

14.

试卷装订线
装订线内不要答题，不要填写考生信息
试卷装订线

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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	14	13	12	11	12	5	12	11	90	

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.

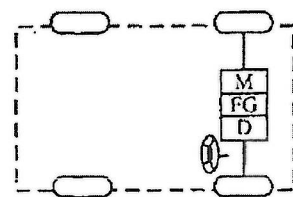


Fig. 1 Layout of Drive System for Battery Electric Vehicle

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)

解: 1. $P_{max} = \frac{u_{max}}{3600\eta_T} (mgf + \frac{C_D A}{21.15} u_{max}^2)$
 $= 34.25 \text{ kW}$

最大功率应不低于 34.25 kW.
 2. 该车为发动机前置前驱式轿车。优点有: ①前轴负荷较大, 有利于增大不足转向趋势。②前轮为驱动轮, 越障能力较强。③变速器与主减速器等都布置在同一壳体内, 结构紧凑。④操纵机构简单。⑤不需要传动轴, 整车质量较小。⑥无传动轴, 车厢内地板无凸起, 可提高乘坐舒适性等。缺点有: ①前轮驱动, 爬坡能力较弱。②前轴负荷大, 轮胎磨损严重。

Marks 13

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)

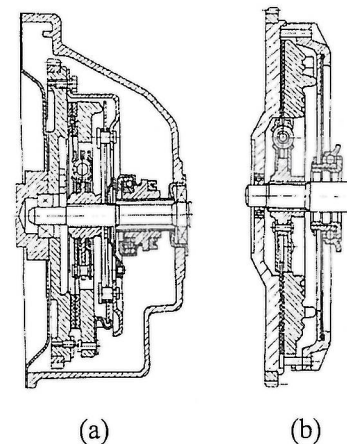
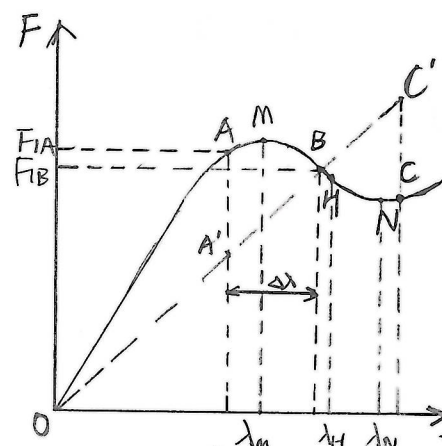


Fig. 2 Diaphragm Spring Clutch

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)

解: 1. (a) 为推式膜片弹簧离合器, (b) 为拉式膜片弹簧离合器。
 拉式优点: ①不需要中间支撑, 结构简单, 轴向尺寸小。②杠杆比较大, 可减轻驾驶员踏板力。③离合器盖变形小, 分离效率高。

2. 如下图所示。



OMN 曲线为膜片弹簧弹性特性曲线
 OAC' 为螺旋弹簧弹性特性曲线

M、N 分别为极值点, H 为拐点。
 且变形量 $\lambda_H = (\lambda_m + \lambda_n)/2$

离合器工作点应尽可能靠近 H 点。

取 $\lambda_B = (0.8 \sim 1.0) \lambda_H$

新膜片弹簧离合器工作点应靠近 B 点。

① C 点是踩下离合器踏板, 分离后所压点。

由图可知踏板力在减小, 即驾驶员

踏踏更轻松。相较于螺旋弹簧, 则需

很大的踩踏力。②当摩擦片有一定的

磨损 $\Delta\lambda$ 后, 膜片弹簧的张紧力变化状

甚至增加, 即摩擦片与飞轮啮合仍较紧, 相

较于 A' 点, 张紧力变化很大, 不采用。这时

踩下踏板, 所需踏板力变化不大, 甚至减小,

更加轻松, 这就是膜片弹簧优点所在。

Marks	12
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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)

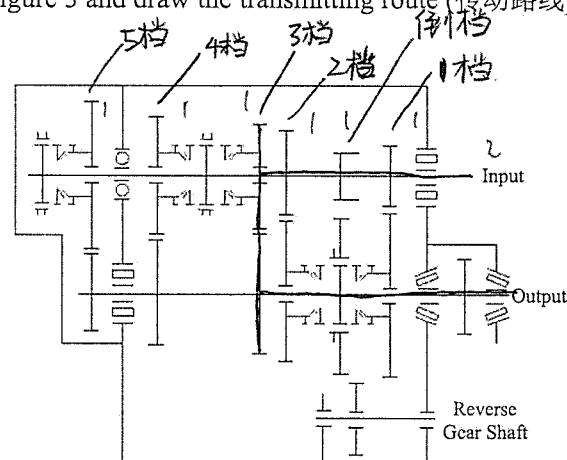


Fig. 3 Schematic Diagram of Transmission of Jetta Car

解: ① 该图所示为两轴式变速器。

② 一共有5个前进挡。

③ 1挡与2挡之间, 以及倒挡, 用的是直齿圆柱主齿轮换挡。
3挡与4挡之间, 以及5挡, 用的是同步器换挡。

④ 1-5挡以及倒挡位置如图标示。

当同步器拨至3挡, 输入轴转动带动3挡主动齿轮, 主动齿轮带动从动齿轮 (从动轴), 然后动力由从动轴输出, 动力传递路线如图示。

Marks	11
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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)

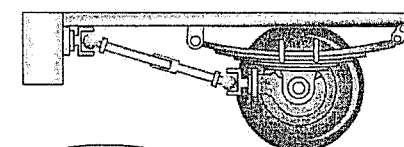


Fig. 4 Schematic Diagram of Rear Wheel Drive System

解: 1. 图示所用为球笼式万向节。
等速传动条件如下图(a), (b)所示。



当万向节相连传动轴所在轴线在同一平面内时, 满足 $\alpha_1 = \alpha_2$ 的以上两种情况, 即可实现等速传动。

2. 临界转速 $n_k = 1.2 \times 10^8 \frac{\sqrt{D_c^4 + d_c^4}}{L_c}$ 式中 L_c 为两向节间传动轴长度。

D_c 、 d_c 分别为传动轴的外径与内径。

临界转速是指该传动轴所能承受的最高转速, 超过该转速则传动轴强度会破损。

当轴距需迅速增大时, 可考虑采用中间支撑的形式将该传动轴分为两个或三个传动轴。

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)

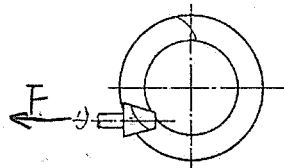


Fig. 5 Hypoid Gear Drive

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

解: 1. ①该偏齿属于上偏齿。

②主动齿轮旋向为右旋! 从动齿轮为左旋。

③主动齿轮轴力方向如图所示。

2. 轮1的最大附着力为 $F_{1\max} = \phi_{\min} \cdot \frac{G_2}{2} = 17500 \text{ N}$ 。

轮2的最大附着力为 $F_{2\max} = \phi_{\max} \cdot \frac{G_2}{2} = 70000 \text{ N}$ 。

$k = 0.6$

$k_b = \frac{1+k}{1-k} = 4$ 。而 $k_b = \frac{T_2}{T_1} = \frac{F_2}{F_1}$

即轮2驱动力最高为轮1的4倍。

当 $F_{1t} = F_{1\max} = 17500 \text{ N}$ 。

$F_{2t} = 4F_{1t} = 70000 \text{ N} = F_{2\max}$ 。可达到。

所以驱动桥可发出最大驱动力 $F_t = F_{1t} + F_{2t} = 87500 \text{ N}$ 。

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)

解: 1. 对于前独立悬架的设计要求。

①. 车轮载荷变化时, 要求左右车轮的车距变化不超过 $\pm 40 \text{ mm}$ 。

②. 车轮载荷变化时, 要求车轮定位参数发生适应性的变化。

③. 当车轮转向, 要求车辆侧倾角与车轮外倾角方向相同, 以增加不足转向。

④. 制动时, 有抗前俯作用, 加速时, 有抗后仰作用, 对后独立悬架的设计要求。

①. 车轮载荷变化时, 要求左右车轮的车距不发生太大变化。

②. 车轮转向时, 要求车辆侧倾角与车轮外倾角方向相反, 以减少过多转向。

2. 双横臂独立悬架, 因为双横臂独立悬架可以调节侧倾中心高度, 以满足设计中车轮转向的一些要求。

Marks

12

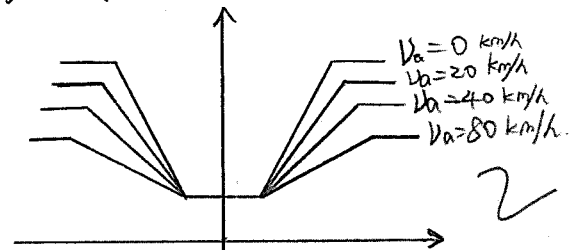
Question VII Steering Gear Design

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)

解: 1. 分为 ①不可逆式转向器 ②完全可逆式转向器 ③临界可逆式转向器

2. 应该设计成车速感应型助力系统, 如下图所示



横坐标表示转向盘施加的力矩。

纵坐标表示助力系统的助力力矩。

当车速较低时, 随着转向盘的转动, 助力系统的助力力矩上升很快, 从而实现转向轻便的特点。

当车速很高时, 助力系统的助力力矩较小, 转向所需力矩较大。

从而让驾驶员更好地感知路面的状况。

Marks

11

Question VIII Brake Design

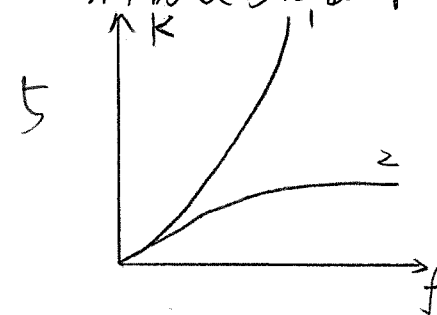
1. What are the advantages and disadvantages of disc brakes compared to drum brakes? (6 marks)

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)

解: 1. 优: ①热稳定性好 ②水稳定性好 ③制动钳受力较均匀, 且受力情况不会随车轮转向而改变。

缺: ①制动钳的磨损较严重, 且需要高材质的材料 ②无法消除制动间隙 ③成本高。

2. 制动效能因数 $K = \frac{M_a}{F \cdot R}$



曲线1为鼓式制动器。

曲线2为盘式制动器。

评价制动稳定性用 $\frac{dK}{df}$, 显而易见。

盘式制动器的制动效能更加稳定。