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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	12	6	3	9	12	5	9	12	68	

Marks	12
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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.

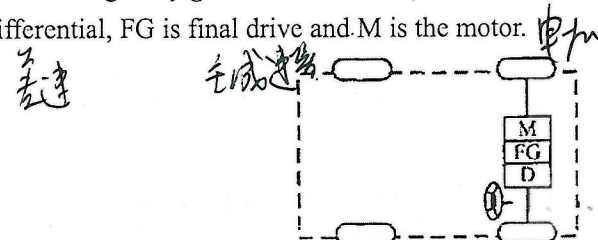


Fig. 1 Layout of Drive System for Battery Electric Vehicle

- Please calculate the required motor power in order to achieve the maximum vehicle speed. (5 marks)
- Please describe the name, advantages and disadvantages of its drive system layout (驱动系统布置型式). (9 marks)

$$P = \frac{u_{max}}{3600 \cdot \eta_T} \left(mgf + \frac{C_D A u_{max}^2}{21.5} \right)$$

$$= \frac{120 \text{ km/h}}{3600 \cdot 0.9} \left(1800 \cdot 9.8 \cdot 0.02 + \frac{0.3 \cdot 2.8 \cdot (120 \text{ km/h})^2}{21.5} \right)$$

$$= 151.7 \text{ kW}$$

2. 前置前驱 (FF)

优: 1. 结构紧凑, 尺寸小

2. 电机, 主减速器, 差速器连在一起, 无传动轴, 乘坐舒适性增加

3. 前轴载荷大, 增加不足转向性

4. 乘客舱有更大空间 (还有储物空间)

5. 若采用前置发动机, 可将双曲面齿锥齿轮换为斜齿圆柱齿轮, 节约成本

缺点: 1. 爬坡时, 后轮附着力不足
2. 制动时, 重心前移, 后轮制动力不足, 易抱死
3. 维修电机时, 接近差速器

Marks

6

Question II Clutch Design

- 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)

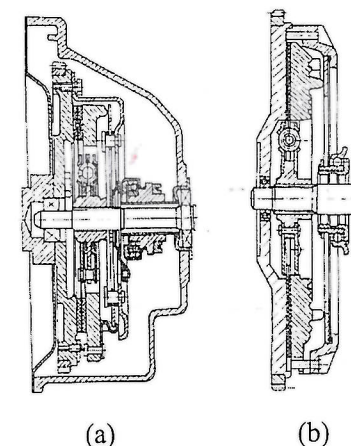
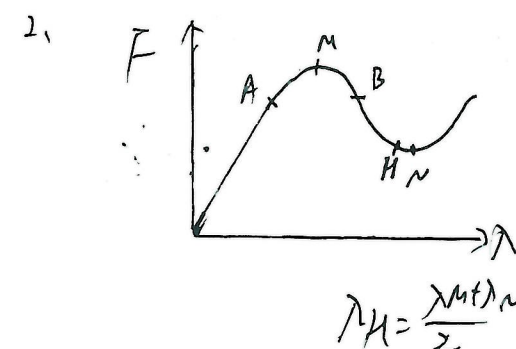


Fig. 2 Diaphragm Spring Clutch

- 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)

- (a) 为推式, (b) 为拉式
- 原因: 1. 膜片弹簧反力大, 简化结构, 安装方便
2. 不像推式, 环状结构受压, 会增大变形与噪声
3. 转矩容量比推式大 30%-50%
4. 盖变形小, 分离效率高



A 为磨损点, B 为工作点
M 为拐点, N 为拐点
 $\frac{\lambda_B}{\lambda_H} = 1.05$

M 为弹簧平衡点

Marks	3
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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)

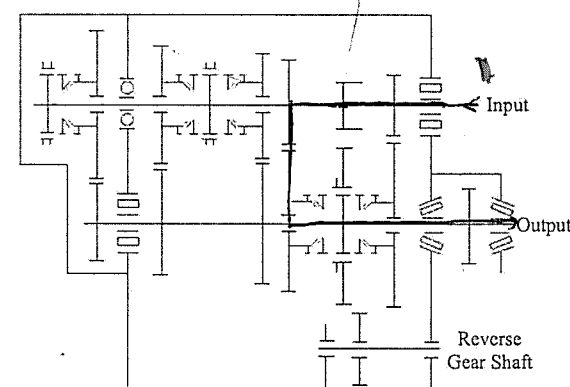


Fig. 3 Schematic Diagram of Transmission of Jetta Car

为2轴式变速器; 5个前进挡
结合套进行换挡

Marks	9
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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)

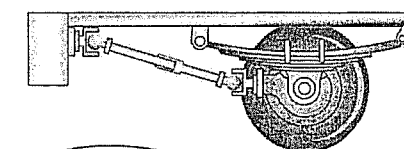


Fig. 4 Schematic Diagram of Rear Wheel Drive System

1. 纵臂式万向节;

同轴的2个万向节在同一平面且2个万向节夹角相等 4

2. 传动轴转速达到(接近)本身固有频率, 引起共振, 使振动突然增大, 引起传动轴断裂的转速

$$n_k \approx 2 \times 10^8 \frac{\sqrt{D^2 d^4}}{L}$$

5

增大传动轴的内径与外径

Marks 12

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)

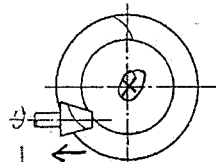


Fig. 5 Hypoid Gear Drive

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 $\phi_{\min}$ equals 0.2. Another wheel 2 of the drive axle is on the wet concrete pavement, and its road adhesion coefficient $\phi_{\max}$ equals 0.8. The drive axle load G_2 equals 17500N. Please calculate the maximum driving force of this drive axle. (8 marks)

1. 上偏移, 左旋(大齿轮), 右旋(小齿轮)

$$2. F_{Z1} = F_{Z2} = \frac{G_2}{2} = \frac{17500N}{2} = 8750N$$

$$\text{轮1 } F_{1\max} = F_{Z1} \cdot \phi_{\min} = 8750N \cdot 0.2 = 1750N$$

$$\text{轮2 } F_{2\max} = F_{Z2} \cdot \phi_{\max} = 8750N \cdot 0.8 = 7000N$$

$$k_b = \frac{1 + \frac{b}{a}}{1 - \frac{b}{a}} = \frac{1 + \frac{1}{4}}{1 - \frac{1}{4}} = 4 = \frac{F_2}{F_1}$$

刚好同时达到最大附着力

$$F_{\max} = F_{1\max} + F_{2\max} = 8750N$$

Marks 5

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) 前轮: 1. 悬架载荷变化时, 前轮定位参数有适当变化, 无过大的纵向加速度
2. 悬架载荷变化时, 轮距变化小, 小于等于4mm
3. 制动加速, 无明显前俯与后仰。
4. 汽车以0.4g做定圆运动, 车身侧倾角 $\leq 7^\circ$, 车轮与车身侧倾角一致
后轮: 1. 悬架载荷变化时, 轮距无变化
2. 汽车以0.4g做定圆运动, 车身侧倾角与车身侧倾角相反

(2) 不等长双横臂

满足前轮侧倾角变化 $\pm 10^\circ$, 使车轮侧倾角在40mm内。

在悬架载荷变化时, 车距变化小于4mm

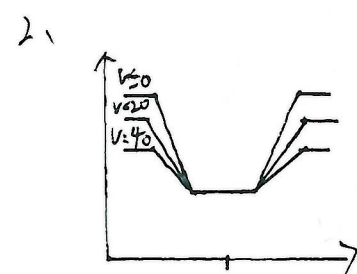
满足其余前轮导向机构要求

Marks 9

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. 可逆转向器, 不可逆转向器, 极限可逆转向器



在速度为0时, 助力最大
随着速度的增大 助力减小

$$i_p = i_{w0} \cdot \frac{F}{2a}, \quad i_p = \frac{2Fw}{F} \quad F_w \text{ 为车轮上的力}$$

$$i_{w0} = \frac{d\varphi}{d\beta} \quad F \text{ 为转向盘上的力}$$

轻便性为 F 的大小; 路感为 $d\beta$ 的大小

Marks 12

Question VIII Brake Design

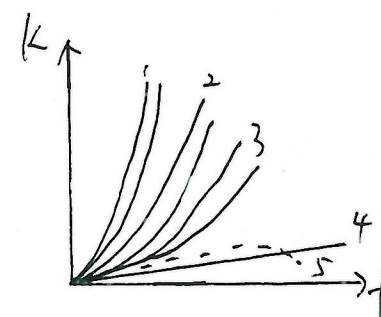
1. What are the advantages and disadvantages of disc brakes compared to drum brakes? (6 marks)
2. What is the brake efficiency factor (制动器效能因数)? Please compare the brake efficiency factor and its stability of disc brakes and drum brakes. (6 marks)

- 优点: 热稳定性好
水稳定性好
不易污染路面
制动效率高
制动稳定性高
可承受更高摩擦力矩
- 缺点: ① 结构复杂
② 易污染路面
③ 制动效率低

1. 制动效能因数: 为制动器输入力矩与输出力矩之比

6

1, 2, 3, 5 为鼓式制动器
4 为盘式制动器



制动稳定性就是 $dK/d\beta$ 的大小, 显然盘式制动器制动力稳定性优于鼓式制动器