

设计计算及说明	结果						
一、设计任务书 <p>1.1 传动方案示意图</p> <p>图一、传动方案简图</p>							
<p>1.2 原始数据</p> <table border="1"> <tr> <th>传送带拉力 F(N)</th> <th>传送带速度 V(m/s)</th> <th>滚筒直径 D (mm)</th> </tr> <tr> <td>2500</td> <td>1.6</td> <td>280</td> </tr> </table>	传送带拉力 F(N)	传送带速度 V(m/s)	滚筒直径 D (mm)	2500	1.6	280	
传送带拉力 F(N)	传送带速度 V(m/s)	滚筒直径 D (mm)					
2500	1.6	280					
<p>1.3 工作条件</p> <p>三班制，使用年限为 10 年，连续单向于运转，载荷平稳，小批量生产，运输链速度允许误差为链速度的±5%。</p>							
<p>1.4 工作量</p> <ol style="list-style-type: none"> 1、传动系统方案的分析； 2、电动机的选择与传动装置运动和动力参数的计算； 3、传动零件的设计计算； 4、轴的设计计算； 5、轴承及其组合部件选择和轴承寿命校核； 6、键联接和联轴器的选择及校核； 7、减速器箱体，润滑及附件的设计； 8、装配图和零件图的设计； 9、设计小结； 10、参考文献； 							
<p>二、传动系统方案的分析</p> <p>传动方案见图一，其拟定的依据是结构紧凑且宽度尺寸较小，传动效率高，适用于恶劣环境下长期工作，虽然所用的锥齿轮比较贵，但此方案是最合理的。其减速器的传动比为 8-15，用于输入轴于输出轴相交而传动比较大的传动。</p>							
<p>三、电动机的选择与传动装置运动和动力参数的计算</p>	结果						

设计计算及说明	
3.1 电动机的选择	
1 、电动机类型选择: 选择电动机的类型为三相异步电动机, 额定电压交流 380V。	
2 、电动机容量选择:	
(1) 工作机所需功率 $P_w = FV / 1000 \eta_{\omega}$	
F— 工作物阻力	$F=2500N$
v— 工作物线速度	$V=1.6m/s$
— η_{ω} 工作物效率可取 0.96	
(2) 电动机输出功率 P_d	
考虑传动装置的功率损耗, 电动机的输出功率为	
$P_d = P_w / \eta_a$	
η_a 为从电动机到工作机主动轴之间的总效率, 即	
$\eta_a = \eta_1^4 \eta_2 \eta_3 \eta_4^2 \eta_5 = 0.833$	$\eta_a = 0.833$
η_1 —滚动轴承传动效率取 0.99	η_2 —圆锥齿轮传动效率取 0.95
— η_3 圆柱齿轮传动效率取 0.97	— η_4 联轴器效率取 0.99
η_5 —卷筒效率取 0.96	
$P_d = FV / 1000 \eta_{\omega} \eta_a = 2500 \times 1.6 / 1000 \times 0.96 \times 0.833 = 5kW$	$P_d = 5kW$
(3) 确定电动机的额定功率 P_{ed}	
因载荷平稳, 电动机额定功率 P_{ed} 略大于 P_d 即可。所以可以暂定电动机的额定功率为 5.5Kw。	$P_{ed} = 5.5kW$
3 、确定电动机转速	
卷筒工作转速	
$n_w = 60 \times 1000V / \pi D = 60 \times 1000 \times 1.6 / 3.14 \times 280 = 109.2r/min$	n_w
由于两级圆锥-圆柱齿轮减速器一般传动比为 8-15, 故电动机的转速的可选范围为	$= 109.2 r/min$
$n_{d1}' - n_{d2}' = (8-15) n_w = 873.6 - 1638r/min.$	
可见同步转速为 1000r/min , 1500r/min 的电动机都符合, 这里初选同步转速为 1000r/min , 1500r/min 的两种电动机进行比较, 而转速越高总传动比越大传动装置的结构会越大, 成本越高。所以应综合考虑电动机和传动装置的尺寸、重量、价格及总传动比。	

设计计算及说明						结果
表 2 电动机方案比较表 (指导书 表 19-1)						
方案	电动机型 号	额定功率 (kw)	电动机转速 (r/min)		电动机 质量 (kg)	传动装置 总传动比
			同步	满载		
1	Y132M2-6	5.5	1000	960	73	8.79
2	Y132S-4	5.5	1500	1440	43	13.19

由表中数据可知, 方案 1 的总传动比小, 传动装置结构尺寸小, 因此可采用方案 1, 选定电动机型号为 Y132M2-6

选 Y132M2-6 型电动机

3.2 传动装置总传动比的计算和各级传动比的分配

1、传动装置总传动比

$$i = n_m / n_w = 960 / 109.2 = 8.79$$

2、分配各级传动比

高速级为圆锥齿轮其传动比应小些约 $i_1 \approx 0.25i$, 低速级为圆柱齿轮传动其传动比可大些。所以可取

$$i_1 = 2.2 \quad i_2 = 4$$

$$i_3 = 2.2 \quad i_4 = 4$$

3.3 计算传动装置的运动和动力参数

1、各轴的转速 (各轴的标号均已在图中标出)

$$n_1 = n_m / i_0 = 960 \text{ r/min}$$

$$n_{II} = n_I / i_1 = 960 / 202 = 436.36 \text{ r/min}$$

$$n_{III} = n_{II} / i_2 = 436.36 / 4 = 109.2 \text{ r/min}$$

$$n_{IV} = n_{III} = 109.2 \text{ r/min}$$

2、各轴输入功率

$$P_I = P_{ed} \eta_4 = 4.95 \text{ kw}$$

$$P_{II} = P_I \cdot \eta_1 \eta_2 = 4.655 \text{ kw}$$

$$P_{III} = P_{II} \cdot \eta_2 \cdot \eta_3 = 4.47 \text{ kw}$$

$$P_{IV} = P_{III} \cdot \eta_3 \eta_4 = 4.38 \text{ kw}$$

3、各轴转矩 $T_I = 9550 \times \frac{P_I}{n_I} = 49.24 \text{ N.m}$

设计计算及说明						结果
$T_H = 9550 \times \frac{P_H}{n_H} = 101.88 \text{ N.m}$						
$T_M = 9550 \times \frac{P_M}{n_M} = 390.92 \text{ N.m}$						
$T_{IV} = 9550 \times \frac{P_{IV}}{n_{IV}} = 383.04 \text{ N.M}$						
将计算结果汇总列表如下						
表 3 轴的运动及动力参数						
项目	电动机轴	高速级轴 I	中间轴 II	低速级轴 III	工作机轴 IV	
转速 (r/min)	960	960	436.36	109.2	109.2	
功率 (kw)	5	4.95	4.655	4.47	4.382	
转矩 (N·m)	49.76	49.24	101.88	390.92	383.04	
传动比	1	2.2	4.0	1		
效率 η	0.99	0.94	0.96	0.98		

四、传动零件的设计计算

4.1 斜齿圆柱齿轮传动的设计（主要参照教材《机械设计（第八版）》）

- 已知输入功率为 $P_H = 4.655 \text{ kW}$ 、小齿轮转速为 $n_H = 436.36 \text{ r/min}$ 、齿数比为 4。工作寿命 10 年（设每年工作 300 天），三班制，带式输送，工作平稳，转向不变。
- 1、选定齿轮类型、精度等级、材料及齿数
- (1) 运输机为一般工作机器，速度不高，故选用 7 级精度。（GB10095-88）
 - (2) 材料选择 由《机械设计（第八版）》表 10-1 小齿轮材料为 40Cr（调质），硬度为 280HBS，大齿轮材料为 45 钢（调质），硬度为 240HBS，二者材料硬度相差 40HBS。
 - (3) 选小齿轮齿数 $z_1 = 22$ ，则大齿轮齿数 $z_2 = 4z_1 = 88$ 初选螺旋角 $\beta = 14^\circ$ 。
- 2、按齿面接触疲劳强度计算按下式设计计算

小齿轮：
40Cr（调质）
280 HBS
大齿轮：
45 钢（调质）
240 HBS
7 级精度

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$d_{1t} \geq \sqrt[3]{\frac{2K_t T_1}{\phi_d \varepsilon_a} \times \frac{u+1}{u} \times \left(\frac{Z_H Z_E}{[\sigma_H]}\right)^2}$	
(1) 确定公式内的各计算数值	
1) 试选载荷系数 $k_{t1} = 1.6$	$k_{t1} = 1.6$
2) 查教材图表 (图 10-30) 选取区域系数 $Z_H = 2.435$	$Z_H = 2.435$
3) 查教材表 10-6 选取弹性影响系数 $Z_E = 189.8 \text{ MPa}^{\frac{1}{2}}$	$Z_E = 189.8$
4) 查教材图表 (图 10-26) 得 $\varepsilon_{a1} = 0.765 \quad \varepsilon_{a2} = 0.88 \quad \varepsilon_a = \varepsilon_{a1} + \varepsilon_{a2} = 1.645$	$\varepsilon_a = 1.645$
5) 由教材公式 10-13 计算应力值环数	
$N_1 = 60n_1 j L_h = 60 \times 436.36 \times 1 \times (3 \times 8 \times 300 \times 10) = 1.885 \times 10^9 \text{ h}$	
$N_2 = 0.471 \times 10^9 \text{ h}$	$K_{HN1} = 0.9$
6) 查教材 10-19 图得: $K_{HN1} = 0.9 \quad K_{HN2} = 0.95$	$K_{HN2} = 0.95$
7) 查取齿轮的接触疲劳强度极限 $\sigma_{Hlim1} = 650 \text{ MPa} \quad \sigma_{Hlim2} = 550 \text{ MPa}$	$\sigma_{Hlim1} = 650 \text{ MPa}$
8) 由教材表 10-7 查得齿宽系数 $\phi_d = 1$	$\sigma_{Hlim2} = 550 \text{ MPa}$
9) 小齿轮传递的转矩 $T_1 = 95.5 \times 10^5 \times P_2 / n_2 = 9550 \times 4655 / 436.36 = 101.88 \text{ N.m}$	
10) 齿轮的接触疲劳强度极限: 取失效概率为 1%, 安全系数 S=1, 应用公式(10-12)得:	$\phi_d = 1 \quad T = 101.88 \text{ N.m}$
$[\sigma_H]_1 = \frac{K_{HN1} \sigma_{Hlim1}}{S} = 0.9 \times 650 = 585 \text{ MPa}$	
$[\sigma_H]_2 = \frac{K_{HN2} \sigma_{Hlim2}}{S} = 0.95 \times 550 = 522.5 \text{ MPa}$	$[\sigma_H] =$
许用接触应力为	
$[\sigma_H] = ([\sigma_H]_1 + [\sigma_H]_2) / 2 = 553.75 \text{ MPa}$	553.75 MPa
(2) 设计计算	
1) 按式计算小齿轮分度圆直径 d_{1t}	
$d_{1t} \geq \sqrt[3]{\frac{2K_t T_1}{\phi_d \varepsilon_a} \times \frac{u+1}{u} \times \left(\frac{Z_H Z_E}{[\sigma_H]}\right)^2}$	
$= \sqrt[3]{\frac{2 \times 1.6 \times 10.188 \times 10^4}{1 \times 1.645} \times \frac{5}{4} \times \left(\frac{2.435 \times 189.8}{553.75}\right)^2} = 55.67 \text{ mm}$	$V = 1.27 \text{ m/s}$
2) 计算圆周速度 $V = \frac{\pi d_{1t} n_1}{60 \times 1000} = 1.27 \text{ m/s}$	

设计计算及说明	结果
3) 计算齿宽 b 及模数 m_{nt}	
b= $\phi_d d_{1t} = 1.5567 = 55.67 \text{ mm}$	
$m_{nt} = \frac{d_{1t} \cos \beta}{Z_1} = \frac{55.67 \times \cos 14^\circ}{22} = 2.455 \text{ mm}$	$m_{nt} = 2.455$
4) 计算齿宽与高之比 b/h	
齿高 h= $2.25m_{nt} = 2.25 \times 2.455 = 5.24 \text{ mm}$	
$b/h = \frac{55.67}{5.24} = 10.62$	$b/h = 10.62$
5) 计算纵向重合度 ε_β $\varepsilon_\beta = 0.318 \phi_d Z_1 \tan \beta = 0.318 \times 1 \times 22 \tan 14^\circ = 1.744$	$\varepsilon_\beta = 1.744$
6) 计算载荷系数 K	
系数 $K_A = 1$, 根据 V=1.27m/s, 7 级精度查图表(图 10-8)得动载系数 $K_v = 1.08$	
查教材图表(表 10-3) 得齿间载荷分布系数 $K_{H\alpha} = K_{F\alpha} = 1.4$	$K_{H\alpha} = K_{F\alpha}$
由教材图表(表 10-4) 查得 $K_{H\beta 1} = 1.420$	= 1.4
查教材图表(图 10-13) 得 $K_{F\beta 1} = 1.32$	$K_{H\beta 1} = 1.420$
所以载荷系数	
$K = K_A K_v K_{H\alpha} K_{H\beta} = 2.147$	$K_{F\beta 1} = 1.32$
7) 按实际载荷系数校正所算得的分度圆直径 d_1	
$d = d_{1t} \sqrt[3]{\frac{K}{K_t}} = 55.67 \times \sqrt[3]{\frac{2.147}{1.6}} = 61.4 \text{ mm}$	$d_1 = 61.4 \text{ mm}$
8) 计算模数 m_{n1}	
$m_n = \frac{d_1 \cos \beta}{Z_1} = \frac{61.4 \times \cos 14^\circ}{22} = 2.7 \text{ mm}$	$m_{n1} = 2.7 \text{ mm}$
3、按齿根弯曲疲劳强度设计	
由弯曲强度的设计公式 $m_n \geq \sqrt[3]{\frac{2KT_1Y_\beta \cos^2 \beta}{\phi_d Z^2 \varepsilon_a} \left(\frac{Y_{F\theta} Y_{S\theta}}{[\sigma_F]} \right)}$ 设计	
(1) 确定公式内各计算数值	
1) 计算载荷系数 $K = K_A K_v K_{F\alpha} K_{F\beta} = 1.99$	
2) 根据纵向重合度 $\varepsilon_\beta = 1.744$ 查教材图表(图 10-28)查得螺旋影响系数 $Y_\beta = 0.88$	
3) 计算当量齿数	$Z_{V1} = 24.08$

$Z_{v1} = Z_1 / c \cos^3 \beta$ 设计计算及说明	结果
$Z_{v2} = Z_2 / \cos^3 \beta = 88 / \cos^3 14^\circ = 96.33$	$Z_{v2} = 96.33$
4) 查取齿形系数 检查教材图表 (表 10-5) $Y_{F\alpha 1} = 2.6476$, $Y_{F\alpha 2} = 2.18734$	$Y_{F\alpha 1} = 2.6474$
5) 查取应力校正系数 检查教材图表 (表 10-5) $Y_{S\alpha 1} = 1.5808$, $Y_{S\alpha 2} = 1.78633$	$Y_{F\alpha 2} = 2.187$
6) 检查教材图表 (图 10-20c) 检查得小齿轮弯曲疲劳强度极限 $\sigma_{FE1} = 520 \text{ MPa}$, 大齿轮弯曲疲劳强度极限 $\sigma_{FE2} = 400 \text{ MPa}$ 。	$Y_{S\alpha 1} = 1.5808$
7) 检查教材图表 (图 10-18) 取弯曲疲劳寿命系数 $K_{FN1} = 0.85$ $K_{FN2} = 0.88$	$K_{FN1} = 0.85$
8) 计算弯曲疲劳许用应力。 取弯曲疲劳安全系数 $S = 1.4$, 由式 $[\sigma_F] = \frac{K_{FN} \sigma_{FE}}{S}$ 得	$K_{FN2} = 0.88$
$[\sigma_F]_1 = \frac{K_{FN1} \sigma_{FE1}}{S} = \frac{0.85 \times 520}{1.4} = 315.71$	$\sigma_{FE1} = 315.7$
$[\sigma_F]_2 = \frac{K_{FN2} \sigma_{FE2}}{S} = \frac{0.88 \times 400}{1.4} = 251.43$	$\sigma_{FE2} = 251.4$
9) 计算大、小齿轮的 $\frac{Y_{F\alpha} Y_{S\alpha}}{[\sigma_F]}$, 并加以比较	
$\frac{Y_{F\alpha 1} F_{S\alpha 1}}{[\sigma_F]_1} = \frac{2.6476 \times 1.5808}{315.71} = 0.01326$	
$\frac{Y_{F\alpha 2} F_{S\alpha 2}}{[\sigma_F]_2} = \frac{2.18734 \times 1.78633}{251.43} = 0.01554$ 大齿轮的数值大. 选用。	
(2) 设计计算 1) 计算模数	
$m_n \geq \sqrt{\frac{2 \times 1.99 \times 10.188 \times 10^4 \times 0.88 \times \cos^2 14 \times 0.01554}{1 \times 22^2 \times 1.645}} \text{ mm} = 1.87 \text{ mm}$	
对比计算结果, 由齿面接触疲劳强度计算的法面模数 m_n 大于由齿根弯曲疲劳强度计算的法面模数, 由于齿轮模数的大小主要取决于弯曲强度所承载的能力。而齿面接触疲劳强度所决定的承载能力, 仅取决于齿轮直径。按 GB/T1357-1987 圆整为标准模数, 取 $m_n = 2 \text{ mm}$ 但为了同时满足接触疲劳强度, 需要按接触疲劳强度算得的分度圆直径 $d_1 = 61.4 \text{ mm}$ 来计算应有的齿数。	$m_n = 2 \text{ mm}$ $Z_1 = 30$

<p>2) 计算齿数 $z_1 = \frac{61.4 \times \cos 14^\circ}{m_n} = 29.78$ 取 $z_1 = 30$ 那么 $z_2 = 4 \times 30 = 120$</p> <p style="text-align: center;">设计计算及说明</p>	<p>$z_2 = 120$</p> <p style="text-align: center;">结果</p>
<p>4、几何尺寸计算</p> <p>(1) 计算中心距</p> $a = \frac{(z_1 + z_2)m_n}{2 \cos \beta} = \frac{(30 + 120)2}{2 \times \cos 14^\circ} = 155 \text{ mm}$ <p>(2) 按圆整后的中心距修正螺旋角</p> $\beta = \arccos \frac{(Z_1 + Z_2)m_n}{2a} = \arccos \frac{(30 + 120) \times 2}{2 \times 155} = 14^\circ 35' 33''$ <p>因 β 值改变不多, 故参数 $\varepsilon_\alpha, k_\beta, Z_h$ 等不必修正.</p> <p>(3) 计算大、小齿轮的分度圆直径</p> $d_1 = \frac{z_1 m_n}{\cos \beta} = \frac{30 \times 2}{\cos 14.5925^\circ} = 62 \text{ mm}$ $d_2 = \frac{z_2 m_n}{\cos \beta} = \frac{120 \times 2}{\cos 14.5925^\circ} = 248 \text{ mm}$ <p>(4) 计算齿轮宽度</p> $B = \Phi d_1 = 1 \times 62 \text{ mm} = 62 \text{ mm}$ $B_2 = 62 \quad B_1 = 67$ <p>(5) 结构设计</p> <p>小齿轮(齿轮1) 齿顶圆直径为 66mm 采用实心结构</p> <p>大齿轮(齿轮2) 齿顶圆直径为 252mm 采用腹板式结构其零件图如下</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td style="text-align: center; vertical-align: top;"> <img alt="Front view of the gear assembly with dimensions: width 62, height 67, and various internal hole diameters like 12.5, 16, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 135, 140, 145, 150, 155, 160, 165, 170, 175, 180, 185, 190, 195, 200, 205, 210, 215, 220, 225, 230, 235, 240, 245, 250, 255, 260, 265, 270, 275, 280, 285, 290, 295, 300, 305, 310, 315, 320, 325, 330, 335, 340, 345, 350, 355, 360, 365, 370, 375, 380, 385, 390, 395, 400, 405, 410, 415, 420, 425, 430, 435, 440, 445, 450, 455, 460, 465, 470, 475, 480, 485, 490, 495, 500, 505, 510, 515, 520, 525, 530, 535, 540, 545, 550, 555, 560, 565, 570, 575, 580, 585, 590, 595, 600, 605, 610, 615, 620, 625, 630, 635, 640, 645, 650, 655, 660, 665, 670, 675, 680, 685, 690, 695, 700, 705, 710, 715, 720, 725, 730, 735, 740, 745, 750, 755, 760, 765, 770, 775, 780, 785, 790, 795, 800, 805, 810, 815, 820, 825, 830, 835, 840, 845, 850, 855, 860, 865, 870, 875, 880, 885, 890, 895, 900, 905, 910, 915, 920, 925, 930, 935, 940, 945, 950, 955, 960, 965, 970, 975, 980, 985, 990, 995, 1000, 1005, 1010, 1015, 1020, 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8495, 8500, 8505, 8510, 8515, 8520, 8525, 8530, 8535, 854</td></tr></table>	<img alt="Front view of the gear assembly with dimensions: width 62, height 67, and various internal hole diameters like 12.5, 16, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 135, 140, 145, 150, 155, 160, 165, 170, 175, 180, 185, 190, 195, 200, 205, 210, 215, 220, 225, 230, 235, 240, 245, 250, 255, 260, 265, 270, 275, 280, 285, 290, 295, 300, 305, 310, 315, 320, 325, 330, 335, 340, 345, 350, 355, 360, 365, 370, 375, 380, 385, 390, 395, 400, 405, 410, 415, 420, 425, 430, 435, 440, 445, 450, 455, 460, 465, 470, 475, 480, 485, 490, 495, 500, 505, 510, 515, 520, 525, 530, 535, 540, 545, 550, 555, 560, 565, 570, 575, 580, 585, 590, 595, 600, 605, 610, 615, 620, 625, 630, 635, 640, 645, 650, 655, 660, 665, 670, 675, 680, 685, 690, 695, 700, 705, 710, 715, 720, 725, 730, 735, 740, 745, 750, 755, 760, 765, 770, 775, 780, 785, 790, 795, 800, 805, 810, 815, 820, 825, 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4180, 4185, 4190, 4195, 4200, 4205, 4210, 4215, 4220, 4225, 4230, 4235, 4240, 4245, 4250, 4255, 4260, 4265, 4270, 4275, 4280, 4285, 4290, 4295, 4300, 4305, 4310, 4315, 4320, 4325, 4330, 4335, 4340, 4345, 4350, 4355, 4360, 4365, 4370, 4375, 4380, 4385, 4390, 4395, 4400, 4405, 4410, 4415, 4420, 4425, 4430, 4435, 4440, 4445, 4450, 4455, 4460, 4465, 4470, 4475, 4480, 4485, 4490, 4495, 4500, 4505, 4510, 4515, 4520, 4525, 4530, 4535, 4540, 4545, 4550, 4555, 4560, 4565, 4570, 4575, 4580, 4585, 4590, 4595, 4600, 4605, 4610, 4615, 4620, 4625, 4630, 4635, 4640, 4645, 4650, 4655, 4660, 4665, 4670, 4675, 4680, 4685, 4690, 4695, 4700, 4705, 4710, 4715, 4720, 4725, 4730, 4735, 4740, 4745, 4750, 4755, 4760, 4765, 4770, 4775, 4780, 4785, 4790, 4795, 4800, 4805, 4810, 4815, 4820, 4825, 4830, 4835, 4840, 4845, 4850, 4855, 4860, 4865, 4870, 4875, 4880, 4885, 4890, 4895, 4900, 4905, 4910, 4915, 4920, 4925, 4930, 4935, 4940, 4945, 4950, 4955, 4960, 4965, 4970, 4975, 4980, 4985, 4990, 4995, 5000, 5005, 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<img alt="Front view of the gear assembly with dimensions: width 62, height 67, and various internal hole diameters like 12.5, 16, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 135, 140, 145, 150, 155, 160, 165, 170, 175, 180, 185, 190, 195, 200, 205, 210, 215, 220, 225, 230, 235, 240, 245, 250, 255, 260, 265, 270, 275, 280, 285, 290, 295, 300, 305, 310, 315, 320, 325, 330, 335, 340, 345, 350, 355, 360, 365, 370, 375, 380, 385, 390, 395, 400, 405, 410, 415, 420, 425, 430, 435, 440, 445, 450, 455, 460, 465, 470, 475, 480, 485, 490, 495, 500, 505, 510, 515, 520, 525, 530, 535, 540, 545, 550, 555, 560, 565, 570, 575, 580, 585, 590, 595, 600, 605, 610, 615, 620, 625, 630, 635, 640, 645, 650, 655, 660, 665, 670, 675, 680, 685, 690, 695, 700, 705, 710, 715, 720, 725, 730, 735, 740, 745, 750, 755, 760, 765, 770, 775, 780, 785, 790, 795, 800, 805, 810, 815, 820, 825, 830, 835, 840, 845, 850, 855, 860, 865, 870, 875, 880, 885, 890, 895, 900, 905, 910, 915, 920, 925, 930, 935, 940, 945, 950, 955, 960, 965, 970, 975, 980, 985, 990, 995, 1000, 1005, 1010, 1015, 1020, 1025, 1030, 1035, 1040, 1045, 1050, 1055, 1060, 1065, 1070, 1075, 1080, 1085, 1090, 1095, 1100, 1105, 1110, 1115, 1120, 1125, 1130, 1135, 1140, 1145, 1150, 1155, 1160, 1165, 1170, 1175, 1180, 1185, 1190, 1195, 1200, 1205, 1210, 1215, 1220, 1225, 1230, 1235, 1240, 1245, 1250, 1255, 1260, 1265, 1270, 1275, 1280, 1285, 1290, 1295, 1300, 1305, 1310, 1315, 1320, 1325, 1330, 1335, 1340, 1345, 1350, 1355, 1360, 1365, 1370, 1375, 1380, 1385, 1390, 1395, 1400, 1405, 1410, 1415, 1420, 1425, 1430, 1435, 1440, 1445, 1450, 1455, 1460, 1465, 1470, 1475, 1480, 1485, 1490, 1495, 1500, 1505, 1510, 1515, 1520, 1525, 1530, 1535, 1540, 1545, 1550, 1555, 1560, 1565, 1570, 1575, 1580, 1585, 1590, 1595, 1600, 1605, 1610, 1615, 1620, 1625, 1630, 1635, 1640, 1645, 1650, 1655, 1660, 1665, 1670, 1675, 1680, 1685, 1690, 1695, 1700, 1705, 1710, 1715, 1720, 1725, 1730, 1735, 1740, 1745, 1750, 1755, 1760, 1765, 1770, 1775, 1780, 1785, 1790, 1795, 1800, 1805, 1810, 1815, 1820, 1825, 1830, 1835, 1840, 1845, 1850, 1855, 1860, 1865, 1870, 1875, 1880, 1885, 1890, 1895, 1900, 1905, 1910, 1915, 1920, 1925, 1930, 1935, 1940, 1945, 1950, 1955, 1960, 1965, 1970, 1975, 1980, 1985, 1990, 1995, 2000, 2005, 2010, 2015, 2020, 2025, 2030, 2035, 2040, 2045, 2050, 2055, 2060, 2065, 2070, 2075, 2080, 2085, 2090, 2095, 2100, 2105, 2110, 2115, 2120, 2125, 2130, 2135, 2140, 2145, 2150, 2155, 2160, 2165, 2170, 2175, 2180, 2185, 2190, 2195, 2200, 2205, 2210, 2215, 2220, 2225, 2230, 2235, 2240, 2245, 2250, 2255, 2260, 2265, 2270, 2275, 2280, 2285, 2290, 2295, 2300, 2305, 2310, 2315, 2320, 2325, 2330, 2335, 2340, 2345, 2350, 2355, 2360, 2365, 2370, 2375, 2380, 2385, 2390, 2395, 2400, 2405, 2410, 2415, 2420, 2425, 2430, 2435, 2440, 2445, 2450, 2455, 2460, 2465, 2470, 2475, 2480, 2485, 2490, 2495, 2500, 2505, 2510, 2515, 2520, 2525, 2530, 2535, 2540, 2545, 2550, 2555, 2560, 2565, 2570, 2575, 2580, 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3415, 3420, 3425, 3430, 3435, 3440, 3445, 3450, 3455, 3460, 3465, 3470, 3475, 3480, 3485, 3490, 3495, 3500, 3505, 3510, 3515, 3520, 3525, 3530, 3535, 3540, 3545, 3550, 3555, 3560, 3565, 3570, 3575, 3580, 3585, 3590, 3595, 3600, 3605, 3610, 3615, 3620, 3625, 3630, 3635, 3640, 3645, 3650, 3655, 3660, 3665, 3670, 3675, 3680, 3685, 3690, 3695, 3700, 3705, 3710, 3715, 3720, 3725, 3730, 3735, 3740, 3745, 3750, 3755, 3760, 3765, 3770, 3775, 3780, 3785, 3790, 3795, 3800, 3805, 3810, 3815, 3820, 3825, 3830, 3835, 3840, 3845, 3850, 3855, 3860, 3865, 3870, 3875, 3880, 3885, 3890, 3895, 3900, 3905, 3910, 3915, 3920, 3925, 3930, 3935, 3940, 3945, 3950, 3955, 3960, 3965, 3970, 3975, 3980, 3985, 3990, 3995, 4000, 4005, 4010, 4015, 4020, 4025, 4030, 4035, 4040, 4045, 4050, 4055, 4060, 4065, 4070, 4075, 4080, 4085, 4090, 4095, 4100, 4105, 4110, 4115, 4120, 4125, 4130, 4135, 4140, 4145, 4150, 4155, 4160, 4165, 4170, 4175, 4180, 4185, 4190, 4195, 4200, 4205, 4210, 4215, 4220, 4225, 4230, 4235, 4240, 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5905, 5910, 5915, 5920, 5925, 5930, 5935, 5940, 5945, 5950, 5955, 5960, 5965, 5970, 5975, 5980, 5985, 5990, 5995, 6000, 6005, 6010, 6015, 6020, 6025, 6030, 6035, 6040, 6045, 6050, 6055, 6060, 6065, 6070, 6075, 6080, 6085, 6090, 6095, 6100, 6105, 6110, 6115, 6120, 6125, 6130, 6135, 6140, 6145, 6150, 6155, 6160, 6165, 6170, 6175, 6180, 6185, 6190, 6195, 6200, 6205, 6210, 6215, 6220, 6225, 6230, 6235, 6240, 6245, 6250, 6255, 6260, 6265, 6270, 6275, 6280, 6285, 6290, 6295, 6300, 6305, 6310, 6315, 6320, 6325, 6330, 6335, 6340, 6345, 6350, 6355, 6360, 6365, 6370, 6375, 6380, 6385, 6390, 6395, 6400, 6405, 6410, 6415, 6420, 6425, 6430, 6435, 6440, 6445, 6450, 6455, 6460, 6465, 6470, 6475, 6480, 6485, 6490, 6495, 6500, 6505, 6510, 6515, 6520, 6525, 6530, 6535, 6540, 6545, 6550, 6555, 6560, 6565, 6570, 6575, 6580, 6585, 6590, 6595, 6600, 6605, 6610, 6615, 6620, 6625, 6630, 6635, 6640, 6645, 6650, 6655, 6660, 6665, 6670, 6675, 6680, 6685, 6690, 6695, 6700, 6705, 6710, 6715, 6720, 6725, 6730, 6735, 6740, 6745, 6750, 6755, 6760, 6765, 6770, 6775, 6780, 6785, 6790, 6795, 6800, 6805, 6810, 6815, 6820, 6825, 6830, 6835, 6840, 6845, 6850, 6855, 6860, 6865, 6870, 6875, 6880, 6885, 6890, 6895, 6900, 6905, 6910, 6915, 6920, 6925, 6930, 6935, 6940, 6945, 6950, 6955, 6960, 6965, 6970, 6975, 6980, 6985, 6990, 6995, 7000, 7005, 7010, 7015, 7020, 7025, 7030, 7035, 7040, 7045, 7050, 7055, 7060, 7065, 7070, 7075, 7080, 7085, 7090, 7095, 7100, 7105, 7110, 7115, 7120, 7125, 7130, 7135, 7140, 7145, 7150, 7155, 7160, 7165, 7170, 7175, 7180, 7185, 7190, 7195, 7200, 7205, 7210, 7215, 7220, 7225, 7230, 7235, 7240, 7245, 7250, 7255, 7260, 7265, 7270, 7275, 7280, 7285, 7290, 7295, 7300, 7305, 7310, 7315, 7320, 7325, 7330, 7335, 7340, 7345, 7350, 7355, 7360, 7365, 7370, 7375, 7380, 7385, 7390, 7395, 7400, 7405, 7410, 7415, 7420, 7425, 7430, 7435, 7440, 7445, 7450, 7455, 7460, 7465, 7470, 7475, 7480, 7485, 7490, 7495, 7500, 7505, 7510, 7515, 7520, 7525, 7530, 7535, 7540, 7545, 7550, 7555, 7560, 7565, 7570, 7575, 7580, 7585, 7590, 7595, 7600, 7605, 7610, 7615, 7620, 7625, 7630, 7635, 7640, 7645, 7650, 7655, 7660, 7665, 7670, 7675, 7680, 7685, 7690, 7695, 7700, 7705, 7710, 7715, 7720, 7725, 7730, 7735, 7740, 7745, 7750, 7755, 7760, 7765, 7770, 7775, 7780, 7785, 7790, 7795, 7800, 7805, 7810, 7815, 7820, 7825, 7830, 7835, 7840, 7845, 7850, 7855, 7860, 7865, 7870, 7875, 7880, 7885, 7890, 7895, 7900, 7905, 7910, 7915, 7920, 7925, 7930, 7935, 7940, 7945, 7950, 7955, 7960, 7965, 7970, 7975, 7980, 7985, 7990, 7995, 8000, 8005, 8010, 8015, 8020, 8025, 8030, 8035, 8040, 8045, 8050, 8055, 8060, 8065, 8070, 8075, 8080, 8085, 8090, 8095, 8100, 8105, 8110, 8115, 8120, 8125, 8130, 8135, 8140, 8145, 8150, 8155, 8160, 8165, 8170, 8175, 8180, 8185, 8190, 8195, 8200, 8205, 8210, 8215, 8220, 8225, 8230, 8235, 8240, 8245, 8250, 8255, 8260, 8265, 8270, 8275, 8280, 8285, 8290, 8295, 8300, 8305, 8310, 8315, 8320, 8325, 8330, 8335, 8340, 8345, 8350, 8355, 8360, 8365, 8370, 8375, 8380, 8385, 8390, 8395, 8400, 8405, 8410, 8415, 8420, 8425, 8430, 8435, 8440, 8445, 8450, 8455, 8460, 8465, 8470, 8475, 8480, 8485, 8490, 8495, 8500, 8505, 8510, 8515, 8520, 8525, 8530, 8535, 854	

图二、斜齿圆柱齿轮 设计计算及说明	
4.2 直齿圆锥齿轮传动设计 (主要参照教材《机械设计(第八版)》)	
已知输入功率为 $P_I = 4.95 \text{ kW}$ 、小齿轮转速为 $n_1 = 436.36 \text{ r/min}$ 、齿数比为 2.2	
由电动机驱动。工作寿命 10 年 (设每年工作 300 天), 三班制, 带式输送, 工作平稳, 转向不变。	
1 、选定齿轮类型、精度等级、材料及齿数	
(1) 圆锥圆锥齿轮减速器为通用减速器, 其速度不高, 故选用 7 级精度 (GB10095-88)	
(2) 材料选择 由《机械设计(第八版)》表 10-1 小齿轮材料可选为 40Cr (调质), 硬度为 280HBS, 大齿轮材料取 45 钢 (调质), 硬度为 240HBS, 二者材料硬度相差 40HBS。	$z_1 = 25$
(3) 选小齿轮齿数 $z_1 = 25$, 则大齿轮齿数 $z_2 = 2.2z_1 = 55$	$z_2 = 55$
2 、按齿面接触疲劳强度设计	
设计计算公式:	
$d_{lt} \geq 2.92 \sqrt[3]{\left(\frac{Z_E}{[\sigma_F]}\right)^2 \frac{KT_1}{\phi_R(1-0.5\phi_R)^2 u}}$	
(1) 、确定公式内的各计算值	
1) 试选载荷系数 $k_{t1} = 1.8$	$k_{t1} = 1.8$
2) 小齿轮传递的转矩 $T_1 = 95.5 \times 10^5 \times P_I / n_1 = 49.24 \text{ KN.Mm}$	$\Phi_R = 0.35$
3) 取齿宽系数 $\Phi_R = 0.35$	
4) 查图 10-21 齿面硬度得小齿轮的接触疲劳强度极限 $\sigma_{Hlim1} = 650 \text{ MPa}$ 大齿轮的接触疲劳极限 $\sigma_{Hlim2} = 550 \text{ MPa}$	
5) 查表 10-6 选取弹性影响系数 $Z_E = 189.8 \text{ MPa}^{\frac{1}{2}}$	
6) 由教材公式 10-13 计算应力值环数	
N ₁ = $60n_1 j L_h = 60 \times 960 \times 1 \times (3 \times 8 \times 300 \times 10) = 4.1472 \times 10^9 \text{ h}$	
N ₂ = $0.471 \times 10^9 \text{ h}$	
7) 查教材 10-19 图得: $K_{HN1} = 0.89$ $K_{HN2} = 0.9$	$K_{HN1} = 0.89$
8) 齿轮的接触疲劳强度极限: 取失效概率为 1%, 安全系数 S=1, 应用公式 (10-12) 得:	$K_{HN2} = 0.9$
	$[\sigma_H]_1 =$

$[\sigma_H]_1 = \frac{K_{HN1}\sigma_{H\lim1}}{S} = 0.89 \times 650 = 578.5 \text{ MPa}$ 设计及设计说明	578.5 MPa 结果
$[\sigma_H]_2 = \frac{K_{HN2}\sigma_{H\lim2}}{S} = 0.9 \times 550 = 495 \text{ MPa}$	$[\sigma_H]_2 = 495 \text{ MPa}$
(2) 设计计算 1) 试算小齿轮的分度圆直径, 带入 $[\sigma_H]$ 中的较小值得 $d_{1t} \geq 2.923 \sqrt{\left(\frac{189.8}{495}\right)^2 \frac{1.8 \times 4920}{0.35 \times (1 - 0.5 \times 0.35)^2 \times 2.2}} = 85.22 \text{ mm}$	$d_{1t} = 85.22 \text{ mm}$
2) 计算圆周速度 V $V = \frac{\pi d_{1t} n_1}{60 \times 1000} = 4.28 \text{ m/s}$	V=4.28m/s
3) 计算载荷系数 系数 $K_A = 1$, 根据 $V=4.28 \text{ m/s}$, 7 级精度查图表(图 10-8)得动载系数 $K_v = 1.15$ 查图表(表 10-3)得齿间载荷分布系数 $K_{H\alpha} = K_{F\alpha} = 1$ 根据大齿轮两端支撑, 小齿轮悬臂布置查表 10-9 得 $K_{H\beta\beta b} = 1.25$ 的 $K_{H\beta} = K_{F\beta} = 1.5 \times 1.25 = 1.875$ 得载荷系数 $K = K_A K_v K_{H\alpha} K_{H\beta} = 2.156$	K=2.156
4) 按实际的载荷系数校正所得的分度圆直径, 得 $d = d_{1t} \sqrt[3]{\frac{K}{K_t}} = 85.22 \times \sqrt[3]{\frac{2.156}{1.8}} = 90.5 \text{ mm}$	
5) 计算模数 M $m = \frac{d_1}{z_1} = \frac{90.50}{25} = 3.62 \text{ mm}$	$M_t = 3.62 \text{ mm}$
3、按齿根弯曲疲劳强度设计 设计公式: $m \geq \sqrt[3]{\frac{4KT_1}{\phi_R(1-0.5\phi_R)^2 z_1^2 \sqrt{u^2 + 1}} \cdot \frac{Y_{Fa} Y_{Sa}}{[\sigma_F]}}$	
(1) 确定公式内各计算数值 1) 计算载荷系数 $K = K_A K_v K_{F\alpha} K_{F\beta} = 1 \times 1.15 \times 1.875 = 2.159$ 2) 计算当量齿数	K=2.159

$Z_{v1} = Z / \cos \delta_1 = 27.4$ 设计及设计说明	结果
$Z_{v2} = Z / \cos \delta_2 = 133.5$ 3) 由教材表 10-5 查得齿形系数 $Y_{F\alpha 1} = 2.562 \quad Y_{F\alpha 2} = 2.1532$ 应力校正系数 $Y_{S\alpha 1} = 1.604 \quad Y_{S\alpha 2} = 1.8168$	$Y_{F\alpha 1} = 2.562$ $Y_{F\alpha 2} = 2.1532$ $Y_{S\alpha 1} = 1.604$ $Y_{S\alpha 2} = 1.8168$
4) 由教材图 20-20c 查得小齿轮的弯曲疲劳强度极限 $\sigma_{FE1} = 520 MP_a$, 大齿轮的弯曲疲劳强度极限 $\sigma_{FE2} = 400 MP_a$	$\sigma_{FE1} = 520 MP_a$ $\sigma_{FE2} = 400 MP_a$
5) 由《机械设计》图 10-18 取弯曲疲劳寿命系数 $K_{FN1} = 0.83 \quad K_{FN2} = 0.85$	$K_{FN1} = 0.83$ $K_{FN2} = 0.85$
6) 计算弯曲疲劳许用应力取弯曲疲劳安全系数 $S = 1.4$, 得 $[\sigma_F]_1 = \frac{K_{FN1}\sigma_{FE1}}{S} = \frac{0.83 \times 520}{1.4} = 308.28 MP_a$ $[\sigma_F]_2 = \frac{K_{FN2}\sigma_{FE2}}{S} = \frac{0.85 \times 400}{1.4} = 242.86 MP_a$	
7) 计算大小齿轮的 $\frac{Y_{Fa} F_{Sa}}{[\sigma_F]}$, 并加以比较 $\frac{Y_{Fa1} F_{Sa1}}{[\sigma_F]_1} = \frac{2.562 \times 1.604}{308.28} = 0.0133$ $\frac{Y_{Fa2} F_{Sa2}}{[\sigma_F]_2} = \frac{2.15 \times 1.8168}{242.86} = 0.016107$	
大齿轮的数值大, 选用大齿轮的尺寸设计计算. (2) 设计计算 $m \geq \sqrt[3]{\frac{4 \times 2.156 \times 49240 \times 0.016107}{0.35 \times (1 - 0.5 \times 0.35)^2 25^2 \sqrt{2.2^2 + 1}}} mm = 2.668 mm$ 取 $M=2.75 mm$ 对比计算结果, 由齿面接触疲劳强度计算的模数 m 大于由齿根弯曲疲劳强度计算的模数, 由于齿轮模数的大小主要取决于弯曲强度所承载的能力。而齿面接触疲劳强度所决定的承载能力, 取决于齿轮直径。按 GB/T1357-1987 圆整为标准模数, 取 $m=2.75 mm$ 但为了同时满足接触疲劳强度, 需要按接触疲劳强度算得的分	$M=2.75 mm$

度圆直径 $d_1 = 90.50 \text{ mm}$ 来计算应有的齿数.

设计及设计说明

结果

$$\text{计算齿数 } z_1 = \frac{d_1}{m} \approx 33 \quad \text{取 } z_1 = 33 \quad \text{那么 } z_2 = 2.2 \times 33 = 73$$

$$z_1 = 33$$

$$z_2 = 33$$

4、计算几何尺寸

$$(1) d_1 = z_1 m = 2.75 \times 33 = 90.75$$

$$d_1 = 90.75$$

$$(2) d_2 = z_2 m = 2.75 \times 73 = 200.75$$

$$d_2 = 200.75$$

$$(3) \delta_1 = \arccot \frac{d_1}{d_2} = 24.325^\circ = 24^\circ 19' 30''$$

$$\delta_1 = 24^\circ 19' 30''$$

$$(4) \delta_2 = 90 - \delta_1 = 65^\circ 40' 30''$$

$$\delta_2 = 65^\circ 40' 30''$$

$$(5) R = d_1 \sqrt{\frac{\mu^2 + 1}{2}} = d_1 \sqrt{\frac{2.2^2 + 1}{2}} = 109.65 \text{ mm}$$

$$R = 109.65 \text{ mm}$$

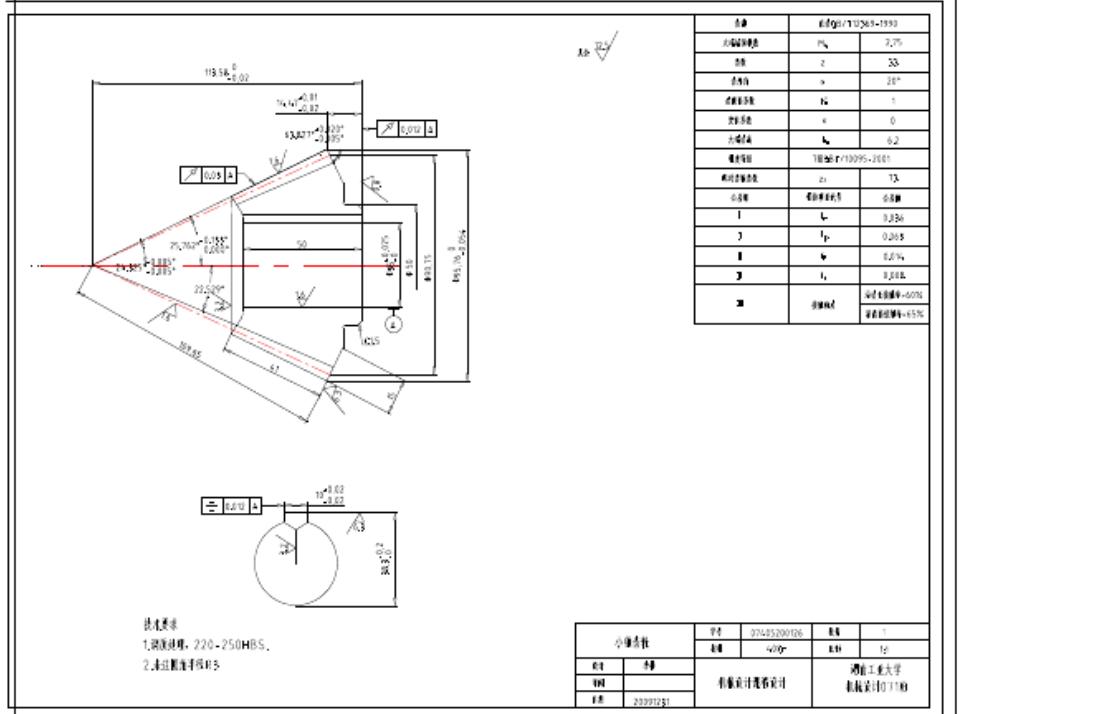
$$(6) b = R \phi k = 38.37 \text{ 圆整取 } B_2 = 36 \text{ mm} \quad B_1 = 41 \text{ mm}$$

$$B_1 = 41 \text{ mm}$$

(7) 机构设计

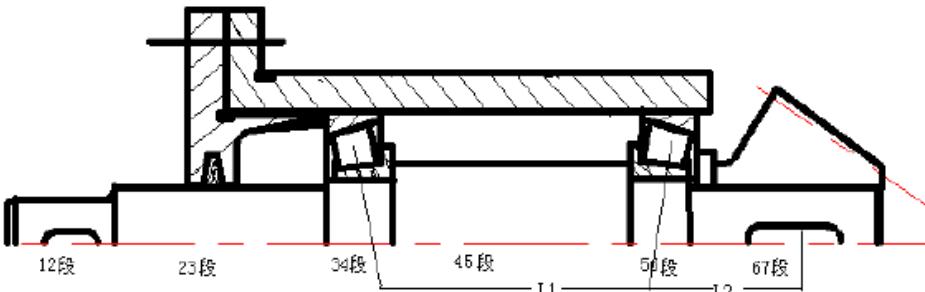
小锥齿轮（齿轮 1）大端齿顶圆直径为 95.76mm 采用实心结构其零件图如下

大锥齿轮（齿轮 2）大端齿顶圆直径为 203mm 采用腹板式结构



图三、直齿锥齿轮

设计计算及说明	结果
<p>五、轴的设计计算</p> <h3>5.1 输入轴 (I 轴) 的设计</h3> <p>1、求输入轴上的功率 P_I、转速 n_I 和转矩 T_I</p> $P_I = 4.95 \text{ kw} \quad n_I = 960 \text{ r/min} \quad T_I = 49.24 \text{ N.M}$ <p>2 、求作用在齿轮上的力 已知高速级小圆锥齿轮的平均分度圆直径为</p> $d_{m1} = d_1(1 - 0.5\phi_R) = 74.87 \text{ mm}$ <p>则 $F_t = 2T/d_{m1} = 2 \times 49240/74.87 = 1315.35 \text{ N}$</p> $F_r = F_t \tan 20^\circ \cos \delta_1 = 436.25 \text{ N}$ $F_a = F_t \tan 20^\circ \sin \delta_1 = 197.19 \text{ N}$ <p>圆周力 F_t、径向力 F_r 及轴向力 F_a 的方向如图二所示</p> <p style="text-align: right;">$F_t = 1315.35 \text{ N}$ $F_r = 436.25 \text{ N}$ $F_a = 197.19 \text{ N}$</p> <p>3 、初步确定轴的最小直径 先初步估算轴的最小直径。选取轴的材料为 45 钢 (调质)，根据《机械设计》</p>	

(第八版)》表 15-3, 取 $A_0 = 112$, 得 设计计算及说明	结果
$d_{\min} = A_0 \sqrt{\frac{P_1}{n_1}} = 112 \sqrt{\frac{4.95}{960}} = 19.35 \text{ mm}$ <p>输入轴的最小直径为安装联轴器的直径 d_{12}, 为了使所选的轴直径 d_{12} 与联轴器的孔径相适应, 故需同时选取联轴器型号。联轴器的计算转矩 $T_{ca} = K_A T_2$, 查《机械设计 (第八版)》表 14-1, 由于转矩变化很小, 故取 $K_A = 1.3$, 则</p> $T_{ca} = K_A T_2 = 1.3 \times 49.24 = 64012 \text{ N.Mm}$ <p>查《机械设计课程设计》表 14-4, 选 Lx3 型弹性柱销联轴器其工称转矩为 1250N.m, 而电动机轴的直径为 38mm 所以联轴器的孔径不能太小。取 $d_{12} = 30 \text{ mm}$, 半联轴器长度 $L = 82 \text{ mm}$, 半联轴器与轴配合的毂孔长度为 60mm。</p>	$d_{12} = 30 \text{ mm}$
<p>4、轴的结构设计</p> <p>(1) 拟定轴上零件的装配方案 (见图五)</p>  <p>The diagram illustrates the assembly of components on the input shaft. It shows a cross-section of the shaft with several segments labeled from left to right: 12段, 23段, 34段, 45段, 56段, and 67段. The segments are separated by stepped shoulders. Two deep groove ball bearings are mounted on the shaft. The outer ring of the left bearing is secured to the 23段 segment, while its inner ring is positioned on the 12段 segment. The outer ring of the right bearing is secured to the 56段 segment, while its inner ring is positioned on the 45段 segment. The distance between the centers of the two bearings is indicated as L1. The total length of the shaft section with bearings is indicated as L2.</p> <p>图五、输入轴轴上零件的装配</p> <p>(2) 根据轴向定位的要求确定轴的各段直径和长度</p> <p>1) 为了满足半联轴器的轴向定位, 12 段轴右端需制出一轴肩, 故取 23 段的直径 $d_{23} = 37 \text{ mm}$。左端用轴端挡圈定位, 12 段长度应适当小于 L 所以取 $L_{12} = 58 \text{ mm}$</p> <p>2) 初步选择滚动轴承。因轴承同时受有径向力和轴向力, 故选用单列圆锥滚子轴承, 参照工作要求并根据 $d_{23} = 37 \text{ mm}$, 由《机械设计课程设计》表 13-1 中初步选取 0 基本游隙组, 标准精度级的单列圆锥滚子轴承 30308, 其尺寸为</p>	$d_{23} = 37 \text{ mm}$ $L_{12} = 58 \text{ mm}$ $d_{34} = 40 \text{ mm}$

设计计算及说明		结果													
<p>$d \times D \times T = 40\text{mm} \times 90\text{mm} \times 25.25\text{mm}$ 所以 $d_{34} = 40\text{mm}$ 而 $L_{34} = 25.25\text{mm}$</p> <p>这对轴承均采用轴肩进行轴向定位，由《机械设计课程设计》表 13-1 查得 30308 型轴承的定位轴肩高度 $d_a = 49\text{mm}$，因此取 $d_{45} = 49\text{mm}$</p> <p>3) 取安装齿轮处的轴段 67 的直径 $d_{67} = 35\text{mm}$；为使套筒可靠地压紧轴承，56 段应略短于轴承宽度，故取 $L_{56} = 24\text{mm}$，$d_{56} = 40\text{mm}$</p> <p>4) 轴承端盖的总宽度为 20mm。根据轴承端盖的装拆及便于对轴承添加润滑油的要求，求得端盖外端面与半联轴器右端面间的距离 $l = 30\text{mm}$，取 $L_{23} = 50\text{mm}$。</p> <p>5) 锥齿轮轮毂宽度为 50mm，为使套筒端面可靠地压紧齿轮取 $L_{67} = 61\text{mm}$ 由于 $L_b \approx 2L_a$，故取 $L_{45} = 98\text{mm}$</p> <p>(3) 轴上的周向定位</p> <p>圆锥齿轮的周向定位采用平键连接，按 $d_{67} = 35\text{mm}$ 由《机械设计（第八版）》表 6-1 查得平键截面 $b \times h = 10\text{mm} \times 8\text{mm}$，键槽用键槽铣刀加工，长为 45mm，同时为保证齿轮与轴配合有良好的对中性，故选择齿轮轮毂与轴的配合为 $H7/n6$；同样，半联轴器处平键截面为 $b \times h \times l = 10\text{mm} \times 8\text{mm} \times 50\text{mm}$ 与轴的配合为 $H7/k6$；滚动轴承与轴的周向定位是由过渡配合来保证的，此处选轴的尺寸公差为 k5。</p> <p>(4) 确定轴上圆角和倒角尺寸</p> <p>取轴端倒角为 $2 \times 45^\circ$，轴肩处的倒角可按 R1.6-R2 适当选取。</p> <p>5、求轴上的载荷（30308 型的 $a=19.5\text{mm}$。所以两轴承间支点距离为 109.5mm 右轴承与齿轮间的距离为 54.25mm。）（见图四）</p> <table border="1"> <thead> <tr> <th>载荷</th> <th>水平面 H</th> <th>垂直面 V</th> </tr> </thead> <tbody> <tr> <td rowspan="2">支反力 F</td> <td>$F_{NH1} = 651.65N$</td> <td>$F_{NV1} = 216.13N$</td> </tr> <tr> <td>$F_{NH2} = 1967N$</td> <td>$F_{NV2} = 652.38N$</td> </tr> <tr> <td>弯矩 M</td> <td>$M_H = 71357.7N\cdot mm$</td> <td>$M_{V1} = 71435.6N\cdot mm$ $M_{V2} = 7789.2N\cdot mm$</td> </tr> <tr> <td colspan="3"></td></tr> </tbody> </table>	载荷	水平面 H	垂直面 V	支反力 F	$F_{NH1} = 651.65N$	$F_{NV1} = 216.13N$	$F_{NH2} = 1967N$	$F_{NV2} = 652.38N$	弯矩 M	$M_H = 71357.7N\cdot mm$	$M_{V1} = 71435.6N\cdot mm$ $M_{V2} = 7789.2N\cdot mm$				$L_{34} = 25.25\text{mm}$ $d_{45} = 49\text{mm}$ $d_{67} = 35\text{mm}$ $L_{56} = 24\text{mm}$ ， $d_{56} = 40\text{mm}$ $L_{23} = 50\text{mm}$ $L_{67} = 61\text{mm}$ $L_{45} = 98\text{mm}$
载荷	水平面 H	垂直面 V													
支反力 F	$F_{NH1} = 651.65N$	$F_{NV1} = 216.13N$													
	$F_{NH2} = 1967N$	$F_{NV2} = 652.38N$													
弯矩 M	$M_H = 71357.7N\cdot mm$	$M_{V1} = 71435.6N\cdot mm$ $M_{V2} = 7789.2N\cdot mm$													

总弯矩	$M = \sqrt{71357.7^2 + 71435.6^2} = 100970.1 \text{ N}\cdot\text{mm}$	结果
扭矩 T	$T_I = 49.24 \text{ N}\cdot\text{m}$	
设计计算及说明		
6 、按弯扭合成应力校核轴的强度		
根据图四可知右端轴承支点截面为危险截面，由上表中的数据及轴的单向旋转，扭转切应力为脉动循环变应力，取 $\alpha = 0.6$ ，轴的计算应力为		
$\sigma_{ca} = \sqrt{\frac{M^2 + (\alpha T_I)^2}{W}} = \sqrt{\frac{1009701^2 + (49240 \times 0.6)^2}{0.1 \times 40^3}} = 16.44 \text{ MPa}$		
前已选定轴的材料为 45 钢（调质），由《机械设计（第八版）》表 15-1 查得 $[\sigma_{-1}] = 60 \text{ MPa}$, $\sigma_{ca} < [\sigma_{-1}]$ ，故安全。		
<h2>5.2 输出轴（III轴）的设计</h2>		
1 、求输出轴上的功率 P_{III} 、转速 n_{III} 和转矩 T_{III}	$M=2.0 \text{ mm}$	
$P_{III} = 4.47 \text{ kW}$ $n_{III} = 109.2 \text{ r/min}$ $T_{III} = 390.92 \text{ N}\cdot\text{m}$		
2 、求作用在齿轮上的力	$\beta = 14^\circ 35' 33''$	
已知大斜齿轮的分度圆直径为	$F_t = 3152.58 \text{ N}$	
$d = mz = 248 \text{ mm}$		
而 $F_t = 2T/d = 2 \times 390920/248 = 315258 \text{ N}$		
$F_r = F_t \tan \beta / \cos \beta = 1185.69 \text{ N}$		
$F_a = F_t \tan \beta = 820.74 \text{ N}$		
圆周力 F_t 、径向力 F_r 及轴向力 F_a 的方向如图六所示		
3 、初步确定轴的最小直径		
先初步估算轴的最小直径。选取轴的材料为 45 钢（调质），根据《机械设计（第八版）》表 15-3，取 $A_0 = 112$ ，得	$d_{min} = 38.6 \text{ mm}$	
$d_{min} = A_0 \sqrt{\frac{P_{III}}{n_{III}}} = 112 \sqrt{\frac{4.47}{109.2}} = 38.6 \text{ mm}$		

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