Shaft Methodologies - Chain Drive Mixer

By:	*Vishant Prasad*
SID:	*470416309*

Problem Brief

The following investigation invlodes two analysis methods in order to identify a suitable design of a shaft to suit the chain drive to a mixer.

The layout of the drive is displayed in *figure 1* . Referenced from SALA catalogue. A shaft mounted gearbox is to be selected from the SALA catalogue supplied on to which the selected design shaft will be matched.

Furthermore, a key is to be designed connecting the shaft to the chain sprocket boss.

Specifications

Key is intended to use an avaliable appropriate synchronous motor rated to operate and possesses the following specifications:

Spec	Value	Units	Variable	Ref.
Motor Rating	1440	RPM		Given
Motor Weight	40	kg		"
Output Gearbox	100	RPM		"
Output Margin	5	%		"
Pitch Circle Diametre	330	mm		"
Highest Tension	12	kN		"
Chain Angle	15	degrees		"

Assumptions

The equipment runs for sifts of 8 hours per day (i.e. 16 hours continues operation), with less than 20 starts per hour and all starts will be carried out with an empty drum.

Produce essentially no shock loads as a result of the movement of the material within the mixing drum.

Start will be carried out with an empty drum.

Executive Summary

After analysis of the system, the selected configuration of the shaft is as follows; the material selected is to be **350 Grade Mild Steel** with a **Shaft Diametre** of **81.22mm** and **Shaft Length** of **1500mm**. Furthermore, the **Key Size** is of the following dimensions; **18 x 32 x 12 mm**, allowing for safe connection between the chain and the shaft. The material used for the key for this investigation has been selected as **AISI 1008 Carbon Steel side-milled keyway**. The bearing selected is selected as a **Rolling Spherical Bearing**. More specifically, with regard of the shaft diameter and size **85mm**. The seal of the bearing selected corresponds to the diametre, and therefore, the seal selected is a **plummer block SONL 218-518** supporting the system with safety. Finally, the gearbox implemented during this investigation is a **TV112**.

Conclusion

The design in summary is safe with the material and model selection. The design hence, can operate under the specified or required conditions of this investigation. The length and the diametre of the shaft has been calculated and defined with consideration of the operating specifications with high speed performance and pressure.

The key and bearing design allow for the system to run under stability and can support the mixer at high speed operation. The gearbox finally, is of appropriate selection and can operate without system failure.

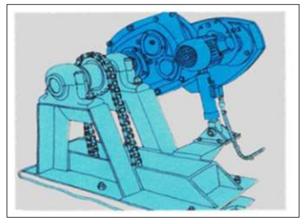


Figure 1- Layout of Chain Drive Mixer

Figure 24 - Plummer Block (SONL 218-518)

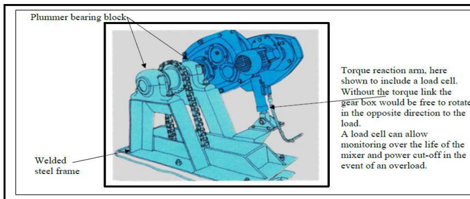


Figure 2 - Layout of Drive (Annotated)

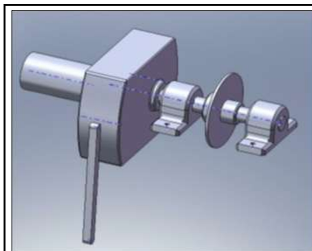


Figure 3 - Model of Proposed Drive Assembly

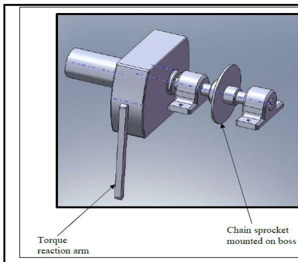


Figure 4 - Model of Proposed Drive Assembly (Annotated)

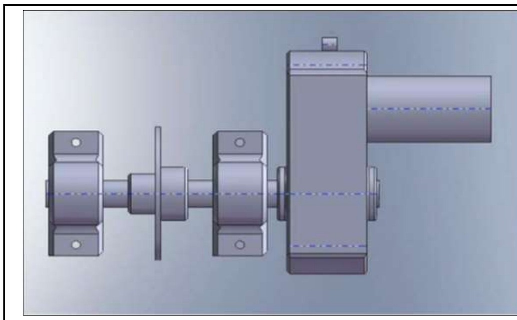


Figure 5 - Possible Top-View of Proposed Gear Drive

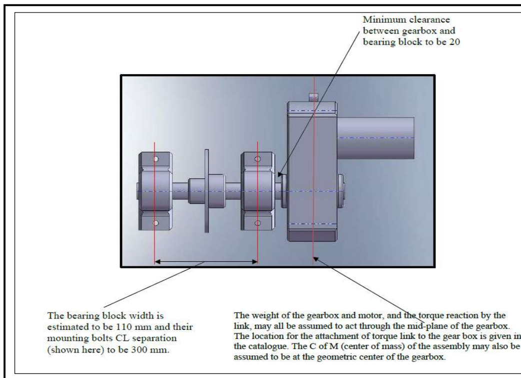


Figure 6 - Possible Top-View of Proposed Gear Drive (Annotated)

Given Data

Comments	Component	Value	Variable	Units	Equation	Ref.
-	Required Shaft Speed	100	shaft_s	RPM	-	Given
-	Motor Input Speed	1440	mtrInput_s	RPM	-	"
-	Chain Tension	12	chain_Ft	kN	-	"
-	Motor Weight	40	mtr_w	kg	-	"
w.r.t Verticle Axis	Angle of Chain	15	angChain_d	degrees	-	"
"	"	0.26	angChain_r	radians	RADIANS(angChain_d)	-
-	Sprocket Diametre	330	spr_d	mm	-	"

Gearbox Selection

Comments	Component	Value	Variable	Units	Equation	Ref.
Services Factors:	F1	1	_F1	-	-	SALA Catalogue - Page 5
3 to 12 Hours/Day, 60 mins, No Shocks, Starts per Hour 11 to 20	F2	1	F2	-	-	"
	F3	1.1	F3	-	-	"
	F4	1.1	_F4	-	_F1*_F2*_F3	SALA Catalogue - Page 18

Power & Torque

Comments	Component	Value	Variable	Units	Equation	Ref.
-	Sprocket Radius	165	spr_r	mm	spr_d/2	Calculated
	Output Torque	1912.53	T_out	Nm	spr_r*chain_Ft*COS(angChain_r)	Lecture Notes
-	Initial Power	20.03	init_P	kW	T_out*shaft_s/9.5488/1000	Researched Formula [7]
	Required Power	22.03	req_P	kW	init_P*_F4	"
	Required Trans Ratio	14.4	req_tr	-	mtrInput_s/shaft_s	"

Model Selection

Comments	Component	Value	Variable	Units	Equation	Ref.
	Trans Ratio	14.83	t_ratio	:1	-	SALA Catalogue - Page 4
MODEL SELECTED: TV112	Power	33	pwr	kW	-	"
	Gearbox Weight	150	gb_w	kg	-	SALA Catalogue - Page 10

Dimensions

Comments	Component	Value	Variable	Units	Equation	Ref.
Approx. distance 'a' and 'b'	V	225	V	mm	-	SALA Catalogue - Page 10
(See Figure 20 & 23):	W	238	W	"	-	"
	X	610	X	"	-	"
	Y	22	Y	"	-	"
	A	240	_A	"	-	"
	J	136	J	"	-	"
	Total Mass	190	m_total	kg	gb_w+mtr_w	Calculated
	Width	240	gb_width	mm	_A	SALA Catalogue - Page 10
	Bearing Clearances	75	bc	mm	20+55	"
	Distance A	113.26	a	mm	((X/2-V)*gb_w+(W*mtr_w))/m_total	Calculated
	Distance B	374	b	"	W+J	"
	Distance C	195	_c	"	bc+gb_width/2	"
	Distance D	150	d	"		SALA Catalogue - Page 10
	Distance E	150	e	"		"

Specification Calculations

Comments	Component	Value	Variable	Units	Equation	Ref.
State p/hr: 20 is 1.9*PWR	Max Starting Torque	62.7	T_max	Nm	1.9*pwr	SALA Catalogue - Page 5
Acceptable: ±5%	Shaft Speed (Real)	97.10	act_spd	RPM	mtrInput_s/t_ratio	"

Reaction Forces & Bending Moments Calculations - X & Y Plane

Comments	Component	Value	Variable	Units	Equation	Ref.
X & Y Plane:	Gravity Constant	9.81	g	m/s^2	-	Researched
Gearbox + Motor	Total Weight	1863.90	w_total	N	m_total*g	Calculated
Torque Reaction Arm	Reaction Force - Arm	4549.26	F_react	N	(T_out-(w_total*a/1000))/(b/1000)	Lecture Notes
(See Figure 10):						
Vertical Force	Force at Point 1	-6413.16	F_1	N	(F_react+w_total)*-1	Lecture Notes
" @ Sprocket	Force at Point 2	-11591.11	F_2	"	(chain_Ft*COS(angChain_r))*-1*1000	"
" @ Bearing B	Force at Bearing B	1627.00	F_B	"	((F_1*_c)-(F_2*d))/(e+d)	"
" @ Bearing A	Force at Bearing A	16377.26	F_A	"	(F_1+F_2+F_B)*-1	"

Moment Calculations - X & Y Plane

Moment Location Equation	Moment Location Value	Units	Moment	Variable	Units	Moment Equation	Ref.
0	0.000	m	0.00	-	Nm	0	Calculated
_c*10^-3	0.195	"	-1250.57	-	"	F_1*_c*10^-3	"
(_c+d)*10^-3	0.345	"	244.05	-	"	(F_1*_c*10^-3)+((F_1+F_A)*d*10^-3)	
(_c+d+e)*10^-3	0.495	"	0.00	-	"	(F_1*_c*10^-3)+((F_1+F_A)*d*10^-3)+((F_1+F_A+F_2)*e*10^-3)	

Shear Calculations - X & Y Plane

Shear Location Equation	Shear Location Value	Units	Shear	Variable	Units	Shear Equation	Ref.
0	0.000	m	0.00	-	N	0	Calculated
0	0.000	"	-6413.16	-	"	F_1	"
_c*10^-3	0.195	"	-6413.16	-	"	F_1	
"	0.195	"	9964.11	-	"	F_1+F_A	
(_c+d)*10^-3	0.345	"	9964.11	-	"	F_1+F_A	
"	0.345	"	-1627.00	-	"	F_1+F_A+F_2	
(_c+d+e)*10^-3	0.495	"	-1627.00	-	"	F_1+F_A+F_2	
"	0.495	"	0.00	-	"	F_1+F_A+F_2+F_B	

Reaction Forces & Bending Moments Calculations - X & Z Plane

Comments	Component	Value	Variable	Units	Equation	Ref.
X & Z Plane (See Figure 11):						
Vertical Force @ Sprocket	Force at Point 2	3105.83	R_2	N	chain_Ft*SIN(angChain_r)*1000	Lecture Notes
" @ Bearing B	Force at Bearing B	1552.91	R_B	"	(R_2*d)/(d+e)	"
" @ Bearing A	Force at Bearing A	1552.91	R_A	"	R_2-R_B	"

Moment Calculations - X & Z Plane

Moment Location Equation	Moment Location Value	Units	Moment	Variable	Units	Moment Equation	Ref.
0	0.000	m	0.00	-	Nm	0	Calculated
_c*10^-3	0.195	"	0.00	-	"	0	"
(_c+d)*10^-3	0.345	"	232.94	-	"	R_A*d*10^-3	"
(_c+d+e)*10^-3	0.495	"	0.00	-	"	R_A*(e+d)-(R_2*e)	"

Shear Calculations - X & Z Plane

Shear Location Equation	Shear Location Value	Units	Shear	Variable	Units	Shear Equation	Ref.
0	0.000	m	0.00	-	N	0	Calculated
0	0.000	"	0.00	-	"	0	"
_c*10^-3	0.195	"	0.00	-	"	0	"
"	0.195	"	1552.91	-	"	R_A	"
(_c+d)*10^-3	0.345	"	1552.91	-	"	R_A	"
"	0.345	"	-1552.91	-	"	R_A-R_2	"
(_c+d+e)*10^-3	0.495	"	-1552.91	-	"	R_A-R_2	"
"	0.495	"	0.00	-	"	R_A-R_2+R_B	"

Combined Bending Moments

Moment Location Equation	Moment Location Value	Units	Moment	Variable	Units	Moment Equation	Ref.
0	0.000	m	0	-	Nm	0	Calculated
_c*10^-3	0.195	"	1250.57	-	"	SQRT(F_1^2)*_c*10^-3	"
(_c+d)*10^-3	0.345	"	4680.15	max_M	"	SQRT(F_1^2)*(_c+d)*10^-3+SQRT(R_A^2+F_A^2)*(d*10^-3)	
(_c+d+e)*10^-3	0.495	"	0	-	"	0	

Discussion

FBD

The *figure 10* , denotes that deflection in the X&Y plane which is considered for the deflection analysis. The deflection forces on the X&Z plane are negligable.

The *figure 8* . demonstrates the free body diagram of the system. The force analysis of the system here includes the gearbox, bearing and plumer. The horizontal forces denote the X & Z plane forces, specifically, the **FA**, **FB** and **F2** vectors. The forces facing in vertical directions denote the forces acting in the X & Y plane, more specifically, the forces **F1**, **F2**, **FA** and **FB**. The force **F1** is the resultant force of the mid-plane through the gearbox and the force vector **F2** is the vertical and horizontal components of the chain's The dimension of the mid-plane are gathered through the information/data in the SALA gearbox catalogue for the TV112.

Gearbox Selection

The SALA catalogue is used to select the gearbox type with the specifications of the **result power required** and **transmission ratio**. The table specifically used from the catalogue is referenced as page four, with the TV112 suitable for implementation in this system. This model has a maximum power limit of 33kW and a transmission ratio of 14.8. Therefore, the design requirements within this investigation is satisfied with this gearbox selection. [7]

Shear & Bending Moment

The calculations surrounding the shear and bending moment denote that the gearbox selected will operate and be valid with implementation into the system. The section specifically named, *specification calculations* denote the limitations of the system designed is within the tolerance range of the selected gearbox. With this, the spreadsheet evidenced the calculations, such as mass of gearbox and force generated by gravity.

The reaction forces and bending moments of each plane are calculated using force analysis diagrams or free-body diagrams, force and moment balance and the distances of the forces to gather the results compiled in this sheet alongside the diagrams generated in the figures. Note that the distance in the X & Z plane is the total dimensions of the whole system, calculated from the X & Y plane calculation sections.

In summation the maximum bending moment is approximately **4680Nm** with no mean bending moment for this case of the system arrangement. The alternating moment is equal to **0.5*M(max)** and therefore is approximately, **2340Nm**. Therefore, with a slight increase for safety and clearances, the shaft length is comfortably choosen as **1500mm**. This slight increase is also to minimize the errors through calculation.

In turn however, this does effect the cost as slightly more material is required.

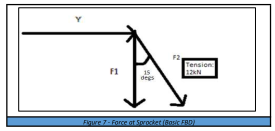


Figure 7 - Force at Sprocket (Basic FBD)

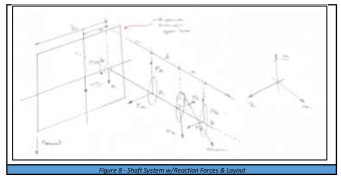


Figure 8 - Shaft System w/Reaction Forces & Layout

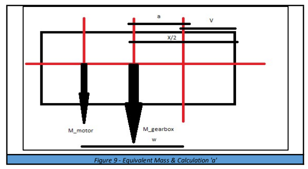


Figure 9 - Equivalent Mass & Calculation 'a'

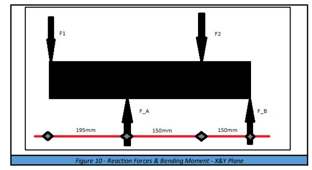


Figure 10 - Reaction Forces & Bending Moment - X&Y Plane

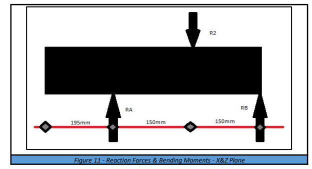


Figure 11 - Reaction Forces & Bending Moments - X&Z Plane

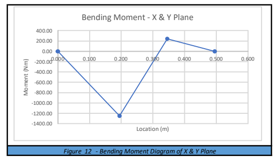


Figure 12 - Bending Moment Diagram of X & Y Plane

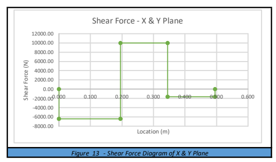


Figure 13 - Shear Force Diagram of X & Y Plane

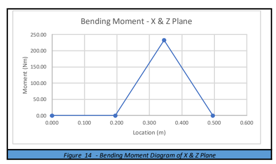


Figure 14 - Bending Moment Diagram of X & Z Plane

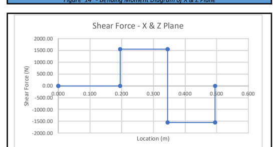


Figure 15 - Shear Force Diagram of X & Z Plane

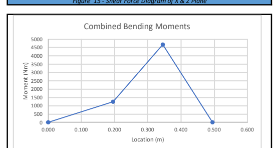


Figure 16 - Combined Bending Moment Diagram

Fatigue Analysis - Shaft for Gear Driven Mixer (Gerber & AS1403 Methods)						
Comments	**Component**	**Value**	**Variable**	**Units**	**Equation**	**Ref.**
	Alternating Torque	0	alt_T	Nmm	-	Given
	Mean Moment	0	mean_M	"	-	"

Initial Shaft Diametre - Estimation						
Comments	**Component**	**Value**	**Variable**	**Units**	**Equation**	**Ref.**
Initial Estimate	Diametre	75.00	diam	mm	-	Change w/Solver
	Factor of Safety	2.5	FOS	-	-	

Endurance Limit Calculation - Concentration Factors						
Comments	**Component**	**Value**	**Variable**	**Units**	**Equation**	**Ref.**
Eqs. For stress concentration factors - Fatigue:	Ultimate Tensile Strength	450	Su	N/mm^2		
	Surface Factor	0.78	Ka	-	1.189*POWER(diam,-0.097)	Lecture Notes & Shigley's Mechanical Engineering Design - 8th Edition Textbook [8]
	Size Factor	0.94	Kb	-	1.58*(POWER(Su,-0.085))	
	Loading Factor	1	Kc	-		
	Temperature Factor	1	Kd	-		
	Reliability Factor	0.753	RF	-		
	Miscellaneous Effect Factor	1.33	Kf	-	1/RF	"
	Test Endurance Limit	202.5	Se_	N/mm^2	0.45*Su	"
	Endurance Limit	112.11	Se	"	Ka*Kb*Kc*Kd*RF*Se_	"
	Diametre of Shaft	115	shaft_d	mm	ROUND(((32*FOS/PI())*((Kf*max_M*1000)/Se+((0.75*(Kf*T_out*1000)^2)^(1/2))/Su))^(1/3),0)	

Gerber Calculation - Solver						
Comments	**Component**	**Value**	**Variable**	**Units**	**Equation**	**Ref.**
	Von Mises Mean Stress	1.31	Von_m	N/mm^2	(32/((diam)^3*(PI())))*SQRT((3/4)*(T_max*1000)^2)	Lecture Notes
	Von Mises Alternating Stress	56.50	Von_alt	"	(32/((diam)^3*(PI())))*SQRT((max_M*1000/2)^2+(3/4)*(T_max*1000/2)^2)	
Solver w/Value: 0	Gerber Line Variable	0.26	GL	-	FOS*Von_alt/Se+(FOS*Von_m/Su)^2-1	"
Solver Output	Gerber Diametre	81.22		mm	Solver	Calculated - Solver

Plotting Gerber Line					
Comments	**Von Mises Mean Stress**	**Von Mises Alternating Stress**	**Units**	**Formula - Von Mises Alternating Stress**	**Ref.**
	0.00	112.11	MPa	(1-(D35/Su)^2)*Se	Calculated
	112.50	105.11	"	(1-(D36/Su)^2)*Se	"
	225.00	84.08	"	(1-(D37/Su)^2)*Se	"
	337.50	49.05	"	(1-(D38/Su)^2)*Se	"
	450.00	0.00	"	(1-(D39/Su)^2)*Se	"

Gerber Calculation using Diametre Desired w/Solver Solution						
Comments	**Component**	**Value**	**Variable**	**Units**	**Equation**	**Ref.**
Gerber Calculation w/Solver Diametre Solution: >81.22 mm	Von Mises Mean Stress	0.36	Von_mf	N/mm^2	(32/((shaft_d)^3*(PI())))*SQRT((3/4)*(T_max*1000)^2)	Textbook [8]
	Von Mises Alternating Stress	15.67	Von_altf	"	(32/((shaft_d)^3*(PI())))*SQRT((max_M*1000/2)^2+(3/4)*(T_max*1000/2)^2)	

Discussion

Shaft

As denoted in the next sheet, the shaft requires material capable of ultimate tensile strength ranging from **350** to **500N/mm^2** of design using steel. The selection has been made through the investigation of mild steel grade 350.
For higher quality material, alloy steel more specifically using nickel-chromium can be used for higher strength.
Specifications for this material is defined in the next sheet. [1]

Factor of Safety Selection

The FOS selected for this investigation has been utilized as a range between **2-2.5** as this is conventional for a design using conventional materials with less severe load and specified conditions. With the system in this investigation the maximum value of safety should be implemented and hence, increasing the service life of the shaft. [4]

AS1403 Method

The method is using a trial shaft diametre and calculating the maximum torque with regard to no alternative torque considered for the shaft. To ensure safety of the design, we utilize the maximum value for bending moment.
Within the calculation we utilize formulars from the textbook and *figure 19* .
Furthermore, we use the equation from table two of the lectures for calculating the shaft diametres.

Gerber Method

The method uses the same parameters from the previous section and use a trial diametre as listed above.
This method in this investigation uses solver for the mean and alternating von mises stresses calculated using the trial diametre.
By using the values in the parametres we then calculate the gerber diametre and try to make the variable (Gerber Line Variable) to equal to 0. We use this value as it is accurate to fatigue failure and ensures safety while minimising material and cost.

Conclusion

The fatigue diagram indicates that the calculated final Gerber method results in a Shaft Diametre of value **81.22mm** is under the Gerber Line. Therefore, the diametre of **81.22**mm is safe for implementation in regards to fatigue failure.
The diameter of the shaft using the AS1403 Method denotes the Shaft Diametre of **115mm**. Therefore, there is a noticable difference in the calculations. The Gerber method Shaft Diametre can be simplified to **82mm**.
Through comparison of both methods, the **82mm** Shaft Diametre can be implemented as the Gerber method has more reliablility and with its method involving direct referencing to the failure limit and safety to a higher degree than the AS1403 method.

In this case the mean moment is not existent and there is no alternating torque as denoted as the reaction forces acting on the shaft do not rotate with the shaft and the torque is constant.

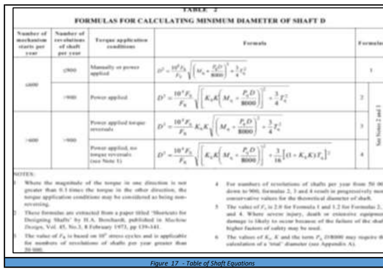

FORMULAS FOR CALCULATING MINIMUM DIAMETER OF SHAFT D

Figure 17 - Table of Shaft Equations

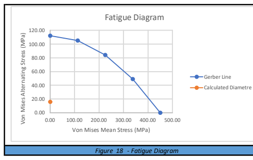


Figure 18 - Fatigue Diagram

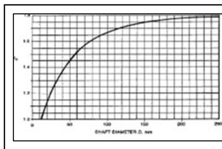


Figure 19 - Size Factor (Ks)

Fatigue Analysis - Shaft for Gear Driven Mixer						
Comments	**Component**	**Value**	**Variable**	**Units**	**Equation**	**Ref.**
	Polar Moment of Area	17170.83	_J	m^4	(PI()*(shaft_d/2)^4)/2	Lecture Notes

Shaft Material Properties - 350 Mild Steel						
Comments	**Component**	**Value**	**Variable**	**Units**	**Equation**	**Ref.**
	Ultimate Shear Strength	360	shaft_ss	MPa	-	Researched - G350 Mild Steel

Key Material Properties - AISI 1008 Carbon Steel						
Comments	**Component**	**Value**	**Variable**	**Units**	**Equation**	**Ref.**
	Ultimate Tensile Strength	340	key_ts	MPa	-	AISI 1008 Carbon Steel (UNS G10080 - Material Properties Researched)
	Ultimate Shear Strength	240	key_ss	MPa	-	

Torques on Shaft & Key						
Comments	**Component**	**Value**	**Variable**	**Units**	**Equation**	**Ref.**
	Max Torque Shaft	134380.40	max_Tsh	Nm	(Su*_J)/(shaft_d/2)	Textbook [8]
Req. for Breaking Pt	Key Torque	4781.33	key_T	"	T_out*FOS	"
	Max Torque/Key Torque	28.11		-	max_Tsh/key_T	"
Size Determined from	Key Height	18	key_h	mm	-	Keyway Metric Sizes Table
115mm Diametre	Key Width	32	key_w	"	-	"
Shaft:	Key Length	10.83	key_l	"	key_T/(key_w*shaft_d*0.5*key_ss)	Textbook [8]

Discussion

The design of a suitable key located between the shaft and the chain sprocket resulted in torque of high value for the shaft to endure. The original diametre of the shaft at approximately **82mm** and therefore, the size of the key selected with the data compiled uses the dimensions: **18 x 32 x 12 mm**. The material selected for the key is **AISI 1008 Carbon Steel** as the tensile and yield strength is lower than that of the shaft and is conventionally employed in key design or applications. [2]

The FOS of the key is used as the identical value as the key is used for connection between the shaft and chain. Therefore, this value is conventional for ordinary materials such as that in this investigation for the same reasons as mentioned for the shaft.

Deflection on Shaft - Constants, Parametres & Properties						
Comments	**Component**	**Value**	**Variable**	**Units**	**Equation**	**Ref.**
	Length of Shaft	0.3	L	m	(d+e)/1000	Calculated
For Steel	Elastic Modulus	2000000000	elastic_M	Pa	-	Researched Value
	Moment of Inertia	1.72E-05	I	m^4	(PI()*(shaft_d/1000/2)^4)/2	"
	Maximum Bending Moment	10302.50	EIL	Pa m^4	elastic_M*I*L	Lecture Notes

Deflection on Shaft @ Different Locations - Due to Sprocket						
Comments	**Component**	**Value**	**Variable**	**Units**	**Equation**	**Ref.**
	Location A	-4.97E-04	defl_A	rad	angChain_r*((F_2*(d/1000)*(e/1000)*(L+(e/1000)))/(6*EIL))	Textbook [8]
Deflection in terms	Location B	3.31E-05	defl_B	"	RADIANS((-1*F_2*(d/1000)*(e/1000)*(L+(d/1000)))/(6*EIL))	"
of angle occuring @	Location C	3.31E-05	defl_C	"	defl_B	"
Locations on Shaft:	Location Gear	0.00E+00	defl_G	"	RADIANS((F_2*(d/1000)*(e/1000)*((e/1000)-(d/1000)))/(3*EIL))	"
	Deflection (Y) @ Gear	-8.44E-09	defl_yG	mm	((F_2*d/1000^2*e/1000^2)/(3*EIL))	"
Deflection in terms of 'mm' occuring @ Locations on Shaft:	Deflection (Y) @ C	6.46E-06	defl_yC	"	defl_B*_c/1000	"

Deflection on Shaft @ Different Locations - Due to Gear						
Comments	**Component**	**Value**	**Variable**	**Units**	**Equation**	**Ref.**
	Location A	1.06E-04	defl_gA	rad	RADIANS((-F_1*_c/1000*L)/(6*EIL))	Textbook [8]
Deflection in terms	Location B	-6.36E-05	defl_gB	"	RADIANS((F_1*_c/1000*L)/(3*elastic_M*I))	"
of angle occuring @	Location C	-2.27E-04	defl_gC	"	RADIANS((F_2*_c/1000*(2*L+3*_c/1000))/(6*elastic_M*I))	"
Locations on Shaft:	Location Gear	0.00E+00	defl_gg	"	0	"
	Deflection (Y) @ Gear	0.00E+00	defl_ygG	mm	0	"
Deflection in terms of 'mm' occuring @ Locations on Shaft:	Deflection (Y) @ C	-6.01E-06	defl_ygC	"	((F_1*_c/1000^2*(L+_c/1000))/(3*elastic_M*I))	"

Total Deflection @ Different Locations						
Comments	**Component**	**Value**	**Variable**	**Units**	**Equation**	**Ref.**
	Location A	-3.91E-04	ttl_deflA	rad	defl_A+defl_gA	Calculated
Deflection in terms	Location B	-3.04E-05	ttl_deflB	"	defl_B+defl_gB	"
of angle occuring @	Location C	-1.94E-04	ttl_deflC	"	defl_C+defl_gC	"
Locations on Shaft:	Location Gear	0.00E+00	ttl_deflG	"	defl_G+defl_gg	"
	Deflection (Y) @ Gear	-8.44E-09	ttl_deflyG	mm	defl_yG+defl_ygG	"
Deflection in terms of 'mm' occuring @ Locations on Shaft:	Deflection (Y) @ C	4.53E-07	ttl_deflyC	"	defl_yC+defl_ygC	"
	Maximum Deflection Angle	3.91E-04	max_deflA	rad	MAX(ABS(E36:E39))	"
	Maximum Deflection Y	4.53E-07	max_deflY	mm	MAX(ABS(E41:E42))	"

Limitations						
Comments	**Component**	**Value**	**Variable**	**Units**	**Equation**	**Ref.**
	Limit Y	0.3002	-	mm	0.0002+(d/1000+e/1000)	Calculated
Angular Limits:	Jurnal Bearing	1.00E-03	-	rad	-	
	Radial Bearing	0.01	-	"	-	
	Self-Aligning Bearing	0.05	-	"	-	

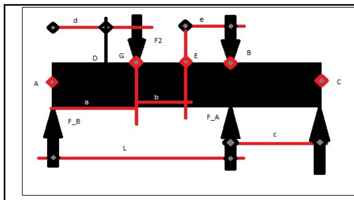


Figure 20 - Shaft Deflection (Due to Sprocket)

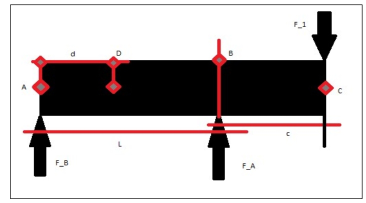


Figure 21 - Shaft Deflection (Due to Gear Assembly)

Discussion

Tolerances

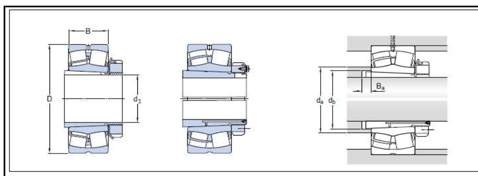
The tolerances for the coplanar alignment are found using the bending for the Jurnal Bearing. The maximum angular misalignment was 0.001 radians and for self-aligning was 0.05 radians.
Therefore, the design is valid with the limitations with the deflection limit **0.3002mm**. When tested the lateral deflection uses the two values that are calculated and summed.
The maximum deflection occurs at the gear as expected with a value of **4.53E-07**. This is a relatively small value and therefore, can be neglected with the system design posing viable.
The value of deflection at point A is safe as it is less than the limit mentioned.

From the force analysis that has been completed in this sheet the calculated radian angular misalignment is done as denoted on this sheet with the cases of the gear and the sprocket.
More specifically, with reference to *figure 20* and *figure 21* .

The deflection is considered in X & Y plane as the deflection due to forces and reaction on the X & Z plane are negligible - referenced from the Lecture Notes.

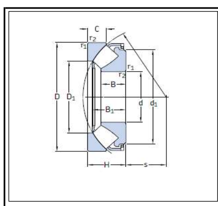
Bearings & Plummer Blocks

With the low shaft deflection and angular misalignment while also operating under high speeds, the **speherical roller bearings** are valid for selection. Furthermore, the design operates under low axial and radial load on the shaft, hence reasoning the selection. [5] The plummer block is indicated on *figure 24* , with the diametre of 85mm from the catalogue.
The shaft has two bearings. We use this selected 85 diametre as is corresponds to the shaft specifications or design that has been calculated of **81.22mm** and **1500mm**.



85	170	51	108	102	9	6,5	* **BS2-2219-2CS5K/VT143**	**H 2319 EL**

Figure 25 - Bearing Seal & Diagram [3]



85	150	39	380	1 060	129	0,11	2 400	4 000	2,75	* **29317 E**
	180	58	735	1 800	212	0,31	2 000	3 600	6,75	* **29417 E**

Figure 26 - Bearing Size & Diagram [3]

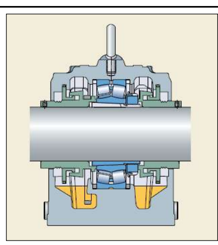


Figure 27 - SONL Plummer Block Selection Illustration [6]

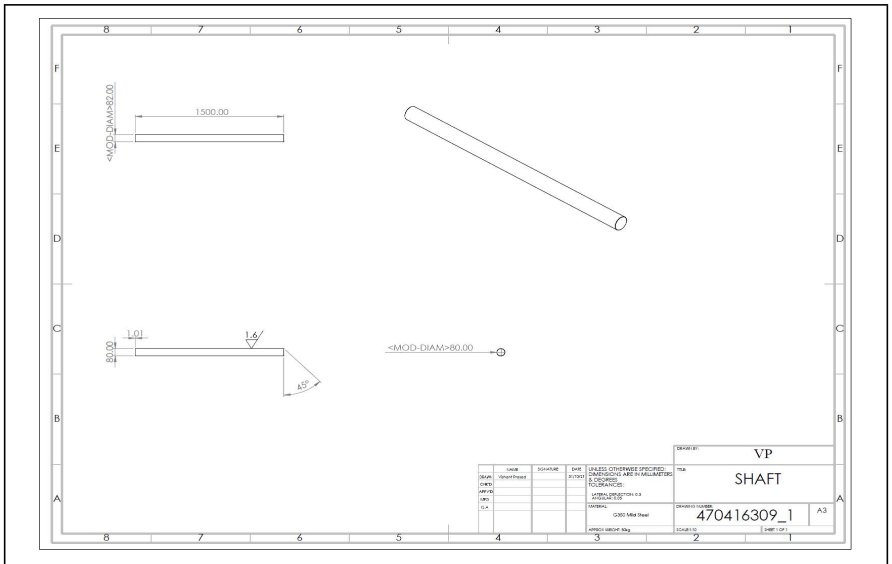


Figure 22 - Detailed Engineering Drawing of Shaft

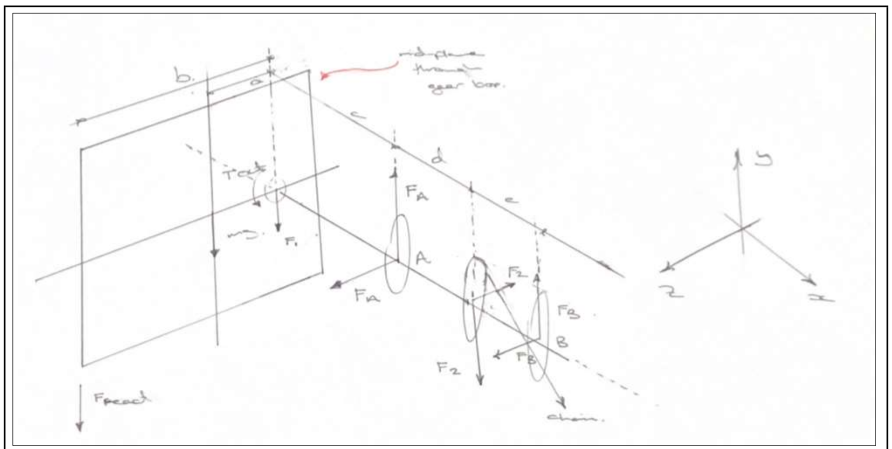


Figure 23 - Frame Drawing

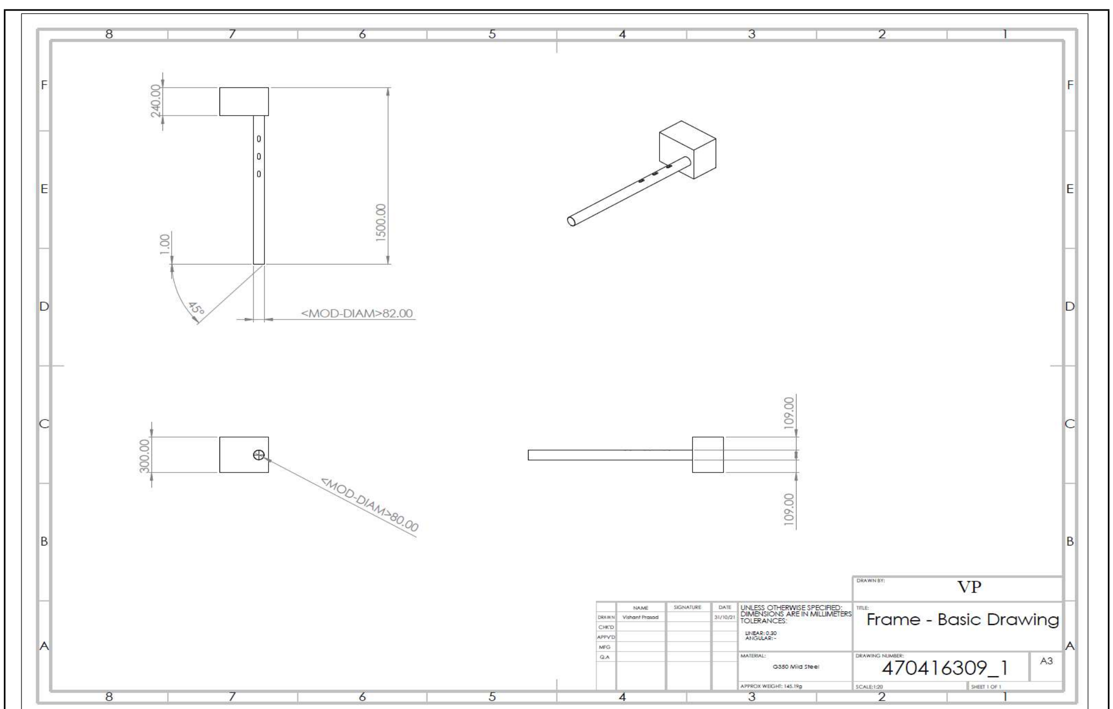


Figure 26 - Basic Frame Dtawing

Citations	Reference
[1]	Australian Steel. 2021. *G350 Steel* . [online] Available at: <https://www.australiansteel.com.au/plate-stock/g350-steel/> [Accessed 29 October 2021].
[2]	AZoM.com. 2021. *AISI 1008 Carbon Steel (UNS G10080)* . [online] Available at: <https://www.azom.com/article.aspx?ArticleID=6538> [Accessed 29 October 2021].
[3]	Skf.com. 2021. *SKF* . [online] Available at: <https://www.skf.com/group/products/mounted-bearings/bearing-housings/split-pillow-block-housings-sonl-series/productid-SONL%20218-518%20%2B%202218%20K%20%2B%20HA%20318> [Accessed 29 October 2021].
[4]	Engineering ToolBox, (2010). Factors of Safety. [online] Available at: https://www.engineeringtoolbox.com/factors-safety-fos-d_1624.html [Accessed 29 October 2021].
[5]	Skf.com. 2021. [online] Available at: <https://www.skf.com/binaries/pub12/Images/0901d196802809de-Rolling-bearings---17000_1-EN_tcm_12-121486.pdf> [Accessed 29 October 2021].
[6]	Skf.com. 2021. *SKF* . [online] Available at: <https://www.skf.com/group/products/rolling-bearings> [Accessed 29 October 2021].
[7]	Team, S., 2021. *Gearbox output torque calculation formula - SDT Transmission* . [online] Industrial gear reducer,gear motor manufacturer - SDT Transmission. Available at: <https://www.sdtgear.com/how-to-calculate-gearbox-output-torque-gearbox-output-torque-calculation-formula/> [Accessed 29 October 202
[8]	Budynas, R. G., Nisbett, J. K., & Shigley, J. E. (2011). Shigley's mechanical engineering design. New York: McGraw-Hill.

1].