Requirements:

-Transmits 25 hp
-Mechanical effeciency of 95%
-Small and compact
-Operates 16hrs, 5 days per week for 5 years
-Rigid housing with proper mounting
-Withstand up to 100 degrees farenheit
-Moderate cost
-Can produce 5000 units per year
-Low noise and vibration

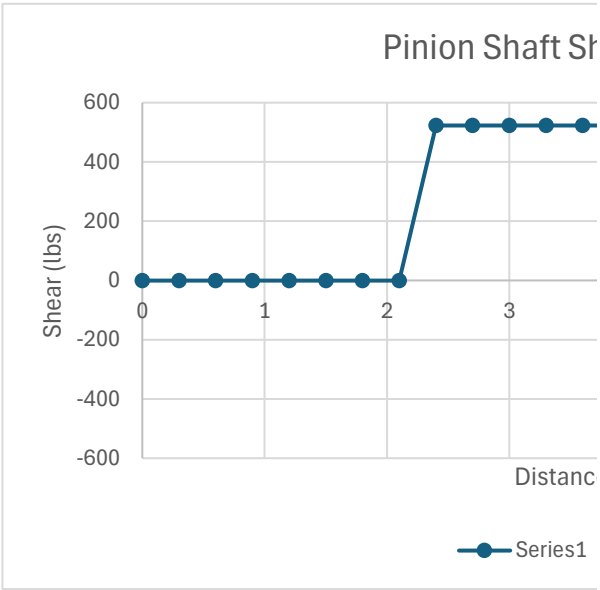
Variables(pinion)	
Rm	0
Rblp	523.0494129
Rbrp	508.6354143
Fgp	1031.684827
dRbl	2.138
dFg	3.90238
dRbr	5.71676

Gear weights		
Gear(lbs)	93.25554	
Pinion(lbs)	8.443705	

Reaction Forces(Pinion)	
Rbrp(lbs)	508.6354143
Rblp(lbs)	523.0494129

lbs
lbs
lbs
in
in
in

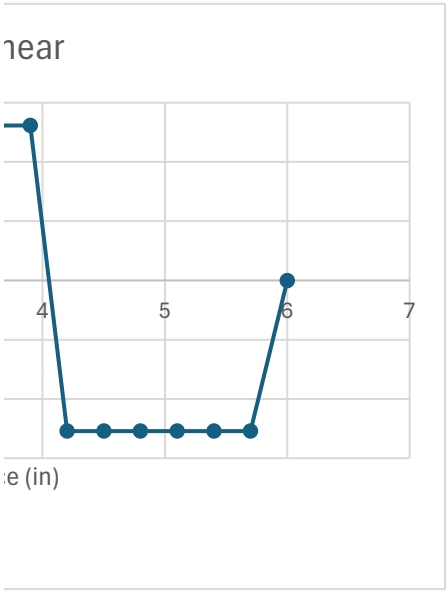
Pinion Shaft		
Load Diagram		
x(m)	Rm<x-0>^0	Rbl<x-dRbl>^0
0	0	0
0.3	0	0
0.6	0	0
0.9	0	0
1.2	0	0
1.5	0	0
1.8	0	0
2.1	0	0
2.4	0	523.0494129
2.7	0	523.0494129
3	0	523.0494129
3.3	0	523.0494129
3.6	0	523.0494129
3.9	0	523.0494129
4.2	0	523.0494129
4.5	0	523.0494129
4.8	0	523.0494129
5.1	0	523.0494129
5.4	0	523.0494129
5.7	0	523.0494129
6	0	523.0494129

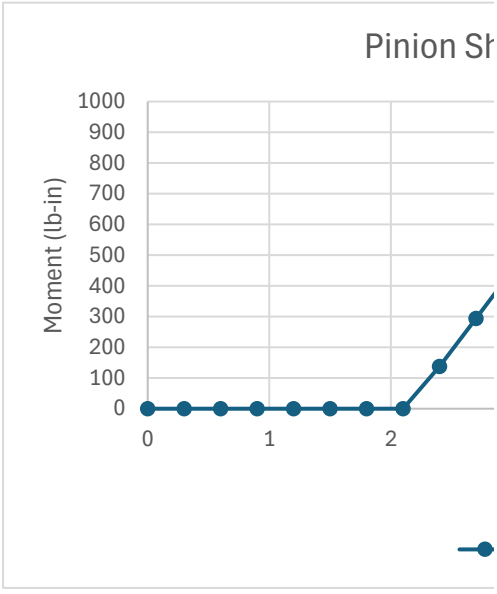


Fg<x-dFg>^0	Rbr<x-dRbr>^0	V(x) (lb)
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	523.0494
0	0	523.0494
0	0	523.0494
0	0	523.0494
0	0	523.0494
0	0	523.0494
-1031.684827	0	-508.635
-1031.684827	0	-508.635
-1031.684827	0	-508.635
-1031.684827	0	-508.635
-1031.684827	0	-508.635
-1031.684827	0	-508.635
-1031.684827	508.6354143	0

Locations for Shaft Analysis

	Moment Diagram		
	x(m)	Rm<x-0>^1	Rbl<x-dRbl>^1
A	1	0	0
B	2.276	0	72.18081898
C	3.90238	0	922.8579231
	0	0	0
	0.3	0	0
	0.6	0	0
	0.9	0	0
	1.2	0	0
	1.5	0	0
	1.8	0	0
	2.1	0	0
	2.4	0	137.0389462
	2.7	0	293.95377
	3	0	450.8685939
	3.3	0	607.7834177
	3.6	0	764.6982416
	3.9	0	921.6130655
	4.2	0	1078.527889
	4.5	0	1235.442713
	4.8	0	1392.357537
	5.1	0	1549.272361
	5.4	0	1706.187185
	5.7	0	1863.102009
	6	0	2020.016832

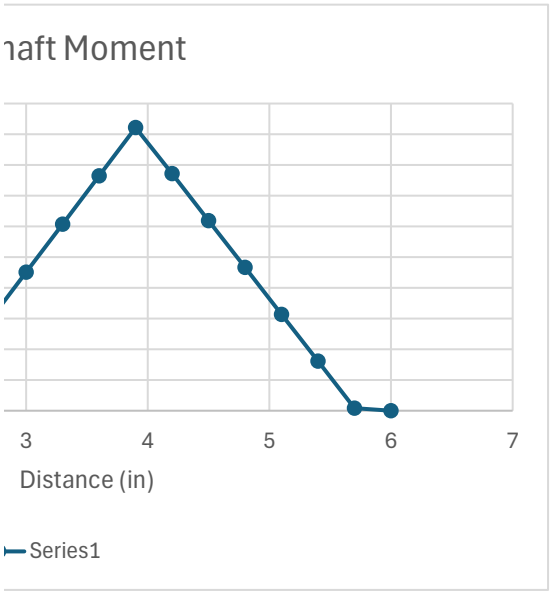


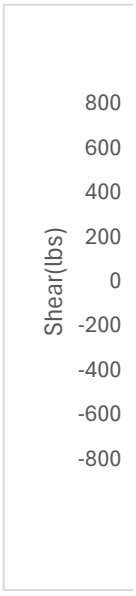


Fg<x-dFg>^1	Rbr<x-dRbr>^1	M(x) (lb-in)
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	137.03895
0	0	293.95377
0	0	450.86859
0	0	607.78342
0	0	764.69824
0	0	921.61307
-307.0500383	0	771.47785
-616.5554864	0	618.88723
-926.0609346	0	466.2966
-1235.566383	0	313.70598
-1545.071831	0	161.11535
-1854.577279	0	8.5247295
-2164.082727	144.0658948	0
0	0	0
0	0	72.180819
0	0	922.85792

Variables(Gear)		
Rm	0	
Rblg	566.047797	lbs
Rbrg	550.4488652	lbs
Fgg	1116.496662	lbs
dRbl	2.438	in
dFg	4.00553	in
dRbr	5.8000205	in

Reaction Forces(Gear)	
Rbrg(lbs)	550.4488652
Rblg(lbs)	566.047797





Gear Shaft

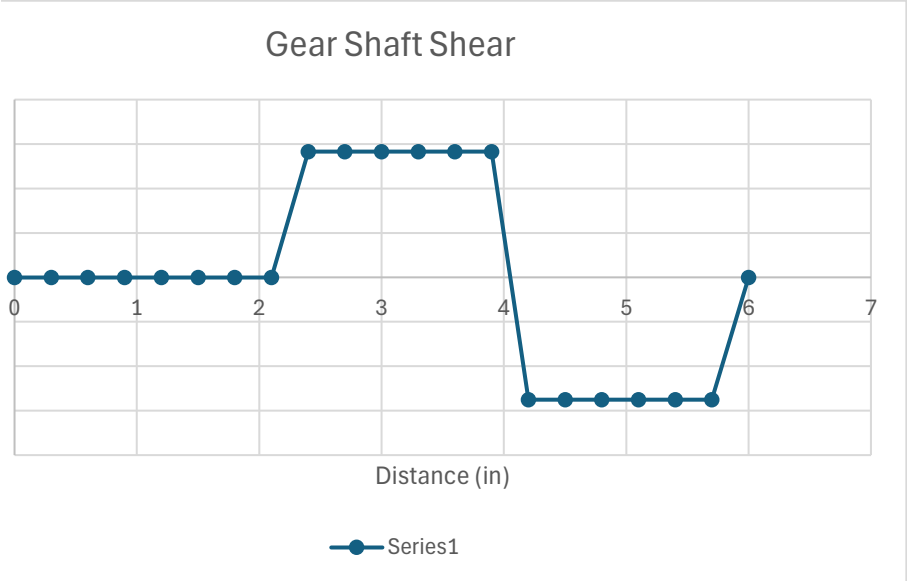
Load Diagram

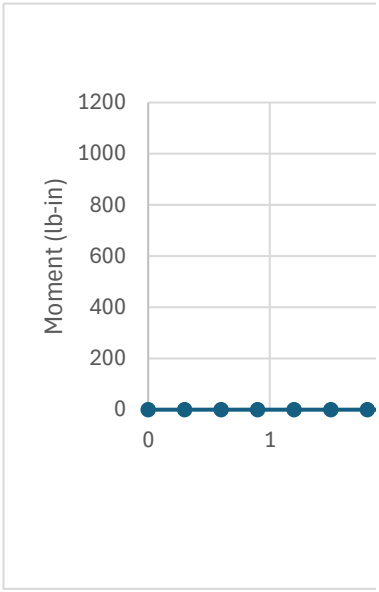
x(m)	Rm<x-0>^0	Rbl<x-dRbl	Fg<x-dFg>^	Rbr<x-dRbr	V(x) (lb)
0	0	0	0	0	0
0.3	0	0	0	0	0
0.6	0	0	0	0	0
0.9	0	0	0	0	0
1.2	0	0	0	0	0
1.5	0	0	0	0	0
1.8	0	0	0	0	0
2.1	0	0	0	0	0
2.4	0	566.0478	0	0	566.047797
2.7	0	566.0478	0	0	566.047797
3	0	566.0478	0	0	566.047797
3.3	0	566.0478	0	0	566.047797
3.6	0	566.0478	0	0	566.047797
3.9	0	566.0478	0	0	566.047797
4.2	0	566.0478	-1116.5	0	-550.4488652
4.5	0	566.0478	-1116.5	0	-550.4488652
4.8	0	566.0478	-1116.5	0	-550.4488652
5.1	0	566.0478	-1116.5	0	-550.4488652
5.4	0	566.0478	-1116.5	0	-550.4488652
5.7	0	566.0478	-1116.5	0	-550.4488652
6	0	566.0478	-1116.5	550.4489	0

Locations for Shaft Analysis		
A	1	0
B	2.576	0
C	4.00553	0

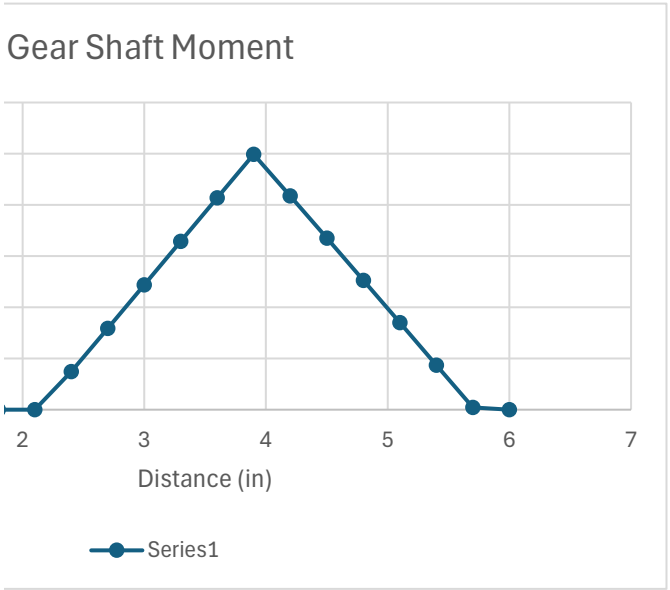
Moment Diagram

x(m)	Rm<x-0>^1
0	0
0.3	0
0.6	0
0.9	0
1.2	0
1.5	0
1.8	0
2.1	0
2.4	0
2.7	0
3	0
3.3	0
3.6	0
3.9	0
4.2	0
4.5	0
4.8	0
5.1	0
5.4	0
5.7	0
6	0





Rbl<x-dRbl	Fg<x-dFg>^	Rbr<x-dRbr	M(x) (lb-in)
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
148.3045	0	0	148.3045
318.1189	0	0	318.1189
487.9332	0	0	487.9332
657.7475	0	0	657.7475
827.5619	0	0	827.5619
997.3762	0	0	997.3762
1167.191	-332.292	0	834.8988
1337.005	-667.241	0	669.7642
1506.819	-1002.19	0	504.6295
1676.634	-1337.14	0	339.4948
1846.448	-1672.09	0	174.3602
2016.262	-2007.04	0	9.225523
2186.077	-2341.99	155.9091	0
0	0	0	0
247.9289	0	0	247.9289
1057.111	-115.167	0	941.9446



	Gear Requirements	
Input Power	P(hp)	25
Efficiency	eta	95%
Output Power	Po(hp)	25
Input Speed	np(rpm)	1750
Output Speed	ng(rpm)	500
Minimum Transmitted Torque	Tsm(lbf*in)	2950

183.259571

52.359878

Using SSG module
from KHK spure gea
(pg. 69)

Life(years)	5
days/week	5
weeks/year	52
hrs/day	16
Pinion Life Hours	20800

Bending Stress		Pinion	Gear
Bending Geometry Factor	Jp	0.341875	0.283125
Quality Factor	Qv	10	
Factor for Calculating Kv	B	0.3968503	
Factor for Calculating Kv	A	83.776385	
Dynamic Factor	Kv	0.9427001	
Load Distribution Factor	Km	1.6	
Application Factor	Ka	1	
Size Factor	Ks	1	
Rim Thickness Factor (pinion)	KB	1	
Rim Thickness	tR(in)	1	
Whole Depth	ht(in)	1	
Rim-Tooth Ratio	mB	1	
Bending Stress	Sb(psi)	5859.8691	7075.824302
Life Cycles	NL	2.184E+09	624000000
Bending Fatigue Strength	Sfb'	3.94E+04	6.26E+04
Life Curve Constant	A	1	
Life Curve Exponent	B	1	
Life Factor	KL	0.9246065	0.550285368
Temperature Factor	KT	1	
Reliability	R	99%	
Reliability Factor	KR	1	
Adjusted Bending Fatigue Strength	Sfb(psi)	3.64E+04	3.44E+04
Saftey Factor Against Fatigue Failure		6.217E+00	4.867E+00

rad/s

rad/s

5 ground spur gear
ar catalog

	Input Data	
Diametral Pitch	pd	5.079997
# of Pinion Teeth	Np	20
Pressure Angle (deg)	phi	20
	Face Width Requirements	
	min	nom
8/pd<F<16/pd; Nom: 12/pd	1.574804	2.362206
Face Width	F	1.9685
Gear Ratio	mG	3.5
Calculated # of Gear Teeth	NG	70
Selected # of Gear Teeth	NG	70

Material	S45C Steel	
Sut	99600	psi
HB	230	
Induction Hardened Teeth		
Grade 2		

*No Rim

(100*HB+16400)

*Use case carborized curve

*Less than 250F

*Table 12-19

	Surface Stress	Pinion
Surface Geometry Factor	I	0.142637
Radius of Curvature - Pinion	rhop	1.758467
Radius of Curvature - Gear	rhog	6.328651
Elastic Coefficient	Cp(psi^1/2)	2300
	Cm=Km	1.6
	Ca=Ka	1
	Cv=Kv	0.9427
	Cs=Ks	1
Surface Finish Coefficient	Cf	0.906453
Surface Stress	Sc(psi)	58029.23
Surface Fatigue Strength	Sfc'(psi)	128530
Life Curve Constant	A	2.466
Life Curve Exponent	b	-0.056
Life Factor	CL	0.739597
Hardness(BH)	HBp	270
Hardness Ratio	HBp/HBg	1
Hardness Factor	CH	1
Temperature Factpr	CT=KT	1
Reliability	CR=KR	1
AdjustedSurface Fatigue Strength	Sfc(psi)	95060.36
Saftey Factor Against Surface Failure		2.683523

max
3.149608

	Gearing Calculations	
Pinion Pitch Diameter(in)	dp	3.93701
Gear Pitch Diameter(in)	dg	13.779535
Center Distance(in)	C	8.8582725
Tangential Force on Gear(lbs)	Wt	457.38378
Pitch Line Velocity(ft/s)	Vt	180.37369
Radial Force (lbs)	Wr	1023.2411

Gear	
2300	Table 11-18 for steel to steel gears
58029.2288	
128530	*fig. 12-27
2.466	
-0.056	
0.79334618	
270	
	*Same material
101968.785	
3.08774116	

nf			1.65	
AISI	1095	Q&T	App. A-9	
Ultimate Stress	Sut		183	ksi
Yeild Stress	Sy		118	ksi

Se'	91.5	ksi

	Neuber Constant	
Bending	sqrt(a)	0.024413
Torsion	sqrt(a)	0.019141

Fatigue Correction Factors				
Load Correction	Cload	1	*Bending only	
Surface Correction Factor	A	2.411	*Refer to L4, slide 25	*Cold Rolled
	b	-0.085		
	Csurf	0.860773459		
Temperature	100 F		*Test for max temp	
	Ctemp	1	*Refer to L4, slide 26	
Reliability	CRel	0.814	*Refer to L4, slide 27	*99% Reliability

*Refer to L4, slide 22 for equation

*Link to Page 1

*Link to Page 1

*Stress concentration chart

*Stress concentration chart

Pinion Shaft		
Initial Shaft Size d(in)	0.787402	Initial Shaft Size d(in)
Csize	0.889	Csize
Se (psi)	57019.45755	Se (psi)
Location	A(Input key)	Location
Ma (lbf*in)	0	Ma (lbf*in)
Mm (lbf*in)	0	Mm (lbf*in)
Ta (lbf*in)	450.1811259	Ta (lbf*in)
Tm (lbf*in)	450.1811259	Tm (lbf*in)
r/d	0.02	r/d
Notch Radius	0.01574804	Notch Radius
qt	0.83714099	qt
qs	0.867658022	qs
Kt	2.14	Kt
Ks	3	Ks
Kf	1.954340729	Kf
Kfs	2.735316045	Kfs
A (in^3)	0.018702616	A (in^3)
B (in^3)	0.005827393	B (in^3)
d (in)	0.74426441	d (in)

Gear Shaft		
Initial Shaft Size d(in)	1.1811	Initial Shaft Size d(in)
Csize	0.855	Csize
Se (psi)	54820.41719	Se (psi)
Location	A(Output Key)	Location
Ma (lbf*in)	0	Ma (lbf*in)
Mm (lbf*in)	0	Mm (lbf*in)
Ta (lbf*in)	1475	Ta (lbf*in)
Tm (lbf*in)	1475	Tm (lbf*in)
r/d	0.02	r/d
Notch Radius	0.023622	Notch Radius
qt	0.862929657	qt
qs	0.889253607	qs
Kt	2.14	Kt
Ks	3	Ks
Kf	1.983739809	Kf
Kfs	2.778507213	Kfs
A (in^3)	0.064742855	A (in^3)
B (in^3)	0.019394701	B (in^3)

d (in)	1.122426678	d (in)

0.787402	Initial Shaft Size d(in)	0.984252
0.889	Csize	0.870
57019.45755	Se (psi)	55798.539
B(LB shoulder)	Location	C(Key)
36.09040949	Ma (lbf*in)	461.42896
36.09040949	Mm (lbf*in)	461.42896
450.1811259	Ta (lbf*in)	450.18113
450.1811259	Tm (lbf*in)	450.18113
0.014999962	r/d	0.02
0.011811	Notch Radius	0.019685
0.816567877	qt	0.8517861
0.850250363	qs	0.8799524
2.7	Kt	2.14
2.2	Ks	3
2.388165391	Kf	1.9710362
2.020300435	Kfs	2.7599049
0.013896182	A (in^3)	0.0252495
0.004329797	B (in^3)	0.0076988
0.674100998	d (in)	0.8211811

Saftey Factors	Pinion	Gear
A	1.953852	1.922516
B	2.629654	2.070312
C	2.841097	1.859181

1.10236	Initial Shaft Size d(in)	1.1811
0.861	Csize	0.855
55188.5227	Se (psi)	54820.417
B(LB shoulder)	Location	C(key)
123.9644675	Ma (lbf*in)	470.97231
123.9644675	Mm (lbf*in)	470.97231
1475	Ta (lbf*in)	1475
1475	Tm (lbf*in)	1475
0.035714376	r/d	0.02
0.0393701	Notch Radius	0.023622
0.89044094	qt	0.8629297
0.912020105	qs	0.8892536
2.7	Kt	2.14
2.2	Ks	3
2.513749598	Kf	1.9837398
2.094424125	Kfs	2.7785072
0.048805033	A (in^3)	0.0669484
0.014718457	B (in^3)	0.0200554

1.02205155	d (in)	1.1350303

Pinion Key		
Variables	1040 Hot Rolled	
w	0.315	off of KHK catalog
h	0.13	off of KHK catalog
Sut	76000	psi
Sy	42000	psi
N	2	
d	0.984252	in
Tmax	900.3622517	
Tmin	0	

Min length based on bearing stress		
Fmax	1829.536037	
L	0.659606045	in

Shear Check	
Ta	450.1811259
Tm	450.1811259
Fa	914.7680185
Fm	914.7680185
Tap	4402.666526
Tmp	4402.666526
Stressa	7625.642111
Stressm	7625.642111

Endurance Limit	
Sep	38000
A95	0.0020475
dequiv	0.1634924
Cload	1
Csurf	1
Ctemp	1
Crel	1
Csize	1
Se	38000

Nf	3.322124611

Input Key		
Variables	1040 Hot Rolled	
w	0.315	off of KHK c
h	0.13	off of KHK c
Sut	76000	psi
Sy	42000	psi
N	2	
d	0.984252	
Tmax	900.3622517	
Tmin	0	

Min length based on bearing stress		
Fmax	1829.536037	
L	0.659606045	in

Shear Check	
Ta	450.1811259
Tm	450.1811259
Fa	914.7680185
Fm	914.7680185
Tap	4402.666526
Tmp	4402.666526
Stressa	7625.642111
Stressm	7625.642111

Endurance Limit	
Sep	38000
A95	0.0020475
dequiv	0.1634924
Cload	1
Csurf	1
Ctemp	1
Crel	1
Csize	1
Se	38000

Nf	3.322124611

Gear Key		
Variables	1040 Cold Rolled	
w	0.315	off of KHK catalog
h	0.13	off of KHK catalog
Sut	85000	psi
Sy	71000	psi
N	2	
d	1.1811	in
Tmax	2950	
Tmin	0	

Output Key
Variables
w
h
Sut
Sy
N
d
Tmax
Tmin

Min length based on bearing stress		
Fmax	5994.399808	
L	1.27843987	in

Min length b
Fmax
L

Shear Check	
Ta	1475
Tm	1475
Fa	2497.671662
Fm	2497.671662
Tap	6202.181717
Tmp	6202.181717
Stressa	10742.49385
Stressm	10742.49385

Shear Chec
Ta
Tm
Fa
Fm
Tap
Tmp
Stressa
Stressm

Endurance Limit	
Sep	42500
A95	0.0020475
dequiv	0.1634924
Cload	1
Csurf	1
Ctemp	1
Crel	1
Csize	1
Se	42500

Endurance
Sep
A95
dequiv
Cload
Csurf
Ctemp
Crel
Csize
Se

Nf	2.63750054

Nf

Pinion Torque Input	900.3623 lb-in

1040 Cold Rolled	
0.315	off of KHK catalog
0.13	off of KHK catalog
85000	psi
71000	psi
2	
1.122426678	in
2950	
0	

based on bearing stress	
5994.399808	
1.27843987	in

k
1475
1475
2628.234039
2628.234039
6526.392299
6526.392299
11304.04305
11304.04305

Limit
42500
0.0020475
0.1634924
1
1
1
1
1
42500

2.506477833

Bearing Requirements			
Bearings must have combined reliability of 90% per shaft			
Ball bearing for high speed			
Deep groove for heavy radial and thrust loads			

Pinion Bearings		
Variables		
Reliability total	90%	
Reliability individual	95%	
Kr individual	0.62	
a for ball bearings	3	
Lp x 10^6	0.5	Figure 12-28
af = (1.1-1.3)	1.3	
Weight of pinion	5.511lbs	
P	523.0494	
Calculated C min	632.9152	lbs
	3250.7	N

Gear Bearings
Variables
Reliability total
Reliability individual
Kr individual
a for ball bearings
Lp x 10^6
af = (1.1-1.3)
Weight of gear
P
Calculated C min

Chosen Bearing	*Use the same bearing on either side for pinion shaft	
61804 Single Row Deep Groove Ball Bearing		
d	0.787402	in
D	1.25984	in
B	0.276	in
C10	905.98	lbs

Chosen Right Bearing
62/68 Single Row Deep G
d
D
B
C10

90%	
95%	
0.62	
3	
0.5	Figure 12-28
1.3	
63.49 lbs	
566.047797	
684.945308	lbs
3428.2	N

Groove Ball Bearing	
1.10236	in
2.28346	in
0.629921	in
3776.79024	lbs

Chosen Left Bearing

61806 Single Row Deep Groove Ball Bearing		
d	1.1811	in
D	1.65354	in
B	0.276	in
C10	1,009.39	lbs