Study on Heat Management System and Control Method of Plugged Hybrid Electric Vehicle

Huizong Feng, Zhongling Lang [a] and Rongdi Yuan

School of Automation, Chongqing University of Posts and Telecommunications, Chongqing 400065, China.

[a] 1275611904@qq.com

Abstract

In order to better manage the heat of the vehicle, a thermal management system is designed for the plug-in hybrid electric vehicle [1]. The system is mainly divided into four parts: the heat pump air conditioning part, the battery cooling part, the motor cooling part and the engine heating part [2]. The integrated management of vehicle refrigeration, heating, battery and motor thermal management is integrated. Heat pump technology is adopted to recover the driving unit heat, and the refrigeration mode takes into account the battery cooling four-wheel drive hybrid vehicle integrated heat management system [3]. The cooling of the motor cooling part is divided into the front drive motor part: the cooling part of the rear drive motor of the generator IPU unit 1 front drive motor: the rear drive motor charger IPU unit [4]. The engine module has a module with an engine cooling circuit. The internal evaporator. The heating and warm air core is used as part of the internal HVAC of the air conditioning assembly. This system is in order to save energy efficiently and reduce the failure rate of the low heat system.

Keywords

Hybrid Electric Vehicle; Thermal Management; Cooling System.

1. Introduction

From now on to 2030, petroleum energy will be gradually transformed into clean energy, and new energy vehicles will certainly become an important direction of development [5]. And our country also takes the new energy vehicle as one of the main development industries.

For the plug in four wheel drive vehicle between fuel and pure electric vehicle [6], the components that need cooling will increase, and there will be cross control, and the control of cooling and heating willalso become more complex. The existing sub systems of the heat management system are relatively scattered and isolated [7], and can not effectively use the residual heat of each subsystem to carry out unified and integrated management. At present, most of the air conditioning system of hybrid electric vehicle is the use of a single refrigeration, the winter heating equipment (PTC) for cabin heating, which would lead to hybrid vehicles pure electric mileage dropped sharply [8], to achieve our goal, can not give full play to advantages of hybrid car mileage and low emissions. At the same time, when the temperature of the environment is low, the battery can not be charged and discharge normally, which makes it difficult to drive the motor.

2. Design thermal management system of hybrid electric vehicle

1. for hybrid heating, cooling and thermal management of battery and motor is relatively isolated, can not effectively unify the drawbacks of integrated management, using heat pump technology, the motor and engine waste heat utilization, taking into account the comprehensive thermal battery cooling and preheating system. In view of the structure of a four drive hybrid electric vehicle, the maximum simplification of the complexity of the system improves the heat efficiency of the heat management system.

2. because the battery is difficult to charge under the low temperature condition, it will affect the charging time, so the battery pack must be preheated before charging. The thermal management

controller preheating the battery according to the state of the charger, the actual preheating demand and the battery module temperature, taking into account the preheating and cooling of the battery, and maximizing the charging and discharging efficiency under the premise of ensuring the normal operation of the battery. When charging, the temperature of the charger is controlled reasonably according to the temperature of the charger.

3., we should define the state and switching conditions of the thermal management system. We should take into account the environmental temperature, the driving state of the vehicle and the comprehensive heating and cooling load of the heat pipe system, making the control more reasonable and efficient, and reducing the complexity of its control.

4., aiming at more cooling components of 4WD hybrid electric vehicle, and only in complex cross control, a special cooling system controller is developed to improve its control efficiency. It is of great significance for the development of the heat management system of the hybrid vehicle and the commercialization of the mass production.

2.1 Heat management system of hybrid electric vehicle

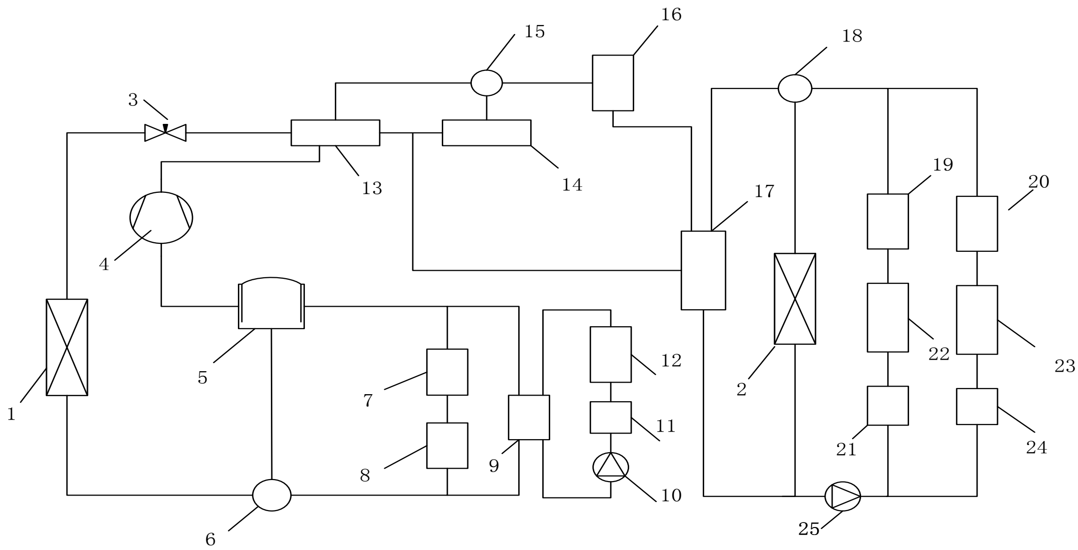

Fig. 1 Diagram of heat management system

1. external heat exchanger 1 2. external radiator 2 3. two valve 4. electric compressor 5. tank 6. three-way valve 1 7. Evaporator 8. electronic expansion valve 9. battery cooler 10. pump 1 11. heating PTC 12. battery module 13. water-cooled condenser 14. engine cooling module 15. three-way valve 2 16. pump 17. heating heater core 18. three-way valve 3 19. generator 20. rear drive motor 21 unit 1 22. IPU 23. Charger 24.IPU unit 2 25. pump

The system is divided into three parts: the heat pump air conditioning part, the battery cooling part, the motor cooling part, the engine heating part. The integrated management of vehicle refrigeration, heating, battery and motor thermal management is integrated. Heat pump technology is adopted to recover the driving unit heat, and the refrigeration mode takes into account the battery cooling four-wheel drive hybrid vehicle integrated heat management system.

The cooling part of the motor is divided into the cooling part of the front motor part: 19. generator 21 IPU unit 122., the cooling part of the rear drive motor of the front drive motor: 20. rear drive motor 23. charger 24.IPU unit.The engine module 14 represents a module with an engine cooling circuit. 7. internal evaporator 17. heating warm air core as part of the interior of the HVAC assembly.

2.2 State logic of heat management system

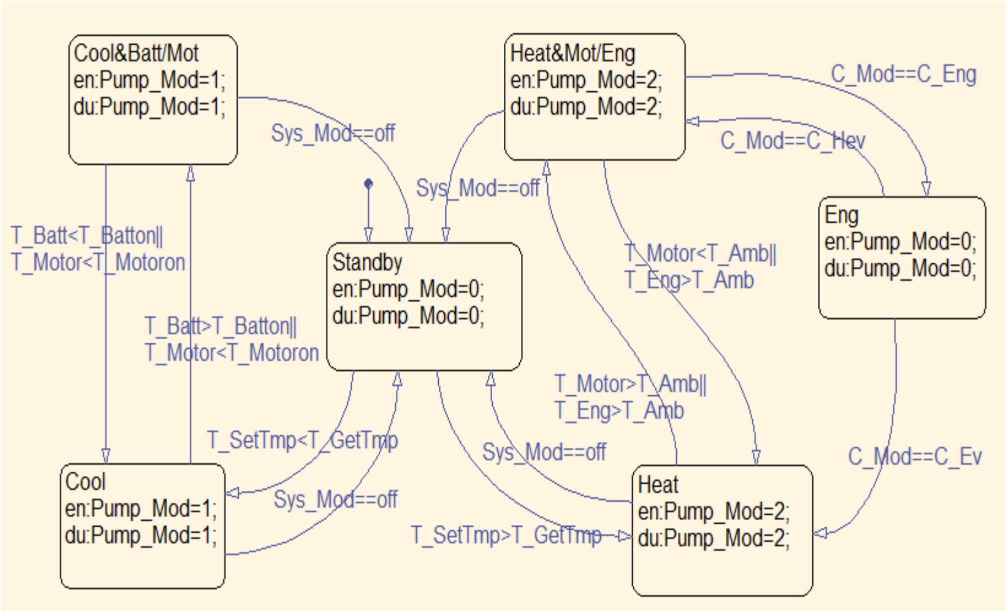

Fig. 1 State logic diagram of heat management system

The graph is the control logic state machine of the thermal management system. The state switches according to the real-time temperature of the car, the temperature of the target, the running state of the system and the driver's action. In each state, the corresponding system module is called to work to realize the corresponding requirements for the realization of the cooling and heating system.

State Description: 1. summer single refrigeration demand, motor and battery do not need cooling, only a single cooling in the car.

2., in summer, the compound refrigeration needs, when the vehicle is cooling, the battery has cooling requirements, then the battery cooling loop is started. When the current motor and the rear drive motor have refrigeration needs, the corresponding cooling circuit is opened.

3. in winter heat pump system heat, car work in the pure electricity mode, the environment temperature is low, the use of heat pump system heating. When the battery has the preheating demand, the heating PTC is opened and the battery is preheated.

4., in winter, heat pump system and heat recovery system are combined to make heat. In the heat pump cycle, the temperature of engine and motor coolant is higher than the ambient temperature, and then the heat recovery loop is opened to improve the heating efficiency.

5., the engine is single heating. When the vehicle is working in the engine mode or the heat pump system is low in the ambient temperature, the heating efficiency is low, and the heating of the engine is used to make the heating.

The 6. system has no request signal, and the system is in standby state.

State switch Description: a:TBat_in>TBat_on|| TMot_in>TMot_on, start the battery cooling circuit or start the motor cooling circuit

B: TBat_in<TBat_on|| TMot_in<TMot_on, turn off the battery cooling circuit or close the motor cooling circuit

C: TMot_in<TAmb|| TEng_in<TAmb, turn off motor waste heat recovery circuit or turn off motor waste heat recovery circuit

D: TMot_in>TAmb|| TEng_in>TAmb, starting motor waste heat recovery loop or starting engine waste heat recovery circuit

E:CMod= CMod_Eng; vehicle driving mode for engine mode

F: CMod= CMod_Ev|| CMod= CMod_Hev; motor driving mode is electric or mixed

G:CMod= CMod_Eng; vehicle driving mode for engine mode

When the ambient temperature is high in summer, the system switches from standby to refrigeration demand state.

At this time, when the passenger compartment needs cooling, the heat pump air conditioning refrigeration loop is opened. At the same time, the external heat exchanger 1 two way valve 3, the electric compressor 4 liquid storage tank 5, the internal evaporator 7 electronic expansion valve, 8 water cooled condenser 13 constitute the heat pump refrigeration cycle. The low temperature and low pressure superheated gas from the internal evaporator 7 enters the liquid storage tank 5 for gas-liquid separation. After separating the liquid, the dry superheated gas is compressed by the electric compressor 4, compressed into high temperature and high pressure gas and discharged into the outdoor heat exchanger to heat and condensate, and then become an undercooling liquid. Supercooled liquid by electronic expansion valve 8 relief after a low pressure fluid, into the indoor heat exchanger 7 evaporation gas-liquid separator, once again enter the next cycle. When the battery or motor works at high temperature, the corresponding cooling circuit is started to cool. The cooling circuit of the battery is: Battery cooler, 9 battery circuit, water pump 10, heating PTC 11, battery module 12. The cooling circuit of motor is external radiator, 2 heating core, 17 motor circuit, three-way valve, 18 generator 19, rear drive motor 20, front drive motor IPU unit 21, front drive motor 22, charger, 23 drive motor IPU unit, 24 water pump 25. The heat pump refrigeration is controlled according to the actual load of the crew cabin and the speed of the compressor is adjusted to control the temperature and air door, so as to achieve the precise control of refrigerating capacity of the cabin and meet the demand of the maximum refrigerating volume and the partial refrigerating volume.

3. Conclusion

The heat management system of hybrid electric vehicle should achieve no heat damage during running, realize the accurate design of the cooling system, design the cooling system on demand, and realize the efficient operation of the thermal management system, so we need to design and optimize the thermal management demand itself. The cooling components of the HEV thermal management system are increased, pure in complex cross control, and the subsystems are relatively independent. The invention combines heat pump technology, heat recovery, recovery of the residual heat of each subsystem and preheating of the battery, and the cooling of battery, motor and charger to realize the unified integrated heat management system.

Cooling mode of hybrid vehicle itself becomes more complex: the majority of pure electric vehicle battery for air-cooled cooling motor is used is the water cooling and cooling fan; and hybrid vehicles due to power system structure itself is relatively complex, in order to ensure the cooling effect of the battery, the cooling circuit cannot bring in specific conditions to meet the when required, can control the compressor for forced cooling, at the same time, motor control for electronic cooling fan at the same time, part of the engine, air conditioning cooling needs.

References

[1] Floyd A.Wyczalek. Heating and Cooling Battery Electric Vehicle-The Final Barrier[C].IEEE AES Systems Magazine.1993,8(11):9-14.

[2] V C. Mei. Study of solar-assisted thermoelectric technology for automobile air conditioning [J].Journal of Solar Energy Engineering,Transactions of the ASME, 1993,115:200-205.

[3] Hosoz M, Direk M. Performance evaluation of an integrated automotive air conditioning and heat pump system[J]. Energy Conversion and Management, 2006, 47(5): 545-559.

[4] Lee D Y, Cho C W, Won J P, et al. Performance characteristics ofmobile heat pump for a large passenger electric vehicle[J]. Applied Thermal Engineering, 2013, 50(1):660-669.

[5] Wei Q, Fang Zheng P,Electronics Conference Honnyong C. Trans-Z-source inverters. 2010 International Power(IPEC). 2010: 1874-1881.

[6] Beinarts, Ivars, Fuzzy logic control method of HVAC equipment for optimization of passengers' thermal comfort in public electric transport vehicles,IEEE EuroCon 2013,July 1, 2013-July 4, 2013, 1180-1186

[7] Ng,Boon Chiang,Mat Darus, Intan Z,Kamar, Haslinda Mohamed,Md Lazin, MdNorazlan and Hussein, Mohamed, Dynamic modeling of an automotive air conditioning system and an auto tuned PID controller using extremum seeking algorithm, 2013 IEEE Symposium on Computers and Informatics, ISCI 2013, April 7, 2013-April 9, 2013,92-97,2013

[8] Khayyam, Hamid, Abawajy, Jemal, Jazar, Reza N. Intelligent energy management control of vehicle air conditioning system coupled with engine, Applied Thermal Engineering, 48, 211-224, 2012.