



Virtual Design Review 4

Team 09: Sprag Clutch Addition to
Reciprocating Lever Transmission

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FAMU-FSU COLLEGE OF ENGINEERING
MECHANICAL ENGINEERING

Project Goals

- Addition of sprag clutches to RLT
- Longer crank arms and sprag clutches have potential to increase efficiency by minimum of 10%

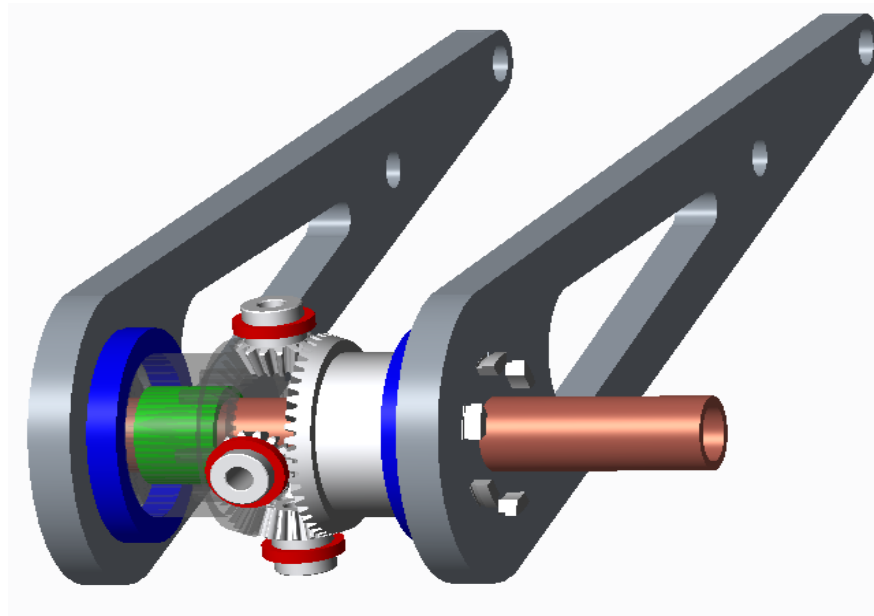


Figure 1. RLT CAD Model.



Purchases

Sprag Clutches

- GMN FE433M
- Outer Diameter: 33mm
- Inner Diameter: 25mm
- 2 sprag clutches per side
- 252 Nm torque capacity per side



Figure 2. FE400M Series Sprag Clutch.

Crank Arms

- Aluminum Sheet
 - 1/2" thick
 - High-Strength 2024
 - 2 arms

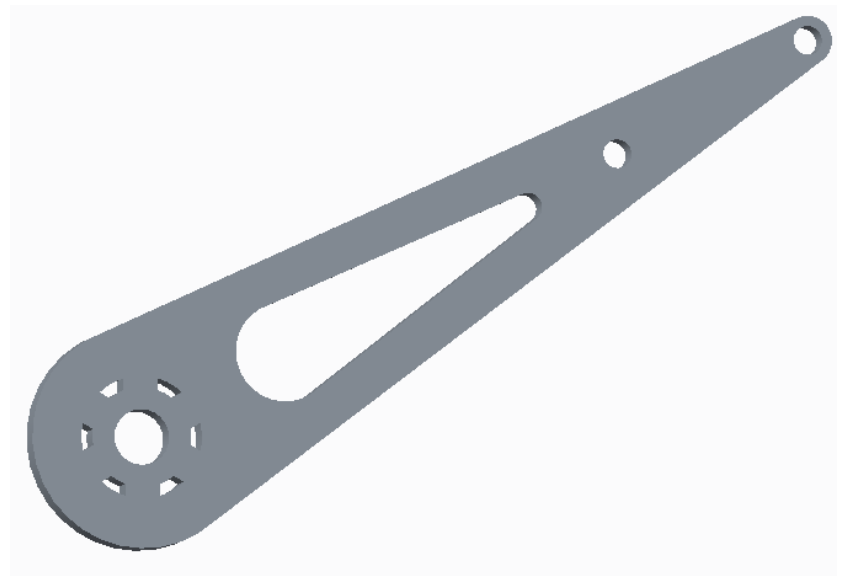


Figure 3. Crank Arm.



Future Purchases

Tight-Tolerance 4140 Alloy Steel Rod

- Diameter: 25mm (0.984in)
- Length: 304.8mm (12in)
- Tolerance: -0.013mm to 0mm (clutches require -0.016mm or less)

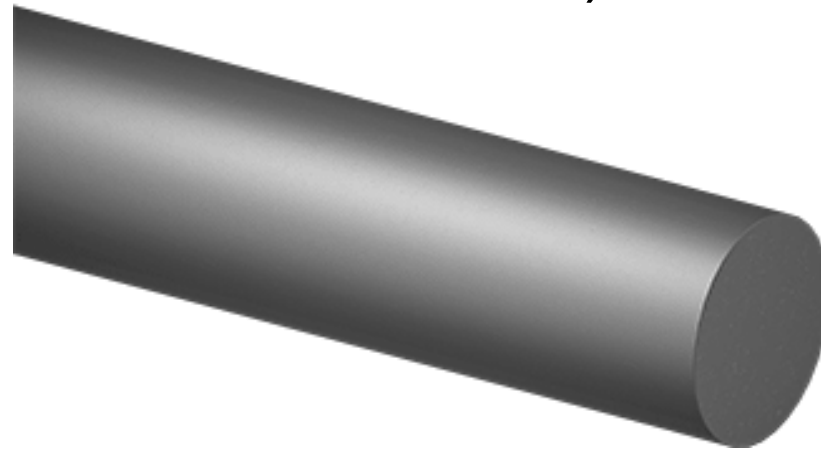


Figure 4. Tight-Tolerance 4140 Alloy Steel Rod



Future Purchases (Cont.)

Pedal Tap

- Left Hand 9/16"-20 Tap
- To be purchased by Jeremy Phillips, Machine Shop Manager

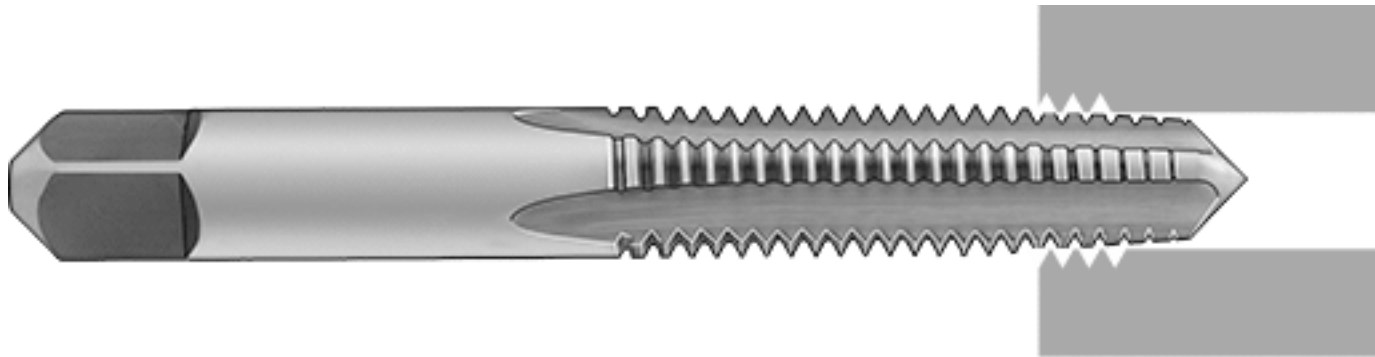


Figure 5. General Purpose Tap.



Future Purchases (Cont.)

Housing

- For holding pinion gears in place
- For keeping dirt and debris out of the RLT

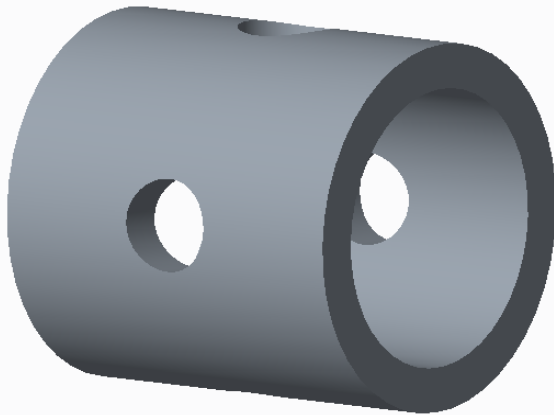


Figure 6. Bevel Housing.

Bearings

- Bevel hub bearing (left): 55mm bore diameter, 72mm outer diameter, 9mm width
- Pinion bearing (right): 18mm bore diameter, 24mm outer diameter, 4mm width



Figure 7. Sealed Bevel Hub Bearing.



Figure 8. Pinion Bearing.



Future Work

- Pin cylinder to bevel gears
- Cut splines and snap ring grooves into bevel gears
- Hollow output shaft to allow for future design of reverse system
- Assemble RLT



Bill of Materials

Item No.	Description	Item	Item Number	Distributor	Unit Price	Quantity	Total Price	Notes
1	Crank Arms	2024 Aluminum Sheet	9040K432	McMaster Carr	\$ 267.88	1	\$ 267.88	12"x24"x0.5"
2	Sprag Clutches	Sprag Clutches	FE433M	Houston Bearing & Supply	\$ 197.40	4	\$ 789.60	D= 33mm d =25mm
Cost Incurred							\$ 1,057.48	



Bill of Materials (One Piece)

Item No.	Description	Item	Item Number	Distributor	Unit Price	Quantity	Total Price	Notes	
3	Outer Race	Custom Bevel Gears	ZSUB0M00 943	KHK Gears	\$ 598.60	2	\$ 1,197.20		
4	Drive Shaft	4140 Alloy Steel Rod	5836T295	McMaster Carr	\$ 27.55	1	\$ 27.55	tol = -0.013mm to 0mm	
5	Outer Race Bearings	Bevel Gear Bearing	6656K21	McMaster Carr	\$ 336.84	2	\$ 673.68	d=63.67mm for no lip gear	
6	Houseing Bearings	Pinion Gear Bearings	5972K84	McMaster Carr	\$ 9.62	4	\$ 38.48	d=18mm	
7	Sprang Snaps Rings	Internal Snap Rings	DIN472	Fastenal	\$ 0.55	2	\$ 1.10	OD = 33mm	
8	Crank arm Snap Rins	External Snap Rings	91590A152	McMaster Carr	\$ 5.20	2	\$ 10.40	ID = 25mm	
9	Chain Wheel Spider	4140 Alloy Steel Sheet	4473T32	McMaster Carr	\$ 30.09	1	\$ 30.09	6"x6"x0.375" for spider	
10	Houseing	Aluminum Rod	86985K44	McMaster Carr	\$ 145.00	1	\$ 145.00	D4"xL6" for Housing	
							Cost Remaining	\$ 2,123.50	
							Total Cost	\$ 3,180.98	\$ (1,180.98)



Bill of Materials (Two Piece)

Item No.	Description	Item	Item Number	Distributor	Unit Price	Quantity	Total Price	Notes
11	Outer Race Gear	Bevel Gears				2	\$ -	In Stock
12	Outer Race Hub	Rod	6628K55	McMaster Carr	\$ 55.30	1	\$ 55.30	d2.5"x12" hardened for bevel gear addition
13	Alignment Pins	Alignment Pins	8472A11	McMaster Carr	\$ 2.36	6	\$ 14.16	
4	Drive Shaft	4140 Alloy Steel Rod	5836T295	McMaster Carr	\$ 27.55	1	\$ 27.55	tol = -0.013mm to 0mm
5	Outer Race Bearings	Bevel Gear Bearing	61811-2RZ	VXB	\$ 24.95	2	\$ 49.90	50mm/72mm
6	Houseing Bearings	Pinion Gear Bearings	E2148	Lily Bearings	\$ 20.00	4	\$ 80.00	d = 18mm
7	Sprang Snaps Rings	Internal Snap Rings	DIN472	Fastenal	\$ 0.55	2	\$ 1.10	OD = 33mm
8	Crank arm Snap Rins	External Snap Rings	91590A152	McMaster Carr	\$ 5.20	2	\$ 10.40	ID = 25mm
9	Chain Wheel Spider	4140 Alloy Steel Sheet	4473T32	McMaster Carr	\$ 30.09	1	\$ 30.09	6"x6"x0.375" for spider
10	Houseing	Aluminum Rod	86985K44	McMaster Carr	\$ 145.00	1	\$ 145.00	D4"xL6" for Housing
11	Shoes	Clipless Shoes		Diamondback	\$ 57.51	5	\$ 287.55	
Cost Remaining							\$ 701.05	
Total Cost							\$ 1,758.53	\$ 241.47



Propulsive Torque

- Torque produced during the upstroke is negligible.
- Ideal cyclic rate for riders is 90-100 RPM.
- Higher rates contribute to a retarding force during the upstroke due to the quadriceps muscle's inability to contract and relax more rapidly.

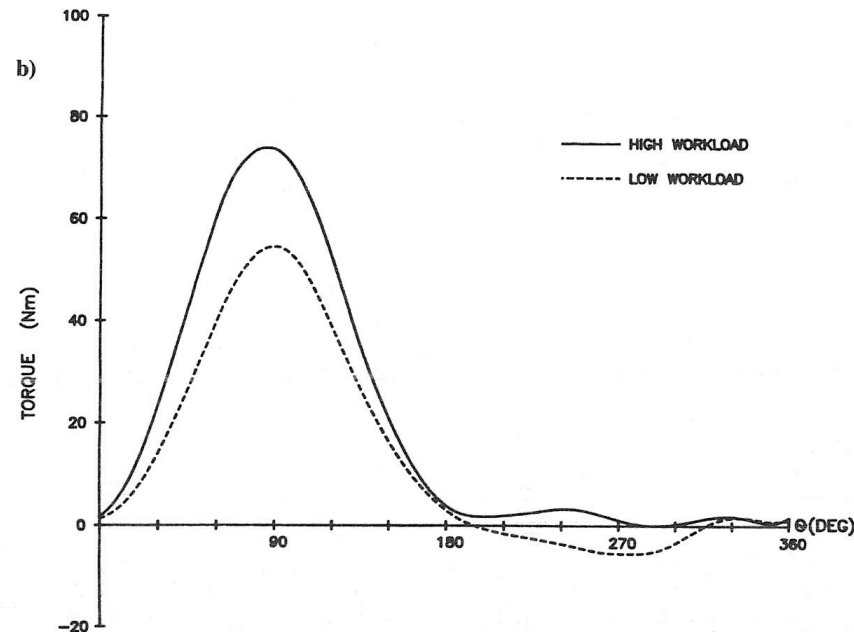


Figure 9. Propulsive Torque over One Revolution [Kautz]



Chain Routing

- The chain will be perpendicular to the rear wheel derailleur.
- Steel tubing to encase the housing and attach to the bicycle frame

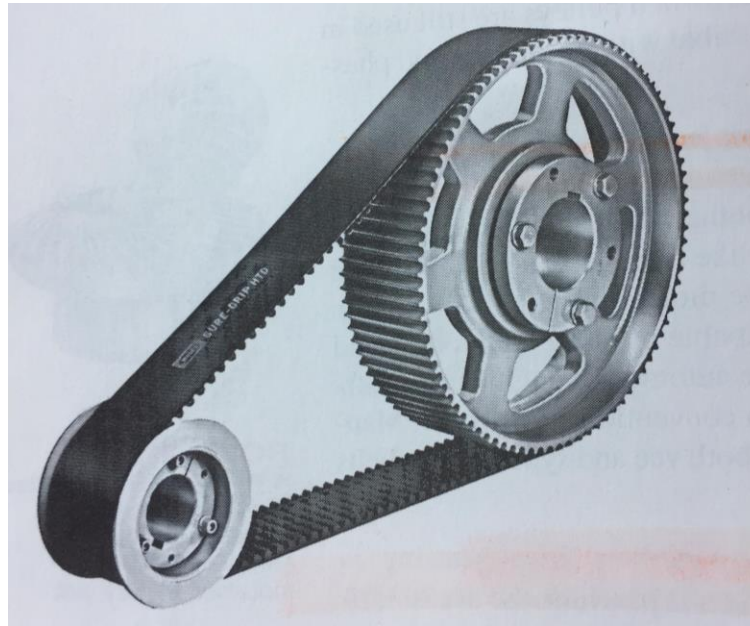


Figure 10. Tangent Chain Routing

References

- Norton, R.L. (2001) "Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms And Machines." Second Addition. Massachusetts, Worcester: McGraw-Hill.
- Kautz, S. A., M. E. Feltner, et al. (1991). "The Pedaling Technique of Elite Endurance Cyclists: Changes with Increasing Workload at Constant Cadence." International Journal of Sport Biomechanics 7(1): 29-53.



Thank you!

Any Questions?



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Assembled View

