

Test Paper of Wuhan University of Technology (A)

2018-2019 Academic Year, 1st Semester, Course: Structures and Theory of New Energy Vehicle, Closed-book Exam

Time: 120 mins, 32 class hours, 2.5 credits, Total Points: 100, Percent in final evaluation result: 60%, Date: December 2018

No.	I	II	III	IV	V	VI	VII	VIII	IX	X	Total
Full score	10	20	15	20	15	20					100
Score	10	20	15	20	15	20					73

Score 4

I. Fill in the blanks (2 points*5=10 points)

- The conventional methods of charging accumulators mainly include: constant-current charging method, variable current charging method, stepped current charging method, constant-voltage charging method, and constant voltage limit etc.
- The main methods of recovering braking energy of electric vehicles include: heat energy storage, hydraulic energy storage and electrochemical energy storage.
- The drive motors commonly used in new energy vehicles include: permanent magnet synchronous motors, AC asynchronous motors, permanent magnet brushless motors and switched reluctance motors.
- Four directions of vehicles as defined in "Made in China 2025" include: HEV, fuel-efficient vehicles, fuel-cell vehicles and intelligent and connected vehicles.
- The key technologies of electric vehicles include: battery and management technology, driving control the technology, vehicle control technology, and vehicle lightweight technology.

得分
Score

II. Single-choice questions (2 points * 10=20 points)

- What is the wrong description about SOC of batteries? (D)
 - Prevent battery from overcharge and overdischarge
 - Serve as a low-battery current limiting threshold
 - Serve as a threshold of vehicle control strategy
 - Serve as an important basis for measuring battery quality
- What's the fuel used by the positive pole of hydrogen cell? (A)
 - O₂
 - H₂
 - Methyl alcohol
 - Ni(OH)₂
- Which of the following options can be expressed as the speed characteristic of a shunt (separately) excited DC motor? (B)
 - $n = \frac{U - R_a I_a}{C_e \Phi}$
 - $n = \frac{U - 2\Delta U - 2I_a R_a}{C_e \Phi}$
 - $s = \frac{n_1 - n}{n_1}$
 - $n = n_0 + \Delta n$
- In order to obtain a high-voltage power battery, the single battery can be: (A)
 - Connected in series
 - Connected in parallel
 - Connected in series or parallel
 - None of the above
- Which of the following instruments in traditional vehicles is not installed in electric vehicles? (C)
 - Voltmeter
 - Power meter
 - Engine tachometer
 - Battery capacity indicator

11. What is the fuel cell most widely applied in fuel-cell electric vehicles? (~~D~~)

- A. AFC B. SOFC C. PAFC D. PEMFC

12. Which of the following components is excluded from the power assembly of a series hybrid electric vehicle? (~~B~~)

- A. Engine B. Generator C. Drive motor D. Control motor

13. What is the main evaluation index of vehicles' dynamic performance? (~~A~~)

- A. Starting acceleration performance and climbing performance
B. Battery performance and motor performance
C. Climbing performance and motor performance
D. Motor performance and starting acceleration performance

14. What is the function of accumulators in hybrid electric vehicles? (~~A~~)

- A. Provide auxiliary power supply for BMS
B. Transmit kinetic energy of automobiles to the accumulator through the traction motor
C. To be charged and discharged in a nonperiodic manner
D. To increase power

15. What's the wrong description about the reaction mechanism of fuel cells? (~~D~~)

- A. The chemical energy in the fuel can be converted into electric energy directly without burning.
B. The chemical energy can be converted into electric energy through electrochemical reaction.
C. In fact, it's the inverse process of water electrolysis.
D. Water will be generated and electric energy will be released through physical reaction between hydrogen and oxygen.

得分
Score

12

III. Short-answer questions (5 points * 3 = 15 points)

16. What are the main requirements of electric vehicles for power batteries? (5 points)

Answer: 1. High specific energy
2. High specific power
3. Long discharge life
4. High charge-discharge efficiency
5. Small volume and light mass.
6. Low cost and easy to manufacture.

17. What are characteristics of permanent magnet synchronous motors? (5 points)

Answer: Including stator, rotor and accessory three parts. Stator produces the magnetic field. always, current coil driving drives the rotor turning in the field, suffering the magnetic power, makes the high power and long working life.

18. What are the advantages of fuel-cell electric vehicles? (5 points)

Answer: 1. High transfer effect and good overload ability.
2. No pollution since the reaction just produces water.
3. Low noise and even no shaking.

20

IV. Fill in the blanks according to the figure (10 points*2=20 points)

use fill in the following table in combination with characteristics of power battery for electric vehicles. (2 points*5=10 points)

Table 4.1 Technical Performance of Three Kinds of Power Batteries

Technical performance	Lead acid battery	Nickel metal hydride battery	Lithium ion battery
Operating voltage (V)	about 2	1.2	3.6
Specific energy (Wh/kg)	40	65	105-140
Specific power (W/kg)	150-200	160-230	250-400
Charge and discharge life (times)	500-700	600-1200	800-1200
Self-discharge rate (%) (monthly)	3	30-35	6-9
With/without memory effect	With	With	no
With/ without pollution	With	no	no

H/O

parts
current
field

water

20. Please fill in the blanks in the figure below according to the characteristics of the series-parallel hybrid electric vehicles (PSHEV). (2 points*5=10 points)

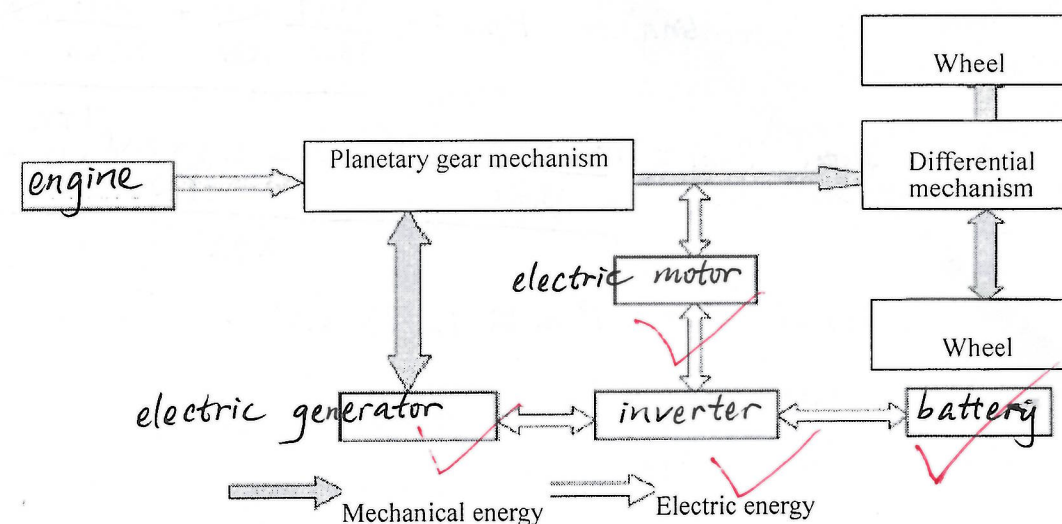


Figure 4.1 Diagram of Power Flow of PSHEV

H/O

得分
Score

V. Calculation and analysis questions (15 points*1=15 points)

21. The relevant data of a full electric vehicle are as follows:

The gross vehicle mass (m): 1,150 kg; coefficient of air resistance (C_D): 0.3; windward area (A): 2.58 m^2 ; rolling resistance coefficient (f): 0.015; transmission efficiency (η_T): 92%; tyre radius (r): 0.305 m; maximum speed ($u_{a_{max}}$): 120 km/h; overall efficiency of motor and motor controller ($\eta_m \eta_{mc}$): 90%; total voltage of power battery pack (V_b): 342 V; allowed discharge depth (DOD): 90%. It is required that when the speed (u_{a_i}) is 10 km/h, the maximum gradability (i) shall be 30%; when the speed (u_{a_s}) is 40 km/h, the mileage (S) for which the vehicle can travel at a constant speed shall be 150 km.

(1) Please work out the motor power P_{mi} (kW) required to reach the specified maximum gradability. (5 points)

SOLUTION: When the vehicle reaches the specified maximum gradability $i = 3\%$ 0.3 , $u_{ai} = 10 \text{ km/h}$
 so according to $P_{mi} = \left(\frac{mgf}{3600} u_{ai} + \frac{C_D A}{76140} u_{ai}^3 + \frac{mgi}{3600} u_{ai} \right)$

$$\text{then } P_{mi} = \frac{1150 \times 9.8 \times 0.015}{3600} \times 10 + \frac{0.3 \times 2.58}{76140} \times 10^3 + \frac{1150 \times 9.8 \times 0.3}{3600}$$

solve that $P_{mi} \approx 10.73 \text{ kW}$.

(2) Please work out the motor power P_{ms} (kW) required to make the vehicle drive at the constant speed (u_{as}) of 40 km/h. (5 points)

SOLUTION: When the speed $u_{as} = 40 \text{ km/h}$
 according to $P_{ms} = \left(\frac{mgf}{3600} u_{as} + \frac{C_D A}{76140} u_{as}^3 \right) / \eta_T$

$$\text{then } P_{ms} = \left(\frac{1150 \times 9.8 \times 0.015}{3600} \times 40 + \frac{0.3 \times 2.58 \times 40^3}{76140} \right) / 0.92$$

solve that $P_{ms} \approx 2.81 \text{ kW}$
 2.75

10

(3) Please work out the battery capacity C_b (Ah) required to enable the vehicle to travel for the specified mileage under the allowed discharge depth. (5 points)

SOLUTION: When the $S = 150 \text{ km}$, $u_{as} = 40 \text{ km/h}$,
 according to question 2, $P_{ms} = 2.75 \text{ kW}$
 Since $C_b = \frac{1000 [P_{ms} / (\eta_m \eta_{mc})] (S / u_{as})}{V_b \cdot DOD}$

then

$$C_b = \frac{1000 \times (2.75 / 0.9) \times (150 / 40)}{342 \times 0.9}$$

solve that $C_b \approx 38.4 \text{ A.h}$
 37.16

The reference formulas are as follows:

Motor power required to reach the specified maximum gradability

$$P_{mi} = \left(\frac{mgf}{3600} u_{ai} + \frac{C_D A}{76140} u_{ai}^3 + \frac{mgi}{3600} u_{ai} \right) / \eta_T$$

Motor power required to make the vehicle drive at the constant speed (u_{as}) of 40 km/h

$$P_{ms} = \left(\frac{mgf}{3600} u_{as} + \frac{C_D A}{76140} u_{as}^3 \right) / \eta_T$$

Battery capacity required to enable the vehicle to travel for specified mileage

$$C_b = \frac{1000 [P_{ms} / (\eta_m \eta_{mc})] (S / u_{as})}{V_b \cdot DOD}$$

得分
Score

六、综合论述题 (每题 20 分, 共 20 分)

VI. Comprehensive essay-type questions (20 points*1=20 points)

22. Combined with the course content of "Structure and Principle of New Energy Vehicle" and according to the development trend of key technologies of new energy vehicles at present, please discuss the following topic:

Topic: Roadmap of the development of new energy vehicles.

Requirements: 300-350 words.

I believe that the HEV should be a suitable solution, before the battery technology makes great program, especially in the stored power and mileage factors. Though traditional engine means pollution and high exhaust, it still has some advantage such as good performance in middle or high load. According the high population and needs for vehicle, the HEV could be admitted to Chinese society.

We know that the HEV includes SHEV, PHEV and PSHEV three kinds. SHEV's engine could always work in the low & good fuel economy situation, to provide power to the electronic motor, which means the vehicle do well in low speed. Although it has some problems such as high energy lost (heat to electric energy to mechanic energy), we still believe that could be solved in big bussniss vehicle, like city busses. As for PHEV, it behaves well in high speed situation. It has a SOC manage system, including start stage, low speed stage, accelerate stage, cruise stage, decelerate stage, idling and parking stage. The system could command the engine or electric motor offer power, or work together. The PSHEV, concluding the below two kinds, gains wonderful performance in both high speed and low speed situation. Although it has some negative factors like heavy structure and high cost, it might

be a pretty nice answer to city using vehicle.

We could not ignore the great advantages of pure electric vehicle, like hydrogen fuel-cell vehicle. No pollution, high transfer effect, low noise and shaking, but single kind of hydrogen fuel, hard to seal, and assist battery system. Maybe the most serious problem is the mileage and lack of offering hydrogen equipment. It still hard to find a place to add hydrogen for the vehicle no matter when or where.

Pure electric vehicle might be the top of the development, but for the last several years, the HEV should be the choice for Chinese citizens.

+18