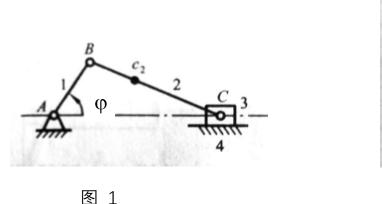
第四章作业题目:

1. 如图 1 所示的曲柄滑块机构中,设已知曲柄长度 Lab=0.1m,连杆长度 Lbc=0.33m,曲柄转速 n=1500rpm,活塞及其附件的重力 G3=21N,连杆重力 G2=25N,连杆对其质心 C2 的转动惯量 lc2=0.0425kg·m²,连杆质心 C2 至曲柄销 B 的距离 Lbc2=Lbc/3。试确定 φ =45° 位置时活塞及连杆的惯性力。(求解方法不限)



 $\begin{array}{c|c}
 & a \\
 & 1 \\
 & A \\
 & \varphi_1
\end{array}$ $\begin{array}{c|c}
 & A \\
 & \varphi_1
\end{array}$ $\begin{array}{c|c}
 & A \\
 & \varphi_3
\end{array}$ $\begin{array}{c|c}
 & \varphi_3
\end{array}$

图 2

2. 如 图 2 所 示 摆 动 导 杆 机 构 中 , 已 知 a=300mm , b=800mm,d=400mm, ω_1 = 5rad/s, ϕ_1 =90°时 ϕ_3 =37°,加于导杆上的力矩 M3=100Nm。试用解析法求曲柄 1 转动一个周期时,每间隔 10°对应的机构各运动副的反力及应加于曲柄 1 上的 Mb 的值,并要求将求得的值用图表软件绘出。

说明:

- 1. 解析法计算第二题时,要求每人都要改变题中已知杆尺寸 a 和导杆上的力矩 M3 数据后计算(改变数据的前提是不能影响机构正常运动),使每人的数据相 互不一样。
- 2. 提交内容含解题过程(手写), 自编程序和程序执行结果及制作的图表等。
- 3. 作业提交日: 4月27日

(2)代码:

```
% 设置曲柄滑块机构的初始数据
11 = 0.1;
12 = 0.33;
omega1 = 50*pi;
m2 = 25/9.8;
m3 = 21/9.8;
J2 = 0.0425;
alpha1 = 45;
acceleration1 = 0;
% 矢量方程 11=S+12
syms S alpha2
%沿x轴
q1 = l1*cosd(alpha1)-S-l2*cosd(alpha2);
%沿y轴
q2 = l1*sind(alpha1)-l2*sind(alpha2);
x0=[0.393,168];
T = vpasolve(q1,q2,x0);
S = T.S;
alpha2 = T.alpha2;
% 矢量方程对时间求一阶导
syms v omega2
%沿×轴
q3 = -l1*sind(alpha1)*omega1-v+l2*sind(alpha2)*omega2;
%沿y轴
q4 = l1*cosd(alpha1)*omega1-l2*cosd(alpha2)*omega2;
P = vpasolve(q3,q4);
v = P.v;
omega2 = P.omega2;
% 矢量方程对时间求二阶导
syms a acceleration2
%沿x轴
q5 = -l1*cosd(alpha1)*omega1^2-l1*sind(alpha1)*acceleration1-
a+l2*cosd(alpha2)*omega2^2+l2*sind(alpha2)*acceleration2;
%沿y轴
```

```
q6 = -
l1*sind(alpha1)*omega1^2+l1*cosd(alpha1)*acceleration1+l2*sind(alpha2)*
omega2^2-l2*cosd(alpha2)*acceleration2;

Q = vpasolve(q5,q6);
a = Q.a;
acceleration2 = Q.acceleration2;

% 12 杆的惯性力求解
FIcx = double(+m2*(omega1^2*l1*cosd(alpha1)-
omega2^2*(1/3*l2)*cosd(alpha2)-(1/3*l2)*acceleration2*sind(alpha2)));
FIcy =
double(+m2*(omega1^2*l1*sind(alpha1)+omega2^2*(1/3*l2)*sind(alpha2)+(1/3*l2)*acceleration2*cosd(alpha2)));
MI = double(-J2*acceleration2);
% 滑块的惯性力计算
FI = double(-m3*a);
```

- (3)输出结果:
- a. 连杆 BC 的惯性力:

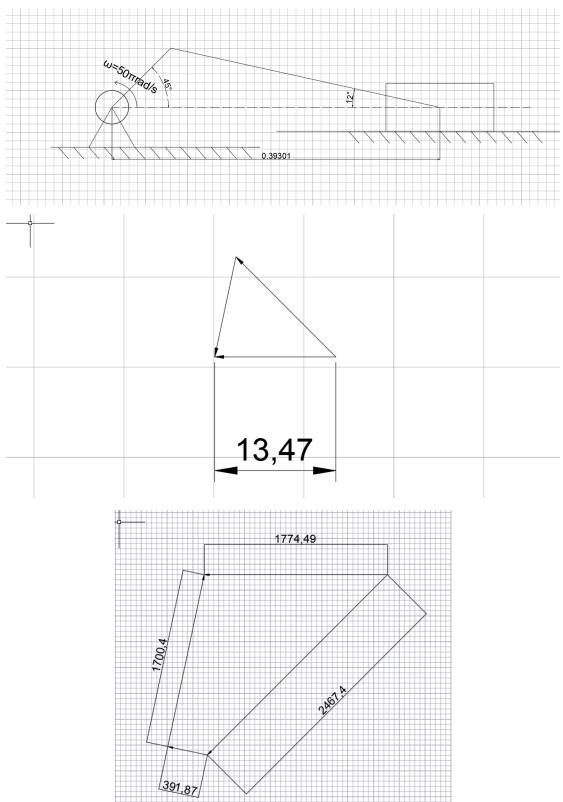
$$F_{Icx} = 4466.468N$$

 $F_{Icy} = 3109.996N$
 $M_I = -218.9710N \cdot m$

b. 滑块 C 的惯性力:

$$F_I = 3778.146N$$

(4) AutoCAD 结果的验证:



```
(2)代码:
%定义11杆的初始数据
11 = 0.3;
alpha1 = 0:10:360;
omega1 = 5;
n = length(alpha1);
% 定义 12 的初始数据
12 = 0.8;
M3 = 100;
%机架长度
m = 0.4;
% 应加于曲柄 1 上的 Mb
Mb = zeros(1,n);
% 支座 A 的约束力
Rax = zeros(1,n);
Ray = zeros(1,n);
% 移动副 B 的约束力
F = zeros(1,n);
% 支座 C 的约束力
Rcx = zeros(1,n);
Rcy = zeros(1,n);
for iterTime = 1:n
%
    运动学分析
syms 122 alpha2 % 122 指的是 B、C 之间的距离
% 矢量方程 m+l1=l22
```

%沿×轴

q1 = l1*cosd(alpha1(iterTime))-l22*cosd(alpha2); q2 = l1*sind(alpha1(iterTime))+m-l22*sind(alpha2);

```
%求解位移方程,得出 122 alpha2
%采用迭代计算的方法,用前一时刻的位移来确定后一时刻的位移
if iterTime == 1
  x0 = [53,500];
end
T = vpasolve(q1,q2,x0);
122 = T.122;
alpha2 = T.alpha2;
  if iterTime > 1
  x0 = [alpha2, 122];
  end
    对矢量方程求一阶导
syms v omega2
%沿x轴
q3 = -l1*sind(alpha1(iterTime))*omega1-
v*cosd(alpha2)+122*sind(alpha2)*omega2;
%沿у轴
q4 = l1*cosd(alpha1(iterTime))*omega1-v*sind(alpha2)-
122*cosd(alpha2)*omega2;
P = vpasolve(q3,q4);
v = P.v;
omega2 = P.omega2;
% 对矢量方程求二阶导
% 虚功率求解 Mb
syms Mbb;
eq1 = Mbb*omega1-M3*omega2;
Mb(iterTime) = vpasolve(eq1);
%隔离12求解各约束反力
syms Rcxx Rcyy FF
%对 C 点取矩
eq1 = -M3+FF*122;
```

```
% 水平方向合力为 0
eq2 = Rcxx-FF*sind(alpha2);
% 竖直方向合力为 0
eq3 = Rcyy+FF*cosd(alpha2);
L = vpasolve(eq1,eq2,eq3);
Rcx(iterTime) = L.Rcxx;
Rcxx = L.Rcxx;
Rcy(iterTime) = L.Rcyy;
Rcyy = L.Rcyy;
F(iterTime) = L.FF;
FF = L.FF;
syms Rayy Raxx
% 对 A 点取矩
eq4 = Mbb-FF*l1*cosd(alpha1(iterTime)-alpha2);% 自动满足 无需计算
% 水平方向合力为 0
eq5 = Raxx+FF*sind(alpha2);
% 竖直方向合力为 0
eq6 = Rayy-FF*cosd(alpha2);
N = vpasolve(eq5,eq6);
Rax(iterTime) = N.Raxx;
Ray(iterTime) = N.Rayy;
end
figure(1)
plot(alpha1, Rax,'-*');
title('导杆机构 支座A水平方向的约束反力');
xlabel('alpha1(°)');
ylabel('Rax(N)');
```

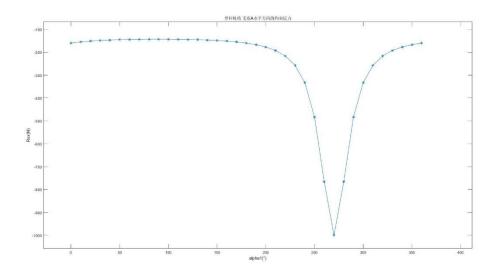
```
figure(2)
plot(alpha1, Ray,'-o');
title('导杆机构 支座A铅垂方向的约束反力');
xlabel('alpha1(°)');
ylabel('Ray(N)');
figure(3)
plot(alpha1, F,'-^');
title('导杆机构 移动副的约束反力');
xlabel('alpha1(°)');
ylabel('F(N)');
figure(4)
plot(alpha1, Rcx,'-*');
title('导杆机构 支座C水平方向的约束反力');
xlabel('alpha1(°)');
ylabel('Rcx(N)');
figure(5)
plot(alpha1, Rcy,'-o');
title('导杆机构 支座 C 铅垂方向的约束反力');
xlabel('alpha1(°)');
ylabel('Rcy(N)');
figure(6)
plot(alpha1, Mb,'-^');
title('导杆机构 应加于曲柄1上的Mb');
xlabel('alpha1(°)');
ylabel('Mb(N*m)');
```

(3)结果与数据:

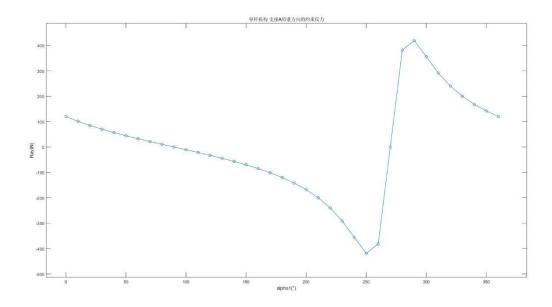
				导杆机;	 构 支座A水-	平方向的约	東反力				
0				\J 11 1/10	19 文庄/ (7)	1 /11-14122					
-160											
10	20	30	40	50	60	70	80	90	100	110	120
-154.999	-151.349	-148.649	-146.644	-145.168	-144.111	-143.401	-142.991	-142.857	-142.991	-143.401	-144.111
130	140	150	160	170	180	190	200	210	220	230	240
-145.168	-146.644	-148.649	-151.349	-154.999	-160	-167.002	-177.11	-192.308	-216.402	-257.276	-332.573
250	260	270		290	300	310	320	330	340	350	360
-482.526	-766.207	-1000	-766.207	-482.526	-332.573	-257.276	-216.402	-192.308	-177.11	-167.002	-160
				E#T#n:	构 支座A铅	五七七<i>仏外</i>	まらも				
0				寸竹机/	的 文座Afa	並 刀 回的约					
120											
10	20	30	40	50	60	70	80	90	100	110	120
101.2914	84.89029	70.21828	56.84663	44.44762	32.7621	21.57737	10.71122	-2.29E-38	-10.7112	-21.5774	-32.7621
130	140	150	160	170	180	190	200	210	220	230	240
-44.4476	-56.8466	-70.2183	-84.8903	-101.291	-120	-141.818	-167.887	-199.852	-240.062	-291.517	-355.839
250	260	270	280	290	300	310	320	330	340	350	360
-419.249	-381.752	5.20E-34	381.7523	419.249	355.8389	291.5166	240.0616	199.852	167.887	141.8184	120
					-1-1/	=1///	- 1				
0				与	汗机构 移动	副的约束及	ス 刀	1			
200											
10	20	30	40	50	60	70	80	90	100	110	120
185.1612	173.5304	164.399			147.7884	145.0149			143.3916		147.7884
130	140	150	160	170	180	145.0149	200	210	220	230	240
151.8203	157.2768	164.399		185.1612	200		244.0366	277.3501	323.2018		487.0585
250	260			290	300	310	320	330	340	350	360
639.2188		1000					323.2018				200
000.2100	000.0121	1000	000.0121	000.2100	101.0000	000.0000	020.2010	211.0001	211.0000	210.0001	200
				导杆机	构 支座C水	平方向的约	束反力				
0				导杆机	构 支座C水	平方向的约	束反力				
160	20	20	40	2				00	100	110	120
160 10	20	30	40	50	60	70	80	90	100	110	120
160 10 154.9991	151.3487	148.6486	146.644	50 145.1682	60	70 143.4007	80 142.991	142.8571	142.991	143.4007	144.1112
160 10 154.9991 130	151.3487 140	148.6486 150	146.644 160	50 145.1682 170	60 144.1112 180	70 143.4007 190	80 142.991 200	142.8571 210	142.991 220	143.4007 230	144.1112 240
160 10 154.9991 130 145.1682	151.3487 140 146.644	148.6486 150 148.6486	146.644 160 151.3487	50 145.1682 170 154.9991	60 144.1112 180 160	70 143.4007 190 167.0018	80 142.991 200 177.1096	142.8571 210 192.3077	142.991 220 216.402	143.4007 230 257.2765	144.1112 240 332.5727
160 10 154.9991 130 145.1682 250	151.3487 140 146.644 260	148.6486 150 148.6486 270	146.644 160 151.3487 280	50 145.1682 170 154.9991 290	60 144.1112 180 160 300	70 143.4007 190 167.0018 310	80 142.991 200 177.1096 320	142.8571 210 192.3077 330	142.991 220 216.402 340	143.4007 230 257.2765 350	144.1112 240 332.5727 360
160 10 154.9991 130 145.1682	151.3487 140 146.644	148.6486 150 148.6486	146.644 160 151.3487	50 145.1682 170 154.9991	60 144.1112 180 160 300	70 143.4007 190 167.0018	80 142.991 200 177.1096	142.8571 210 192.3077	142.991 220 216.402	143.4007 230 257.2765	144.1112 240 332.5727
160 10 154.9991 130 145.1682 250	151.3487 140 146.644 260	148.6486 150 148.6486 270	146.644 160 151.3487 280	50 145.1682 170 154.9991 290	60 144.1112 180 160 300	70 143.4007 190 167.0018 310	80 142.991 200 177.1096 320	142.8571 210 192.3077 330	142.991 220 216.402 340	143.4007 230 257.2765 350	144.1112 240 332.5727 360
160 10 154.9991 130 145.1682 250 482.5256	151.3487 140 146.644 260	148.6486 150 148.6486 270	146.644 160 151.3487 280	50 145.1682 170 154.9991 290 482.5256	60 144.1112 180 160 300	70 143.4007 190 167.0018 310 257.2765	80 142.991 200 177.1096 320 216.402	142.8571 210 192.3077 330	142.991 220 216.402 340	143.4007 230 257.2765 350	144.1112 240 332.5727 360
160 10 154.9991 130 145.1682 250 482.5256	151.3487 140 146.644 260	148.6486 150 148.6486 270	146.644 160 151.3487 280	50 145.1682 170 154.9991 290 482.5256	60 144.1112 180 160 300 332.5727	70 143.4007 190 167.0018 310 257.2765	80 142.991 200 177.1096 320 216.402	142.8571 210 192.3077 330	142.991 220 216.402 340	143.4007 230 257.2765 350	144.1112 240 332.5727 360
160 10 154.9991 130 145.1682 250 482.5256	151.3487 140 146.644 260 766.207	148.6486 150 148.6486 270 1000	146.644 160 151.3487 280 766.207	50 145.1682 170 154.9991 290 482.5256	60 144.1112 180 160 300 332.5727 构 支座C铅	70 143.4007 190 167.0018 310 257.2765	80 142.991 200 177.1096 320 216.402	142.8571 210 192.3077 330 192.3077	142.991 220 216.402 340 177.1096	143.4007 230 257.2765 350 167.0018	144.1112 240 332.5727 360 160
160 10 154.9991 130 145.1682 250 482.5256	151.3487 140 146.644 260 766.207	148.6486 150 148.6486 270 1000	146.644 160 151.3487 280 766.207	50 145.1682 170 154.9991 290 482.5256 导杆机	60 144.1112 180 160 300 332.5727 构 支座C铅	70 143.4007 190 167.0018 310 257.2765 垂方向的约	80 142.991 200 177.1096 320 216.402 束反力	142.8571 210 192.3077 330 192.3077	142.991 220 216.402 340 177.1096	143.4007 230 257.2765 350 167.0018	144.1112 240 332.5727 360 160
160 10 154.9991 130 145.1682 250 482.5256 0 -120 10 -101.291	151.3487 140 146.644 260 766.207	148.6486 150 148.6486 270 1000 30 -70.2183	146.644 160 151.3487 280 766.207	50 145.1682 170 154.9991 290 482.5256 导杆机.	60 144.1112 180 160 300 332.5727 构 支座C铅 60 -32.7621	70 143.4007 190 167.0018 310 257.2765 垂方向的约	80 142.991 200 177.1096 320 216.402 東反力 80 -10.7112	142.8571 210 192.3077 330 192.3077	142.991 220 216.402 340 177.1096	143.4007 230 257.2765 350 167.0018 110 21.57737	144.1112 240 332.5727 360 160 120 32.7621
160 10 154.9991 130 145.1682 250 482.5256 0 -120 10 -101.291	151.3487 140 146.644 260 766.207 20 -84.8903 140	148.6486 150 148.6486 270 1000 30 -70.2183	146.644 160 151.3487 280 766.207 40 -56.8466 160	50 145.1682 170 154.9991 290 482.5256 导杆机 50 -44.4476 170	60 144.1112 180 160 300 332.5727 构 支座C铅 60 -32.7621 180	70 143.4007 190 167.0018 310 257.2765 垂方向的约 70 -21.5774 190	80 142.991 200 177.1096 320 216.402 束反力 80 -10.7112 200	142.8571 210 192.3077 330 192.3077 90 2.29E-38 210	142.991 220 216.402 340 177.1096 10.71122 220	143.4007 230 257.2765 350 167.0018 110 21.57737 230	144.1112 240 332.5727 360 160 120 32.7621 240
160 10 154.9991 130 145.1682 250 482.5256 0 -120 10 -101.291 130 44.44762	151.3487 140 146.644 260 766.207 20 -84.8903 140 56.84663	148.6486 150 148.6486 270 1000 30 -70.2183 150 70.21828	146.644 160 151.3487 280 766.207 40 -56.8466 160 84.89029	50 145.1682 170 154.9991 290 482.5256 导杆机 50 -44.4476 170	60 144.1112 180 160 300 332.5727 构 支座C铅 60 -32.7621 180 120	70 143.4007 190 167.0018 310 257.2765 垂方向的约 70 -21.5774 190 141.8184	80 142.991 200 177.1096 320 216.402 束反力 80 -10.7112 200 167.887	142.8571 210 192.3077 330 192.3077 90 2.29E-38 210 199.852	142.991 220 216.402 340 177.1096 10.71122 220 240.0616	143.4007 230 257.2765 350 167.0018 110 21.57737 230 291.5166	144.1112 240 332.5727 360 160 120 32.7621 240 355.8389
160 10 154.9991 130 145.1682 250 482.5256 0 -120 10 -101.291 130 44.44762	151.3487 140 146.644 260 766.207 20 -84.8903 140 56.84663 260	148.6486 150 148.6486 270 1000 30 -70.2183 150 70.21828	146.644 160 151.3487 280 766.207 40 -56.8466 160 84.89029 280	50 145.1682 170 154.9991 290 482.5256 导杆机 50 -44.4476 170 101.2914 290	60 144.1112 180 300 332.5727 构 支座C铅 60 -32.7621 180 120 300	70 143.4007 190 167.0018 310 257.2765 垂方向的约 -21.5774 190 141.8184 310	80 142.991 200 177.1096 320 216.402 束反力 80 -10.7112 200 167.887 320	142.8571 210 192.3077 330 192.3077 90 2.29E-38 210 199.852 330	142.991 220 216.402 340 177.1096 10.71122 220 240.0616 340	143.4007 230 257.2765 350 167.0018 110 21.57737 230 291.5166 350	144.1112 240 332.5727 360 160 120 32.7621 240 355.8389 360
160 10 154.9991 130 145.1682 250 482.5256 0 -120 10 -101.291 130 44.44762	151.3487 140 146.644 260 766.207 20 -84.8903 140 56.84663 260	148.6486 150 148.6486 270 1000 30 -70.2183 150 70.21828	146.644 160 151.3487 280 766.207 40 -56.8466 160 84.89029	50 145.1682 170 154.9991 290 482.5256 导杆机 50 -44.4476 170 101.2914 290	60 144.1112 180 300 332.5727 构 支座C铅 60 -32.7621 180 120 300	70 143.4007 190 167.0018 310 257.2765 垂方向的约 -21.5774 190 141.8184 310	80 142.991 200 177.1096 320 216.402 束反力 80 -10.7112 200 167.887	142.8571 210 192.3077 330 192.3077 90 2.29E-38 210 199.852 330	142.991 220 216.402 340 177.1096 10.71122 220 240.0616 340	143.4007 230 257.2765 350 167.0018 110 21.57737 230 291.5166 350	144.1112 240 332.5727 360 160 120 32.7621 240 355.8389
160 10 154.9991 130 145.1682 250 482.5256 0 -120 10 -101.291 130 44.44762	151.3487 140 146.644 260 766.207 20 -84.8903 140 56.84663 260	148.6486 150 148.6486 270 1000 30 -70.2183 150 70.21828	146.644 160 151.3487 280 766.207 40 -56.8466 160 84.89029 280	50 145.1682 170 154.9991 290 482.5256 导杆机 50 -44.4476 170 101.2914 290	60 144.1112 180 300 332.5727 构 支座C铅 60 -32.7621 180 120 300	70 143.4007 190 167.0018 310 257.2765 垂方向的约 -21.5774 190 141.8184 310	80 142.991 200 177.1096 320 216.402 束反力 80 -10.7112 200 167.887 320	142.8571 210 192.3077 330 192.3077 90 2.29E-38 210 199.852 330	142.991 220 216.402 340 177.1096 10.71122 220 240.0616 340	143.4007 230 257.2765 350 167.0018 110 21.57737 230 291.5166 350	144.1112 240 332.5727 360 160 120 32.7621 240 355.8389 360
160 10 154.9991 130 145.1682 250 482.5256 0 -120 10 -101.291 130 44.44762 250 419.249	151.3487 140 146.644 260 766.207 20 -84.8903 140 56.84663 260	148.6486 150 148.6486 270 1000 30 -70.2183 150 70.21828	146.644 160 151.3487 280 766.207 40 -56.8466 160 84.89029 280	50 145.1682 170 154.9991 290 482.5256 导杆机。 50 -44.4476 170 101.2914 290 -419.249	60 144.1112 180 300 332.5727 构 支座C铅 60 -32.7621 180 120 300	70 143.4007 190 167.0018 310 257.2765 垂方向的约 -21.5774 190 141.8184 310 -291.517	80 142.991 200 177.1096 320 216.402 東反力 80 -10.7112 200 167.887 320 -240.062	142.8571 210 192.3077 330 192.3077 90 2.29E-38 210 199.852 330	142.991 220 216.402 340 177.1096 10.71122 220 240.0616 340	143.4007 230 257.2765 350 167.0018 110 21.57737 230 291.5166 350	144.1112 240 332.5727 360 160 120 32.7621 240 355.8389 360
160 10 154.9991 130 145.1682 250 482.5256 0 -120 10 -101.291 130 44.44762 250 419.249	151.3487 140 146.644 260 766.207 20 -84.8903 140 56.84663 260	148.6486 150 148.6486 270 1000 30 -70.2183 150 70.21828	146.644 160 151.3487 280 766.207 40 -56.8466 160 84.89029 280	50 145.1682 170 154.9991 290 482.5256 导杆机。 50 -44.4476 170 101.2914 290 -419.249	60 144.1112 180 160 300 332.5727 构 支座C铅 60 -32.7621 180 120 300 -355.839	70 143.4007 190 167.0018 310 257.2765 垂方向的约 -21.5774 190 141.8184 310 -291.517	80 142.991 200 177.1096 320 216.402 東反力 80 -10.7112 200 167.887 320 -240.062	142.8571 210 192.3077 330 192.3077 90 2.29E-38 210 199.852 330	142.991 220 216.402 340 177.1096 10.71122 220 240.0616 340	143.4007 230 257.2765 350 167.0018 110 21.57737 230 291.5166 350	144.1112 240 332.5727 360 160 120 32.7621 240 355.8389 360
160 10 154.9991 130 145.1682 250 482.5256 0 -120 10 -101.291 130 44.44762 250 419.249	151.3487 140 146.644 260 766.207 20 -84.8903 140 56.84663 260 381.7523	148.6486 150 148.6486 270 1000 30 -70.2183 150 70.21828 270 -5.20E-34	146.644 160 151.3487 280 766.207 40 -56.8466 160 84.89029 280 -381.752	50 145.1682 170 154.9991 290 482.5256 导杆机: 50 -44.4476 170 101.2914 290 -419.249	60 144.1112 180 160 300 332.5727 构 支座C铅 60 -32.7621 180 120 300 -355.839	70 143.4007 190 167.0018 310 257.2765 垂方向的约 -21.5774 190 141.8184 310 -291.517	80 142.991 200 177.1096 320 216.402 東反力 80 -10.7112 200 167.887 320 -240.062	90 2.29E-38 210 199.852 330	142.991 220 216.402 340 177.1096 10.71122 220 240.0616 340 -167.887	143.4007 230 257.2765 350 167.0018 110 21.57737 230 291.5166 350 -141.818	144.1112 240 332.5727 360 160 120 32.7621 240 355.8389 360 -120
160 10 154.9991 130 145.1682 250 482.5256 0 -120 10 -101.291 130 44.44762 250 419.249	20 -84.8903 260 381.7523	30 -70.2183 270 -5.20E-34	146.644 160 151.3487 280 766.207 40 -56.8466 160 84.89029 280 -381.752	50 145.1682 170 154.9991 290 482.5256 导杆机 50 -44.4476 170 101.2914 290 -419.249	60 144.1112 180 300 332.5727 构 支座C铅 60 -32.7621 180 120 300 -355.839	70 143.4007 190 167.0018 310 257.2765 垂方向的约 -21.5774 190 141.8184 310 -291.517	80 142.991 200 177.1096 320 216.402 i束反力 80 -10.7112 200 167.887 320 -240.062	90 2.29E-38 2199.852 330 -199.852	142.991 220 216.402 340 177.1096 10.71122 220 240.0616 340 -167.887	143.4007 230 257.2765 350 167.0018 110 21.57737 230 291.5166 350 -141.818	144.1112 240 332.5727 360 160 120 32.7621 240 355.8389 360 -120
160 10 154.9991 130 145.1682 250 482.5256 0 -120 10 -101.291 130 44.44762 250 419.249 0 36 10 38.00037	20 -84.8903 260 381.7523	148.6486 150 148.6486 270 1000 30 -70.2183 150 70.21828 270 -5.20E-34	146.644 160 151.3487 280 766.207 40 -56.8466 160 84.89029 280 -381.752	50 145.1682 170 154.9991 290 482.5256 导杆机 50 -44.4476 170 101.2914 290 -419.249	60 144.1112 180 300 332.5727 构 支座C铅 60 -32.7621 180 120 300 -355.839 机构 应加=	70 143.4007 190 167.0018 310 257.2765 垂方向的约 -21.5774 190 141.8184 310 -291.517 F曲柄1上的	80 142.991 200 177.1096 320 216.402 i束反力 80 -10.7112 200 167.887 320 -240.062 iMb	90 2.29E-38 2199.852 330 -199.852 90 42.85714	142.991 220 216.402 340 177.1096 10.71122 220 240.0616 340 -167.887	143.4007 230 257.2765 350 167.0018 110 21.57737 230 291.5166 350 -141.818	144.1112 240 332.5727 360 160 120 32.7621 240 355.8389 360 -120 120 42.35551
160 10 154.9991 130 145.1682 250 482.5256 0 -120 10 -101.291 130 44.44762 250 419.249 0 36 10 38.00037	20 -84.8903 260 381.7523 20 39.46052	148.6486 150 148.6486 270 1000 30 -70.2183 150 70.21828 270 -5.20E-34 30 40.54054 150	146.644 160 151.3487 280 766.207 40 -56.8466 160 84.89029 280 -381.752 40 41.3424 160	50 145.1682 170 154.9991 290 482.5256 导杆机 50 -44.4476 170 101.2914 290 -419.249	60 144.1112 180 300 332.5727 构 支座C铅 60 -32.7621 180 120 300 -355.839 机构 应加=	70 143.4007 190 167.0018 310 257.2765 垂方向的约 -21.5774 190 141.8184 310 -291.517 F曲柄1上的	80 142.991 200 177.1096 320 216.402 束反力 80 -10.7112 200 167.887 320 -240.062	90 2.29E-38 210 199.852 330 -199.852 90 42.85714 210	142.991 220 216.402 340 177.1096 10.71122 220 240.0616 340 -167.887 100 42.80359 220	143.4007 230 257.2765 350 167.0018 110 21.57737 230 291.5166 350 -141.818 110 42.63973 230	144.1112 240 332.5727 360 160 120 32.7621 240 355.8389 360 -120 120 42.35551 240
160 10 154.9991 130 145.1682 250 482.5256 0 -120 10 -101.291 130 44.44762 250 419.249 0 36 10 38.00037 130 41.93271	151.3487 140 146.644 260 766.207 20 -84.8903 140 56.84663 260 381.7523 20 39.46052 140 41.3424	30 -70.21828 -5.20E-34 -30 -40.54054 -150 -40.54054	146.644 160 151.3487 280 766.207 40 -56.8466 160 84.89029 280 -381.752 40 41.3424 160 39.46052	50 145.1682 170 154.9991 290 482.5256 导杆机 50 -44.4476 170 101.2914 290 -419.249 50 41.93271 170 38.00037	60 144.1112 180 160 300 332.5727 构 支座C铅 60 -32.7621 180 120 300 -355.839 机构 应加=	70 143.4007 190 167.0018 310 257.2765 垂方向的约 -21.5774 190 141.8184 310 -291.517 F曲柄1上的 42.63973 190 33.19928	80 142.991 200 177.1096 320 216.402 216.402 217.7112 200 167.887 320 -240.062 9Mb	90 2.29E-38 210 199.852 330 -199.852 330 -199.852 210 23.07692	142.991 220 216.402 340 177.1096 107.1122 220 240.0616 340 -167.887 100 42.80359 220 13.43921	143.4007 230 257.2765 350 167.0018 110 21.57737 230 291.5166 350 -141.818 110 42.63973 230 -2.91059	144.1112 240 332.5727 360 160 120 32.7621 240 355.8389 -120 42.35551 240 -33.0291
160 10 154.9991 130 145.1682 250 482.5256 0 -120 10 -101.291 130 44.44762 250 419.249 0 36 10 38.0037 130 41.93271 250	20 -84.8903 260 381.7523 20 39.46052	148.6486 150 148.6486 270 1000 30 -70.2183 150 70.21828 270 -5.20E-34 30 40.54054 150 40.54054 270	146.644 160 151.3487 280 766.207 40 -56.8466 160 84.89029 280 -381.752 40 41.3424 160 39.46052	50 145.1682 170 154.9991 290 482.5256 导杆机 50 -44.4476 170 101.2914 290 -419.249 50 41.93271 170 38.00037 290	60 144.1112 180 300 332.5727 构 支座C铅 60 -32.7621 180 120 300 -355.839 机构 应加= 60 42.35551 180 36 300	70 143.4007 190 167.0018 310 257.2765 垂方向的约 -21.5774 190 141.8184 310 -291.517 F曲柄1上的 42.63973 190 33.19928 310	80 142.991 200 177.1096 320 216.402 東反力 80 -10.7112 200 167.887 320 -240.062 9Mb	90 2.29E-38 -199.852 -199.852 -207 -207 -207 -207 -207 -207 -207 -20	142.991 220 216.402 340 177.1096 107.1122 220 240.0616 340 -167.887 100 42.80359 220 13.43921 340	143.4007 230 257.2765 350 167.0018 110 21.57737 230 291.5166 350 -141.818 110 42.63973 230 -2.91059 350	144.1112 240 332.5727 360 160 120 32.7621 240 355.8389 360 -120 120 42.35551 240

图表 1-运用 matlab 所分析的导杆机构的各项数据

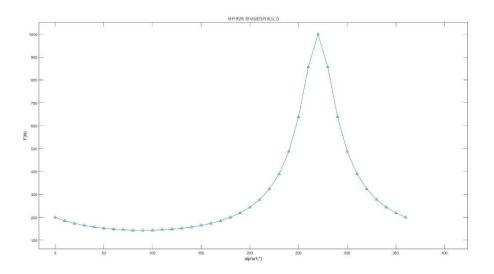
(4) 图表分析:



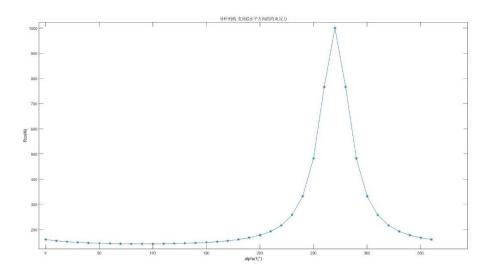
图表 2-导杆机构 支座 A 水平方向的约束反力与杆 a 转过的角度的关系



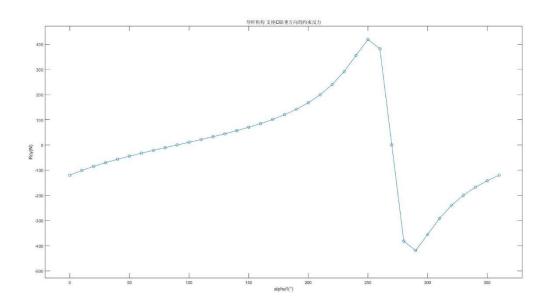
图表 3-导杆机构 支座 A 铅垂方向的约束反力与杆 a 转过的角度的关系



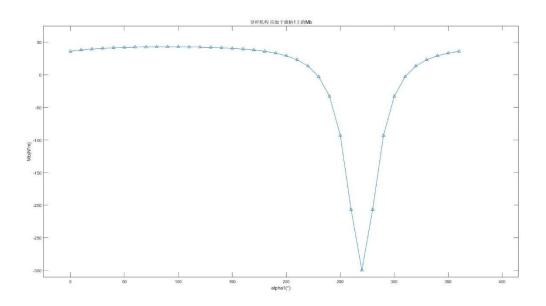
图表 4-导杆机构 移动副的约束反力与杆 a 转过的角度的关系



图表 5-导杆机构 支座 C 水平方向的约束反力与杆 a 转过的角度的关系



图表 6-导杆机构 支座 C 铅垂方向的约束反力与杆 a 转过的角度的关系



图表 7-导杆机构 应加于曲柄 1 上的 Mb 与杆 a 转过的角度的关系

(6)结果分析:

导杆机构在 a 杆转到 240°~300°左右处时,各运动副的约束反力会发生突变,且会随杆的长度的变化发生指数式突变,应合理设计杆的尺寸与材料防止材料失效或断裂。