

Wuhan University of Technology, Examination Paper (A)

Academic Year 2018-2019 Second Semester Vehicle Design Closed Book

Time: 120minutes Credit: 5 Total Marks: 100

June 2019

Question	I	II	III	IV	V	VI	VII	VIII	Total	Teacher
Full marks	14	13	13	12	12	12	12	12	100	
Marks	14	12	6	10	11	6	10	11	80	

Marks 14

Question I Overall Design

The battery electric vehicle parameters are as follows: total vehicle mass m is 1800kg, air resistance coefficient C_D is 0.3, frontal area A is 2.8m², rolling resistance coefficient f is 0.02, transmission efficiency η_T is 90%, wheel radius r is 0.288m, the maximum vehicle speed u_{max} is 120km/h, and the acceleration of gravity g is 9.8m/s². The layout of the drive system is shown in Figure 1, where D is the differential, FG is final drive and M is the motor.

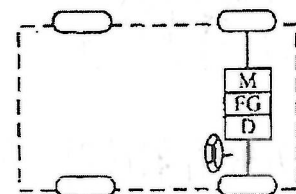


Fig. 1 Layout of Drive System for Battery Electric Vehicle

1. Please calculate the required motor power in order to achieve the maximum vehicle speed. (5 marks)

2. Please describe the name, advantages and disadvantages of its drive system layout (驱动系统布置型式). (9 marks)

$$1) F_t = F_f + F_w + F_i = C_f + \frac{C_D A u_{max}^2}{21.15} = 1800 \times 9.8 \times 0.02 + \frac{0.3 \times 2.8 \times 120^2}{21.15} = 924.7$$

$$P_e = \frac{u_{max}}{3600 \eta_T} \cdot F_t = \frac{120}{3600 \times 0.9} \times 924.7 = 34.25 \text{ kW} \cdot h$$

$$W = P_e \cdot t = 34.25 \text{ kJ}$$

2) 该车为前置前驱式
优点: (1) 具有良好的行驶特性 (2) 机动性好, 转弯半径小
(3) 地板无鼓包, 乘客舒适性好 (4) 动力总成结构紧凑
(5) 悬架结构简单 (6) 通风散热效果好
(7) 行李厢空间大 (8) 容易维修
缺点: (1) 发动机和传动系统结构复杂, 维护成本高, 难度大
(2) 高速行驶时传动系统容易发热, 接近性能, (3) 爬坡能力差。

Marks

12

Question II Clutch Design

1. Please indicate which is the push-type (推式) diaphragm spring clutch and which is the pull-type (拉式) diaphragm spring clutch in Figure 2. Please explain the reason why the pull-type diaphragm spring clutch is better than the push-type diaphragm spring clutch. (5 marks)

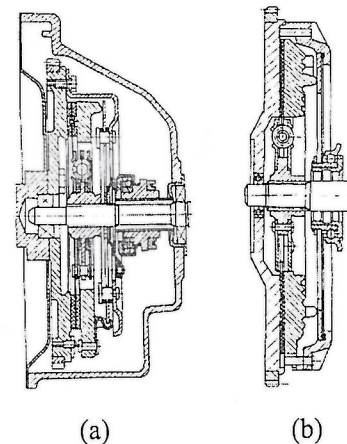
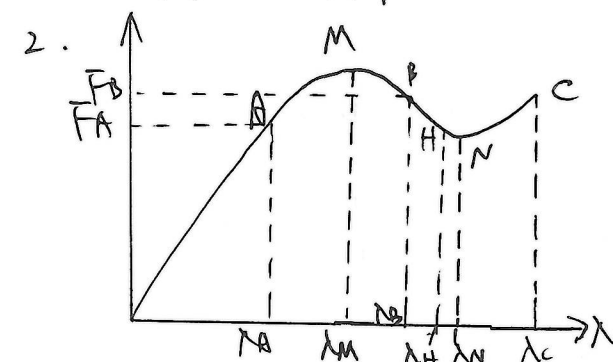


Fig. 2 Diaphragm Spring Clutch

2. Please draw the elastic characteristic curve (弹性特性曲线) of diaphragm spring, describe its advantages, and illustrate how to determine the suitable position of its working point. (8 marks)

1. (a) 为推式膜片弹簧离合器, (b) 为拉式膜片弹簧离合器。
原因: 拉式膜片弹簧离合器将膜片反装后, 同时具有弹性装置和杠杆的作用, 节省了离合器内部空间, 简化了结构。



A: 摩擦点 M: 拐点 B: 拐点
H: 膜片弹簧压平位置
N: 拐点 C: 各点

膜片弹簧离合器的优点
1) 拥有良好的非线性弹性特性, 在摩擦后摩擦力可能不会下降甚至上升, 不像普通弹性元件为线性分布, 膜片弹簧不易损坏, 寿命长。
2) 膜片弹簧受力均匀, 平衡性好。
3) 散热性好。
4) 在高速运转时运行平稳, 不受车速改变而产生较大影响。

Marks 6

Question III Transmission Design

The transmission of Jetta car is shown in Figure 3. Whether is it a two-shaft transmission or a three-shaft transmission? How many forward gears (前进挡) does it have? What kind of shift mechanism (换挡机构) is used in each gear (各挡) including reverse gear (倒挡)? Please mark the position of each gear in Figure 3 and draw the transmitting route (传动路线) of the third gear (III 挡). (13 marks)

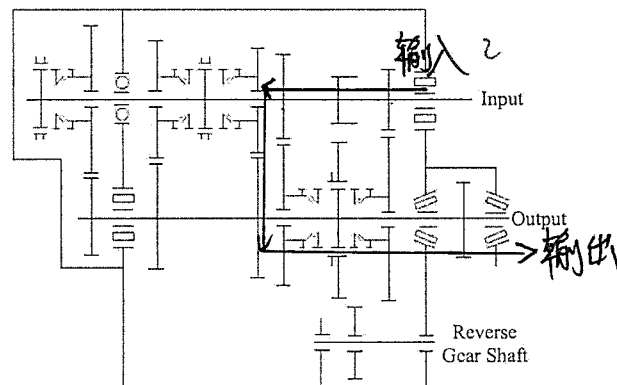


Fig. 3 Schematic Diagram of Transmission of Jetta Car

1. 该变速器为三轴式变速器，因为输入轴和输出轴不在一条直线上。
2. 有五个前进挡，在输入轴由左到右依次为 5、4、3、2、1 挡。
3. 四、五挡之间为同步器换挡，二、三挡之间为同步器换挡，一挡为啮合套换挡，倒挡为滑动齿轮换挡。
4. 三挡传动路线如图。

Marks 10

Question IV Universal Joint and Transmission Shaft Design

1. What type of universal joint (万向节) is used in Figure 4? What are the conditions for their constant speed transmission (等速传动)? (5 marks)
2. What is the critical speed (临界转速) of transmission shaft (传动轴)? How to calculate it? When the vehicle wheelbase (轴距) needs to be increased greatly, how to adjust the structure of the transmission shaft? (7 marks)

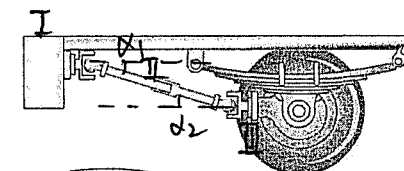


Fig. 4 Schematic Diagram of Rear Wheel Drive System

1. 图中为十字轴式万向节。三根轴名称 I、II、III 已在图中标出。等速传动的条件为 I 轴、II 轴分别与 III 轴的夹角相等。2. 即 $\alpha_1 = \alpha_2$ 时，可实现等速传动。

2. 传动轴的临界转速为传动轴在转动时，由于振动频率等于系统的固有频率，即出共振现象时，传动轴发生结构上的变形，断裂时的最大转速，即 $n_k = 1.2 \times 10^4 \sqrt{\frac{D^2 + d^2}{L^2}}$ 。一般当轴距增加，到达 1.5m 时，由于其轴距过长，容易出现轴的强度、轴承和轴的刚度不能达到要求时常将一根轴拆分为三根轴，用 2 或 4 个万向节进行连接，以保证轴的强度和轴承刚度。

Marks 11

Question V Drive Axle Design

1. Please describe the offset type (偏移类型) of the hypoid gear (双曲面齿轮) of the final drive (主减速器) in Figure 5, the helix angle direction (旋向) of the driving gear (主动齿轮) and the driven gear (从动齿轮), and the direction of the axial force (轴向力) acting on the driving gear. (4 marks)

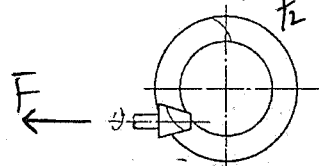


Fig. 5 Hypoid Gear Drive

2. A truck uses a friction disc type differential (摩擦片式差速器), and its locking coefficient k equals 0.6. One wheel 1 of the drive axle is on the snow-covered pavement, and its road adhesion coefficient $\varphi_{\min}$ equals 0.2. Another wheel 2 of the drive axle is on the wet concrete pavement, and its road adhesion coefficient $\varphi_{\max}$ equals 0.8. The drive axle load G_2 equals 17500N. Please calculate the maximum driving force of this drive axle. (8 marks)

1. 图中为下偏双曲面齿轮。从动齿轮为左旋，主动齿轮为右旋。
且从动齿轮旋转方向为如图方向的逆时针方向。
主动齿轮轴向力方向为由主动齿轮小端指向大端(如图)！

2. 冰面附着力: $F_1 = 175000 \times 0.5 \times 0.2 = 17500N$
湿水泥附着力: $F_2 = 175000 \times 0.5 \times 0.8 = 70000N$

$$K_b = \frac{1+k}{1-k} = \frac{1+0.6}{1-0.6} = 4$$

为转速慢的半轴力矩 T_2 与转速快的半轴力矩 T_1 的比值，
又半径相同，则 $K_b = \frac{F_{\text{湿}}}{F_{\text{冰}}}$

$$F_{\text{冰}} = F_1 = 17500N$$

$$\Rightarrow F_{\text{湿}} = 70000N$$

$$F_{\text{max}} = 17500 + 70000 = 87500N$$

Marks 6

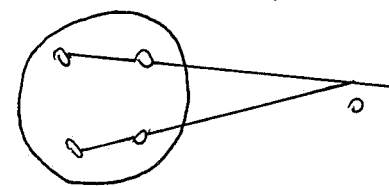
Question VI Suspension Design

1. What is the basis (依据) for choosing different guiding mechanisms (导向机构) for suspension (悬架)? (7 marks)

2. What kind of guide mechanism is usually suitable for the front suspension of ordinary car? Explain the reason. (5 marks)

1. 前悬架
- ① 悬架上载荷增加时，轮距变化不超过 $\pm 4mm$ ，防止轮胎早期磨损。
 - ② 悬架上载荷增加时，车轮侧偏角变化特性不大。
 - ③ 转弯和加速时应有抗侧倾和抗后仰。
 - ④ 前轮侧倾角与车身侧倾角方向相同，以增加不足转向。
- 后轮
- ① 悬架上载荷增加时，轮距几乎无变化。
 - ② 后轮侧倾角与车身侧倾角方向相反，以减少过多转向。

2. 通常选用不等长双横臂式悬架或麦弗逊式悬架。
因为不等长双横臂将上横臂缩短为点即麦弗逊结构，
此车结构可由侧倾中心，不易形成制动点头现象。



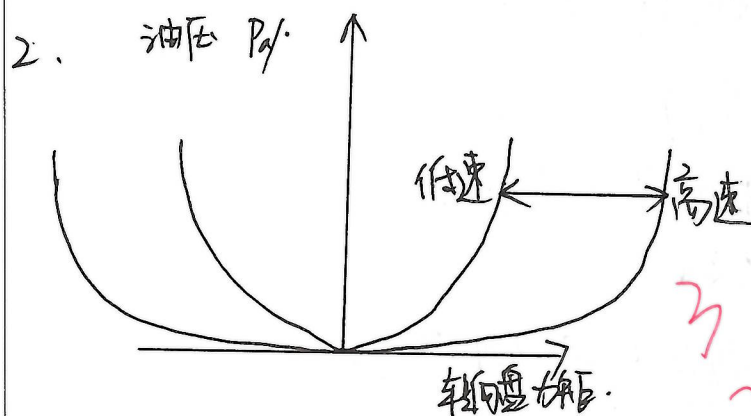
Marks

10

Question VII Steering Gear Design

1. According to the reverse efficiency (逆效率) of steering gear (转向器), what are three kinds of steering gear? (3 marks)
2. How to design the power assisting characteristics (助力特性) of power steering system (动力转向系统), in order to achieve enough steering portability (轻便性) at low speed and good road feeling (路感) at high speed? (9 marks)

1. 分为可逆转向器、不可逆转向器和极限可逆转向器。



根据如图曲线设计动力转向系统的助力特性, 可知汽车在低速转向时更为轻便, 高速转向时需更大的转向盘转矩, 即可产生更明显的路感。

Marks

11

Question VIII Brake Design

1. What are the advantages and disadvantages of disc brakes compared to drum brakes? (6 marks)
2. What is the brake efficiency factor (制动器效能因数)? Please compare the brake efficiency factor and its stability of disc brakes and drum brakes. (6 marks)

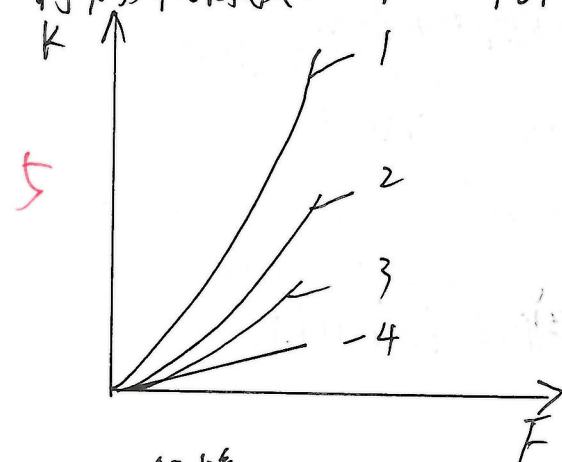
1. 盘式制动器相对于鼓式制动器

优点: (1) 制动效能稳定性好 (2) 热稳定性好 (3) 水稳定性好 (4) 制动力随前进或倒车变化不大 (5) 摩擦更均匀, 磨损小 (6) 磨损均匀, 且损失小, 寿命长 (7) 制动踏板力受车速影响小 (8) 散热更好

缺点: (1) 制动盘和制动钳外露, 易腐蚀

(2) 制动效能差

2. 制动效能因数为 $K = \frac{M_u}{F_o R}$



1 - 双领蹄

2 - 3 领蹄

4 - 盘

鼓式制动器具有较大的制动效能因数, 同时双领蹄对领蹄, 盘式制动器制动效能较差, 但制动效能稳定性好, 因而被广泛使用。