Gearbox Ratio Verification

Jacob Kuoha & Cameron Williams

Introduction

In the MEEN 2655 lab we have, we are building a gearbox. This gearbox has a shaft on the side that receives input rotations, and an output shaft in the center. The input shaft is part of a larger piece that includes a worm drive that rotates the larger main gear. The main gear is connected and provides rotation to the output shaft. All parts except the screws are made by students in the machining lab.

Objectives

Our goal in conducting this experiment was to verify the gear ratio. We wanted to run a test with several trials to see how the advertised ratio of 50:1 compared to the calculated ratio.

Testing Procedure

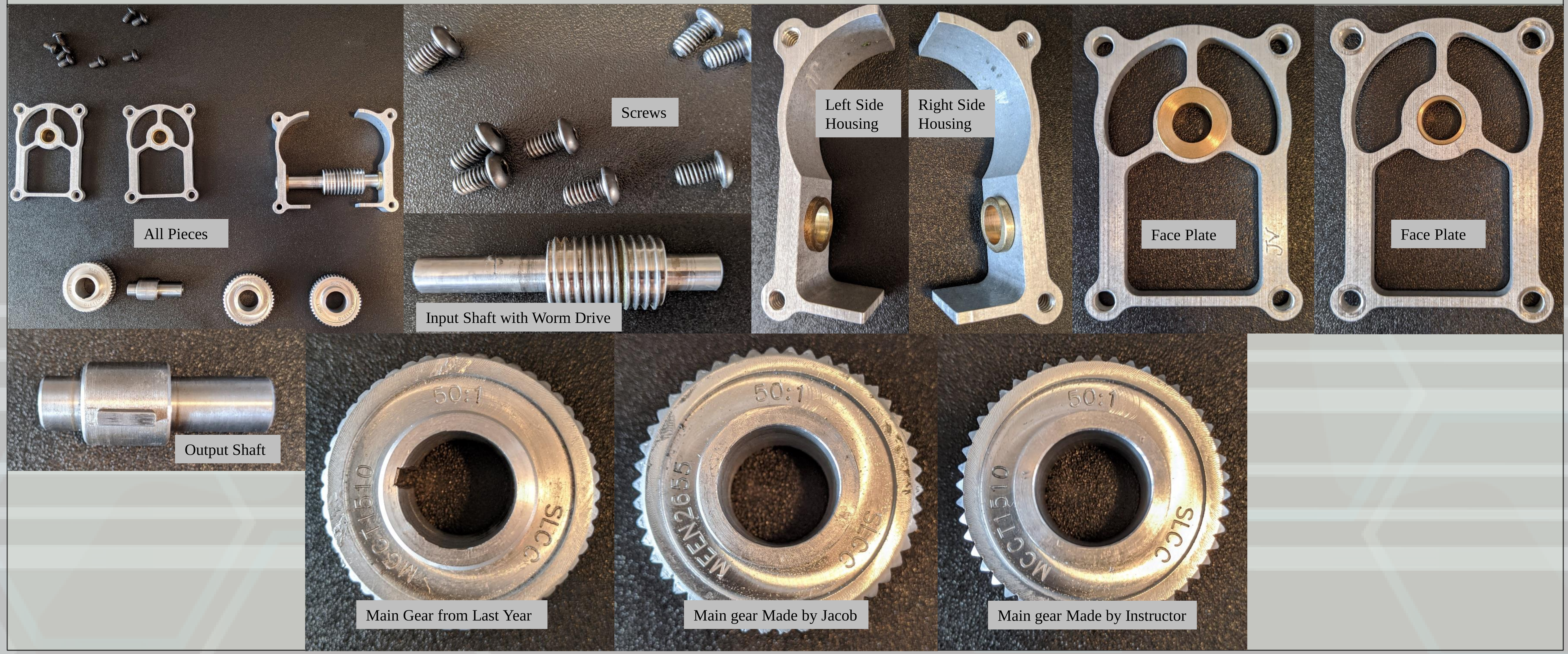
We began our preliminary testing by filling cups with water so that we had a significant weight that would need to be lifted using the gearbox. These cups were attached to two segments of cord, which were attached to the input and output sides of the box. Our plan was to let the cup attached to the input side pull the cord using gravity and it would rotate the gear, and the second cup would then be raised at a 50:1 ratio of height relative to the distance the first cup dropped. We found out the distances where too small to measure accurately without the proper measuring tools. We then found out that it was easier to measure the angle that the input and output shafts moved through than the heights of the loads. The problem we ran into measuring the angles, is that this measurement gave us the same result every time. We assumed that with even more precise measurements we would get exactly the same result every time. We finally decided to go back to heights and moved our measurements to a wall in the room that allowed us to more accurately measure the distances the loads moved.

Preliminary Results

	TEST 1				
Trial #	Measured (cm)		Expected 50:1 (cm)	Expected 54:1 (cm)	Measured Ratio
	Cup A	Cup B			
1	69	1.4	1.38	1.278	49.286:1
2	69.5	1.7	1.39	1.287	40.882:1
3	69	1.8	1.38	1.278	38.33:1
4	69.3	1.75	1.386	1.283	39.6:1
5	69.3	1.85	1.386	1.283	37.459:1

The results of our preliminary testing displayed a trend that was unexpected. What is listed above in the Cup A column is the measured distance that the first cup (Cup A) fell, and in the next column is the measured distance that the second cup (Cup B) was raised due to the gears turning. The third column lists the expected distance that Cup B should have raised based on the Cup A distance and a 50:1 gear ratio. The fourth column lists the expected distances for Cup B based on a 54:1 ratio. We obtained the 54:1 gear ratio by marking on the flat face of each of the gear shafts with a line at 0 radians and rotating the input shaft a certain number of rotations (28π radians) and measuring the change in angle of the output shaft. After 4 trials, we noticed that it measured the exact same every time, giving us a ratio of 54:1, not the expected 50:1. The last column lists the calculated ratio based on the measured distances from both Cup A and Cup B.

Materials



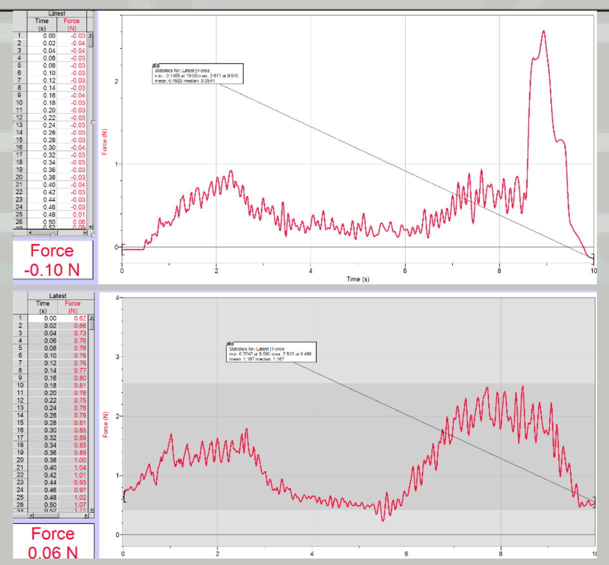
Preliminary Discussion

Based on the data from our preliminary testing, we found that we were getting some results that didn't match what we were expecting. The cord we used did not have a negligible diameter, causing Cup B to be raised at a faster rate than we hoped. By replacing the cord with a much thinner thread, we believe that we will be able to see more accurate results. By increasing the length of the cord, we hope to get data that will be easier to measure with a smaller margin of error. Increasing the length of the cord presents a challenge, however, in that we would need to measure a much greater height, making the measurement process more difficult to plan and execute. By making the test horizontal instead of vertical, we make the process much easier. We will remove the cups filled with water and replace Cup B with some solid block that is not too heavy so that the thread doesn't stretch trying to move it, and simply pull on the longer thread to create the rotation on the worm drive.

Second Round of Testing

	Distance Testing				
Trial #	Measured (cm)		Expected 50:1 (cm)	Expected 48:1 (cm)	Measured Ratio
	Pull	Block			
1	66	1.375	1.32	1.375	48
2	65.5	1.25	1.31	1.364583333	52.4
3	67	1.375	1.34	1.395833333	48.72727273
4	66.9	1.375	1.338	1.39375	48.65454545
5	66.75	1.3125	1.335	1.390625	50.85714286
Avg	66.43	1.3375	1.3286	1.383958333	49.72779221

	Force Testing			
Trial #	Block Pull (N)		Gear Box Pull (N)	
	Static	Kinetic	No Block	Block
1	0.596	0.272	1.006	0.8727
2	0.619	0.3194	0.6529	0.8366
3	0.652	0.345	1.278	1.436
4	0.66	0.3156	1.041	1.187
5	0.633	0.3171	0.5622	1.107
Avg	0.632	0.31382	0.90802	1.08786
Weight:	2.667 N		0.17984	8.992
μ=F/N	μ	0.236913	0.117668	



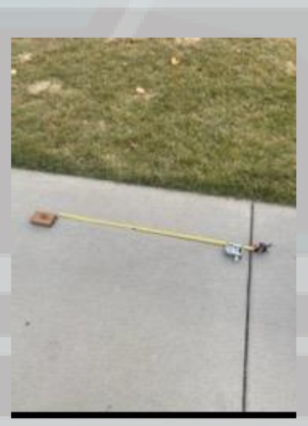
The second round of testing included two separate tests: one to verify the 50:1 ratio of distance that the gear reduces, and one to measure the force that it requires to pull an object using the gearbox compared to the force required to move the object without using the gearbox. We counted the teeth of the gear to make sure that the advertised ratio matched the number of teeth on the gear. If the gear has 50 teeth, it should have a 50:1 ratio. The gear only had 48 teeth, so we adjusted our expected values in the data sheet. After taking several trials, we found that the average ratio for distance to be 49.73:1. This tells us that the gear is closer to 50:1 than 48:1 as we had expected going into this round of testing. The force testing was even more interesting, however. We measured 5 trials of the average force required to get the block to start moving (static friction) and how much force it took to keep it moving (kinetic friction). We used a Vernier force sensor to measure these pulling forces, as well as the weight of the block. In order to get a baseline with which to compare our data, we measured how much force it takes to pull the gearbox without the block attached. Using all the data we gathered, we were able to calculate the coefficients of static and kinetic friction, and the difference of force that the gearbox requires to pull the block.

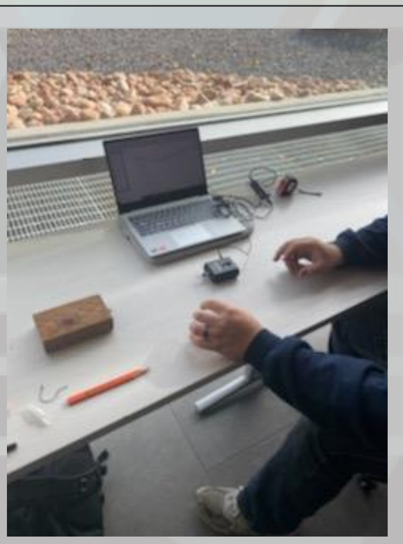
Conclusion

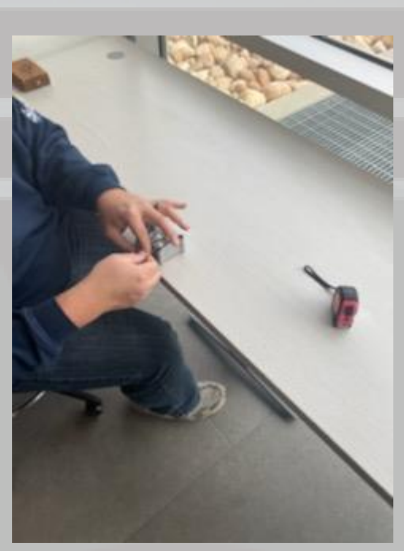
Our findings based on the data we gathered are that the gearbox does in fact have a gear ratio of near 50:1 as stated on the gear itself. However, we found that this is only true when it comes to the distance input vs output. Our testing did not have enough conclusive data to say whether the torque is impacted at or near a 50:1 ratio. We found that the light weight of the wood block we pulled did not require much force at all, and that required force was much less than the force required to move the gearbox, either with the block attached or not attached. This result is due to friction in the gearbox. The gear had been greased prior to testing to help reduce friction, however it is considered widely known in the machining industry that worm drive gearboxes are notoriously high in friction. Due to the friction in the gearbox system, instead of reducing the required pulling force by a factor of 50, the gearbox increased the required pulling force by more than 2 times.

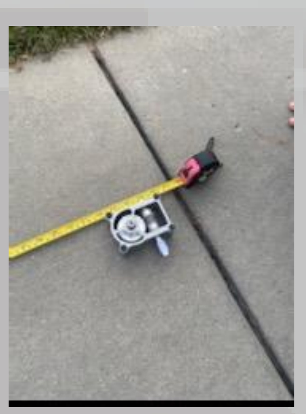
Additional Future Testing

We believe, due to these findings, that the gearbox did not reduce the required force because the block was so lightweight. We believe that if we increase the weight of the object being moved, then we will see the gearbox successfully reduce the required pulling force. We plan on future testing to prove this hypothesis, and we want to see what the relationship between different weights and the force required to pull them through the gearbox. We will also hope to find the amount of energy lost due to the friction in the system and compare that to the weights of the objects we pull in future rounds of testing









Acknowledgments

Jesse Shelkey – Dynamics Instructor
Nicholas Dorius – Machining Lab Instructor
Joel Clarkson – Machining Lab Instructor