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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	9	7	10	5	0	1	4	48	

Marks 12

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 2.8m^2 , rolling resistance coefficient f is 0.02, transmission efficiency η_T is 90%, wheel radius r is 0.288m, the maximum vehicle speed $u_{a\max}$ is 120km/h, and the acceleration of gravity g is 9.8m/s^2 . 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.

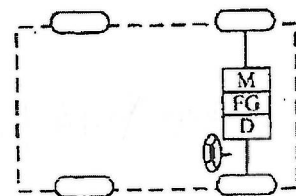


Fig. 1 Layout of Drive System for Battery Electric Vehicle

- 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)

Solution: $F_{\max} = F_w + F_i + F_j + F_t =$

$P = \frac{F_{\max}}{V_{\max}} = 135\text{ kW}$

2) 如图所示为前置前驱, 其优点为:

- ① 发动机、离合器、主减速器、差速器均在一根轴上, 不需要传动轴穿过乘客区, 保证乘客的舒适性, 使空间布置良好。
- ② 节省空间
- ③ 发动机前置时, 不足转向量增大, 操纵稳定性好。
- ④ 主减速器的螺旋锥齿轮可换成斜齿圆柱齿轮, 节省成本, 此费用可抵消万向节前置的费用
- ⑤ 行李舱和驾驶舱容易变形, 空间大。

缺点: ①

Marks 9

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)

Solution: 图(a)为推式, 图(b)为拉式

2. 拉式离合器的膜片反装, 有利于支撑作用, 且利于膜片弹簧的安装和更换, 而推式离合器的支撑柱磨损后与膜片弹簧的距离增大, 从而增大空行程和噪音。此后, 拉式离合器的压紧力更大, 扭矩容量比推式多30%-50%, 离合器盖变形小, 恢复效率高, 故拉式比推式更好。

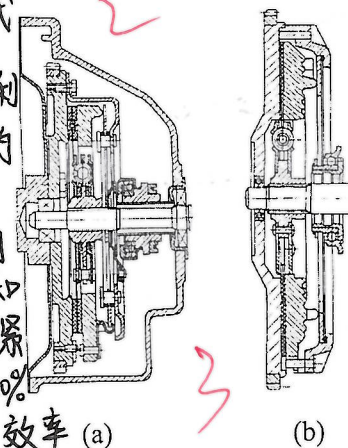
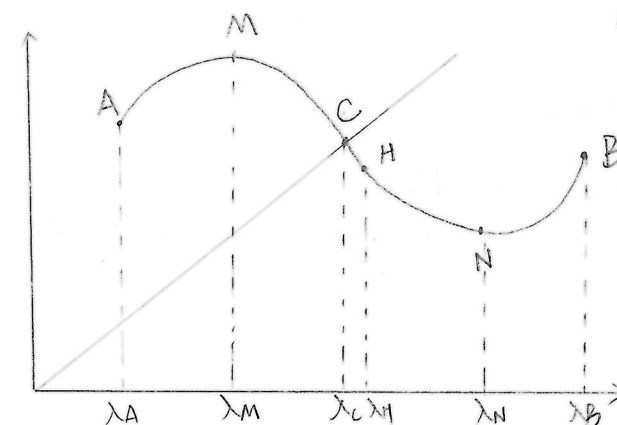


Fig. 2 Diaphragm Spring Clutch

- 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)

Solution:



A: 磨损点
H: 膜片弹簧的压平位置也是拐点
B: 分离点
C: 新离合器接合状态, 膜片弹簧工作点

优点: 分离快速, 接合柔和。

Marks	7
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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)

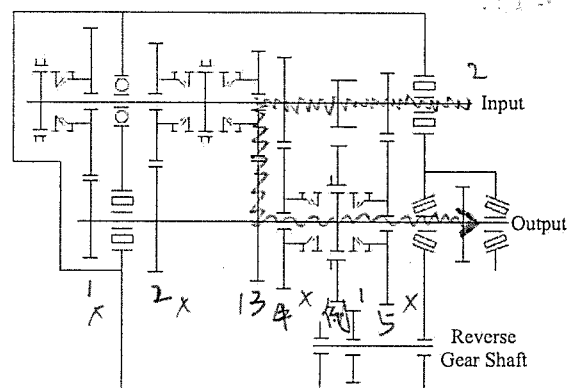


Fig. 3 Schematic Diagram of Transmission of Jetta Car

Solution: 两轴式

共5个前进挡

滑动齿轮式 —— 倒挡

啮合套式 —— 1, 2, 3, 4, 5 挡

Marks	10
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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)

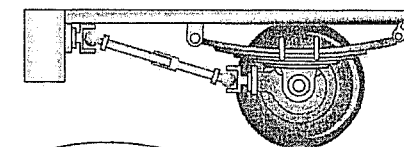
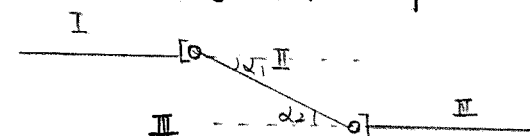


Fig. 4 Schematic Diagram of Rear Wheel Drive System

Solution: 1. 十字轴式万向节



输入轴I与输出轴II被包含在I, II轴轴线所在平面内时, 由公式

$$\frac{\tan \gamma_3}{\tan \gamma_1} = \frac{\cos \alpha_2}{\cos \alpha_1}$$

当 $\alpha_1 = \alpha_2$ 时, 必有 $\gamma_1 = \gamma_3$, 此时输入轴I与输出轴II等速传动

2. 临界转速: 当转速极大, 以至于传动轴产生共振断裂时, 此时的转速即为临界转速。

$$n_k = 2.16 \times 10^8 \times \frac{\sqrt{F_1^2 + F_2^2}}{T^2}$$

当轴距变化大时, 应调整为可调式传动轴万向节组合式万向节。

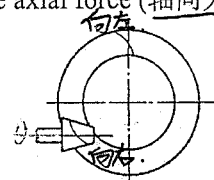
Marks	5
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Question V Drive Axle Design

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)

Solution: 下偏移 ×

主动齿轮旋向向左, 从动
齿轮旋向向右. ×



轴向力方向: 从纸内指向纸外. ×

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 175000N. Please calculate the maximum driving force of this drive axle. (8 marks)

$$F_1 = 175000 \times 0.5 \times 0.2 = 17500 \text{ N} \cdot 2$$

$$F_2 = 175000 \times 0.5 \times 0.8 = 70000 \text{ N}$$

由于各轴半径相同. $k_b = \frac{1+k}{1-k} = \frac{1+0.6}{1-0.6} = 4 \cdot 2$

$$F_{\max} = F_b + F_s = F_1 + F_2 \times k_b = 17500 + 70000 \times 4 = 297500 \text{ N} \cdot x$$

Marks	10
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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)

前悬架.

Solution: 1. 选择导向机构的依据: ① 传递力的方式, 发动机的位置及驱动轮的位置. ② 车辆类型, 座位数以及载重量. ③ 悬架的类型, 如 II 型, X 型, LL 型, HH 型及 HL 型.

2. 哪种导向机构更适合同前悬架? 为什么?

X 型更合适, 因为两边导向平衡, 可以避免受力不均衡的情况.

Marks

1

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)

Solution: 1. 根据转向器逆效率, 转向器有多少种类型?
2. 如何设计转向系统的助力特性, 来满足轻便性和路感?

1. 齿轮齿条式.
 - 滚珠式
 - 蜗杆
 - 蜗杆直轴
 - 其他

2. 在设计助力特性时, 由于小转向与大转向更多, 所以中间部分的磨损更大, 故设计时要考虑间隔, 保证稳定性, 同时保持良好路感。

Marks

4

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)

盘式 → 鼓式 优缺点.

制动效能因数.

Solution: 4 缺点: 1.
优点 1. 热效率高
2. 水效率高
3. 更加稳定
4. 制作简单, 成本低
5. 与传统结构更搭, 应用广泛
6. "路感"更好
7. 更加灵敏, 反应迅速
8.

2. 传动轴传递发动机最大扭矩的可靠程度.

制动效能因数必须大于1.