the thermal mass according to the transient distribution of the required battery power. The feedback of thermal mass to the battery is given, so that the battery temperature can be known and the influence on the battery can be analyzed. In this parallel model, the reference output power of the battery is set to 300w and the initial temperature is 25℃. The battery model and its parameter settings are shown in Figure 8 .

Main | Ambient | Condenser | Receiver | Battery | AC-Circuit | TXV | HVAC | All

Parameter	Unit	Description	Case 1	Case 2
Case On/Off		Check Box to Turn Case On	☑	☐
Case Label		Unique Text for Plot Legends	NEDC-25degC_...	NEDC-25degC_...
FM_Battery		Liquid Phase Friction Multip...	100 ...	
Battery_orifice_Diameter	mm	Output 1	0.4 ...	0.45
Battery-Temp-Init	C	Initial Temperature	25 ...	
Battery_HX_HI_Mult		Liquid Phase Heat Transfer M...	20 ...	
Battery_Power	W	Constant or Dependency Refer...	3000 ...	

Figure8. Battery Structure

Event manager: The battery temperature can be controlled between 25℃ and 30℃. If the battery temperature is not within this range, the event manager can open ToBatteryBranch-1 and ToBatteryBranch-2 to let the cooling liquid flow through the battery, thus completing the thermal management of the battery. The event manager model and its parameter settings are shown in Figures 9 and 10.

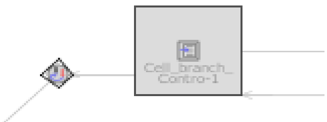

Figure. 9 Event Manager Model

Att...	Event Description	Event Exit Criterion	Next Event No.	
0				
1	temp too low ...	temp>=30 ...	2 ...	
2	temp too high ...	temp<=25 ...	1 ...	[Batt
3	...	...	...	
4	...	...	...	

Figure.10. Event Manager Parameter Settings

Motor: The motor is the power output component of electric vehicle energy. In this model, the motor power is set at 3800w W.The motor model and its parameters are shown in Figures 11 and 12.

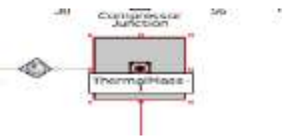

Figure. 11. Motor model

Main | Ports | Plots

Attribute	Unit	Object Value
Material Properties Object		Aluminum ...
Mass	kg	25 ...
Initial Temperature	See Ca...	[Battery-Temp-Init] ...
Source Heat Rate	W	3800 ...

Figure12. Motor parameter setting

3. PARAMETER ANALYSIS OF THERMAL MANAGEMENT MODEL OF ELECTRIC VEHICLE

Battery (Figure13):Initial temp. fixed at 25°C. Outdoor temp. (0°C/45°C) causes battery temp. to cycle between 25–30°C. Cooling accelerates at 30°C due to "event manager" activating ToBatteryBranch-1/2 for coolant flow.

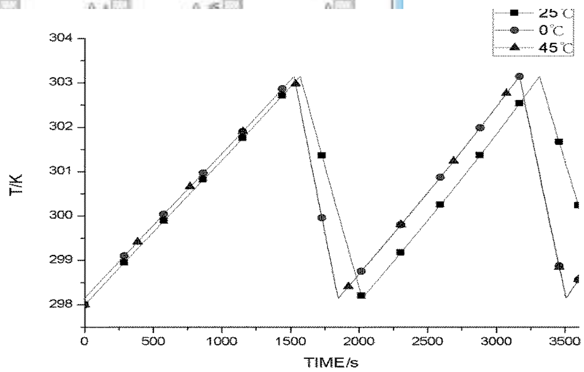

Figure.13Influence of outdoor temperature on battery heat dissipation

Motor (Figure. 14):Stabilizes at 22°C (25°C outdoor), 16°C (0°C), or 28°C (45°C). Temporary temp. spikes occur when coolant diverts to battery.

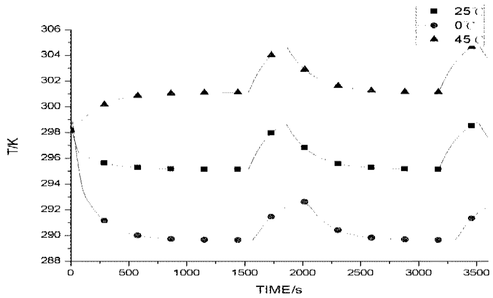

Figure.14 Influence of outdoor temperature on heat dissipation of motor

Battery (Figure.15):** Airflow (0.4–0.9 kg/s) shows negligible effect on battery temp. (25–30°C) or cooling rate due to event-controlled coolant flow.

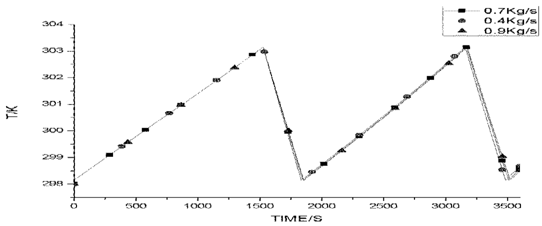

Figure.15 Influence of air flow on battery heat dissipation

Motor (Figure.16):Temp. stabilizes similarly across airflow rates, as coolant continuously cools the motor.

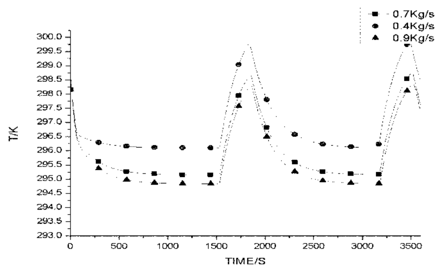

Figure.16 Influence of air flow on heat dissipation of motor

Battery (Figure.17): Higher compressor RPM (700–1500) increases cooling rate at 30°C (lower coolant temp.) but maintains 25–30°C range.

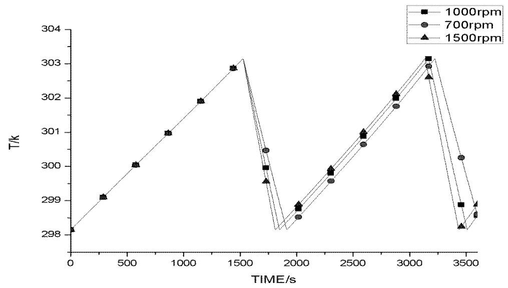

Figure.17 Influence of compressor speed on battery heat dissipation

Motor (Figure.18):Excessive RPM (1500) over-cools the motor, reducing efficiency. Optimal speed balances cooling and energy use.

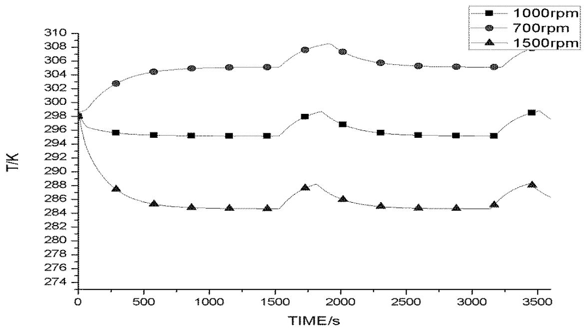

Figure.18. Influence of compressor speed on heat dissipation of motor

KeyMechanism:Event manager triggers coolant flow to battery only when temp. exceeds 25–30°C, ensuring stability. Motor cooling remains uninterrupted, explaining its steady-state behavior.

4. CONCLUSION

With rapid EV industry growth, optimal thermal management for batteries and motors is critical. Literature review of EV thermal systems, analyzing structures, components, and benchmarks.Parallel thermal management system design, including component parameters and control logic. GT-SUITE model under reference conditions (battery: 3000W/25°C; motor: 3800W; compressor: 1000rpm; airflow: 0.7kg/s; ambient: 25°C). Parametric tests varying outdoor temp. (0°C/45°C), airflow (0.4/0.9kg/s), compressor speed (700/1500rpm), battery power (5000/7000W), and initial temp. (10°C/40°C). Results show minimal impact of ambient temp., airflow, and compressor speed on battery temp. (stabilized at 25–30°C via event controller). High battery power (5000W) challenges long-term thermal stability.

5. REFERENCES

[1] Feng Li. Thermal management system development and control algorithm research of plug-in hybrid electric vehicle [D]. Jilin: Jilin University, 2016.

[2] Cui Chengwei. Integrated analysis of multi-thermal system disaster power cabin of pure electric vehicle [D]. Jilin: Jilin University, 2017.

[3] Bousbaine, W. F. Low, M. McCormick. Novel Approach Stray Load Losses in Induction Motors. Electric Power Applications, IEE Proceedings, 1996,143 (1): 78-86.

[4] Zheng Guangyong. Application of working process calculation in engine development [D]. Technical Center of FAW Group.

[5] Pan Hongda, Su Jian, Wang Jianqiang, Zhang Xiaolong, Guo Keyou, Lin Huiying hub bearing, and the discussion on the automatic detection method of loose gap of the main pin [D]. Jilin: Jilin University, 2003.