

姓名 Name	李逸成
学号 Student ID	0121528250211
专业班级 Class	车辆工程1502
学院 School	机械工程学院

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	6	12	15	20	12	18					83

Score	6
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I. Fill in the blanks (2 points*5=10 points)

1. The conventional methods of charging accumulators mainly include: constant-current charging method, stepped current charging method, constant-voltage charging method, and constant voltage limiting current method ^{恒压限流充电法}.

2. The main methods of recovering braking energy of electric vehicles include: cooling energy storage ^{冷却储能}, hydraulic energy storage and electrochemical energy storage.

3. The drive motors commonly used in new energy vehicles include: DC motors ^{直流电机}, AC asynchronous motors, permanent magnet brushless motors and switched reluctance motors.

4. Four directions of vehicles as defined in "Made in China 2025" include: electric vehicles ^{电动汽车}, fuel-efficient vehicles, fuel-cell vehicles and intelligent and connected vehicles.

5. The key technologies of electric vehicles include: battery and management technology, 整车布置技术 ^{整车布置技术}, vehicle control technology, and vehicle lightweight technology.

得分
Score

12

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

6. What is the wrong description about SOC of batteries? (D)

- A. Prevent battery from overcharge and overdischarge
- B. Serve as a low-battery current limiting threshold
- C. Serve as a threshold of vehicle control strategy
- D. Serve as an important basis for measuring battery quality

7. What's the fuel used by the positive pole of hydrogen cell? (B)

- A. O₂
- B. H₂
- C. Methyl alcohol
- D. Ni(OH)₂

8. Which of the following options can be expressed as the speed characteristic of a shunt (separately) excited DC motor? (A)

- A. $n = \frac{U - R_a I_a}{C_e \Phi}$
- B. $n = \frac{U - 2\Delta U - 2I_a R_a}{C_e \Phi}$
- C. $s = \frac{n_1 - n}{n_1}$
- D. $n = n_0 + \Delta n$

9. In order to obtain a high-voltage power battery, the single battery can be: (A)

- A. Connected in series
- B. Connected in parallel
- C. Connected in series or parallel
- D. None of the above

10. Which of the following instruments in traditional vehicles is not installed in electric vehicles? (C)

- A. Voltmeter
- B. Power meter
- C. Engine tachometer
- D. Battery capacity indicator

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

- 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? (~~D~~)

- 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? (~~D~~)

- 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

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

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

Solution: ① high specific energy (高比能量) ⑥ low noise and pollution (低噪音, 低污染)
② high specific power (高比功率) ⑦ cost low (成本低)
③ long service life (使用寿命长) ⑧ green, environmental friendly (绿色, 环保)
④ good uniformity (均匀一致性) ⑤ good high and low temperature performance, good environmental adaptation (良好的高低温特性, 好的环境适应能力)

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

Solution: ① rotation rate: 6000-10000 r/min (转速 6000-10000 r/min) ⑥ control performance is good (控制性能好)
② the volume is small (体积小) ⑦ the structure is sturdy (结构坚固)
③ the weight is light (重量轻) ⑧ reliability is high (可靠性好)
④ the overload power can reach 300% (过载功率可达 300%)
⑤ the cost is high (成本高)

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

Solution: ① can save energy, the conversion efficiency is high (节能, 转化效率高)
② emission has basically zero pollution (排放基本无污染, 若是由碳氢转化成的氢作燃料, 生成 H₂O, CO₂, CO; 若是氮氧化合物转化成的氢作燃料, 仅生成水)
③ no vibration low noise (无振动, 噪音低, 减小了能量的损失)
④ simple structure and stable operation (结构简单, 运行稳定)

得分
Score

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

19. Please fill in the following table in combination with characteristics of power battery for electric vehicles. (2 point*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)	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 有	With	without 无
With/ without pollution	With	without 无	without 无

10

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)

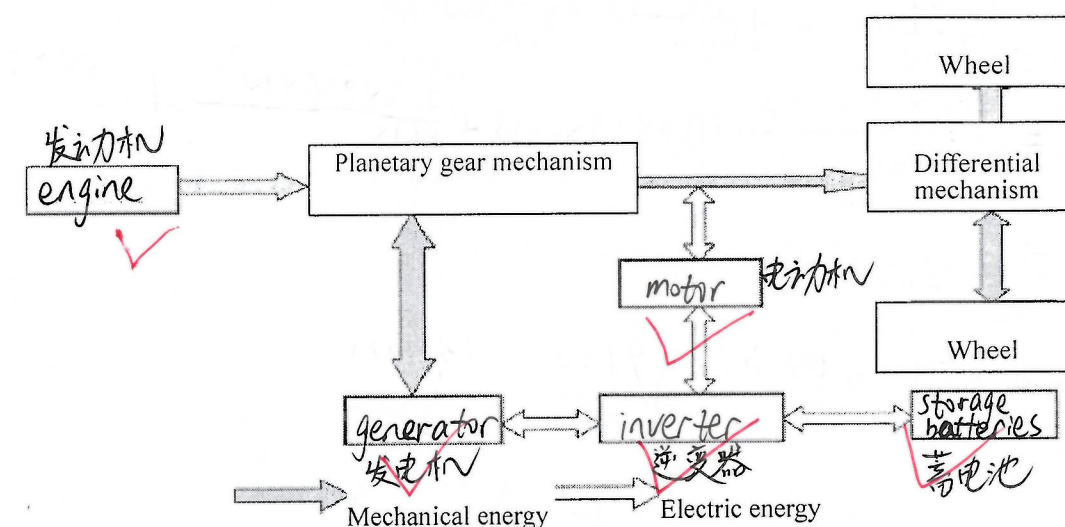


Figure 4.1 Diagram of Power Flow of PSHEV

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 m²; 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_{ai}) is 10 km/h, the maximum gradability (i) shall be 30%; when the speed (u_{as}) 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: In this condition $a=0$.

$$\begin{aligned} \text{So } P &= \left(\frac{mgf}{3600} u_{ai} + \frac{C_D A}{76140} u_{ai}^3 + \frac{m g i}{3600} u_{ai} \right) / \eta_T \\ &= \frac{10}{3600 \times 0.92} \left(1150 \times 9.8 \times 0.015 + \frac{0.3 \times 2.58 \times 10^2}{21.15} + 1150 \times 9.8 \times 0.3 \right) \text{ kW} \\ &= 10.7 \text{ kW} \end{aligned}$$

$$P_{mi} = P / \eta_{mc} = 10.7 \div 0.9 \text{ kW} = 11.9 \text{ kW}$$

(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:

$$\begin{aligned} P &= \left(\frac{mgf}{3600} u_{as} + \frac{C_D A u_{as}^3}{76140} \right) / \eta_T \\ &= \frac{u_{as}}{3600 \eta_T} \left(mgf + \frac{C_D A u_{as}^2}{21.15} \right) \\ &= \frac{40}{3600 \times 0.92} \times \left(1150 \times 9.8 \times 0.015 + \frac{0.3 \times 2.58 \times 40^2}{21.15} \right) \text{ kW} \\ &= 2.75 \text{ kW} \end{aligned}$$

$$P_{ms} = P / \eta_{mc} = 2.75 \div 0.9 \text{ kW} = 3.05 \text{ kW}$$

(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:

$$\begin{aligned} C_b &= \frac{1000 [P_{ms} / (\eta_m \eta_{mc})] [S / u_{as}]}{V_b \cdot DOD} \\ &= \frac{1000 \times 3.05 \times \frac{150}{40}}{342 \times 0.9} \text{ Ah} \\ &= 37.16 \text{ Ah} \end{aligned}$$

The reference formulas are as follows:

Motor power required to reach the specified maximum gradability

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

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.

Solution:

First of all, we need to know that, recently there are generally 3 types of new energy vehicles, they are pure electric vehicle, hybrid electric vehicle and fuel-cell battery electric vehicle. pure electric vehicle has a mature technology now, and in our daily life, we can see many EV around us. In Wuhan, many taxis also choose to use EV. Because of the support of government, EV is a little cheaper to them and they will have many advantages using an EV taxi. However, although pure EV has many advantages, but their disadvantages are deadly. It can support enough power. and the torque is small. so it can be applied in the city vehicle. but when you need strong performance of climbing or acceleration, that is not a good choice.

Then, after that, here comes the hybrid EV, that is, the HEV. It has the engine in the vehicle. There are three types of HEV. the first

one is — series. That is, only the motor to give power. The engine works through the generator and at the end, acts on the motor. Also, the storage batteries give power to the motor. whatever, only motor acts on the drive shaft. This type is widely used in the city bus, the working condition of which is not so complex. The second one is parallel, in this type, the engine and motor can separately act on the transmission, or together. For example, when you drive in a low speed and the road is flat. we only use storage batteries. when you want to have a big acceleration or climbing, the two works together. The last type is series parallel, it combines the series and parallel together. You can change the mode according to the real condition.

Finally, we come to the fuel-cell battery electric vehicle. the fuel cell battery contains 3 parts. electrode, electrolyte membrane and current collector. And this type of new energy vehicle is what we are working on. There are many problems waiting us to solve. For example. the electrolyte membrane is very expensive and not easy to get. Also, how to store the H remains a big problem. It needs a very high quality of sealing to ensure the safety. Totally speaking, the cost is really high. But apart from this problems, FCEV must be the trend of the future. The fuel is clean and nearly no pollution. Also, it has a high efficiency. Its structure is simple and can be operated stably.

As far as I'm concerned, Since many scientists are working on solving the problem of FCEV. In the future, after all problems solved, FCEV will be the most widely used vehicle in the world.

Thanks for Mr. Bin. I have learned a lot in this semester.