Mobility Electric Tricycle: Reducing Wear in the Drive Shaft

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Introduction

The electric tricycle made for the Centre for the Advancement of the Handicapped in Mahadaga, Burkina Faso utilizes a planetary speed reducer to reduce the rotation speed of the motor. The drive shaft of the trike's motor mates with the planetary with a D-shaft, the planetary reduces the motor's rotation speed to increase its torque, and a splined shaft transmits power from the planetary to the trike's sprocket and chain. Figure 3 shows how the planetaries and splined shafts fit together. The planetaries have been quickly wearing until they are unusable. This premature failure renders the trikes unusable because power is no longer transmitted to the trike's chain, thereby taking away users' mode of transportation and source of independence.

Figure 1: Unused sintered metal planetary

Figure 2: Worn sintered metal planetary

A solution to prolong the life of the planetaries is necessary. The work done this year was in two phases. To start, we needed to correlate the accelerated testing that we do to field testing. This is because field testing takes too long for it to be a feasible method to test the effectiveness of new solutions; accelerated testing is faster. To perform the accelerated tests, we place the planetaries in a machine that cyclically applies an 80 pound load to a moment arm that is connected to the splined shaft. This effectively simulates the repeated loading that is applied to the splined socket of the planetaries during normal use. We compare that data to data that we collect after riding the tricycle in the field to find a correlation. The second phase of our research was to do that accelerated testing on a steel planetary. We did this because the steel planetaries are harder (tests showed that ours were) and so should wear more slowly than the sintered metal models do.

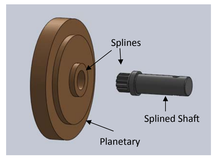

Figure 3: Planetary and a splined shaft

Testing

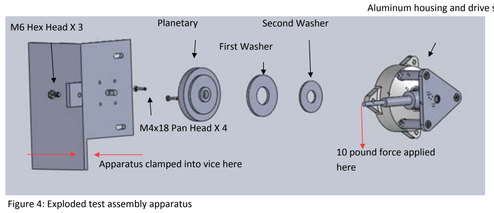

Figure 4: Exploded test assembly apparatus

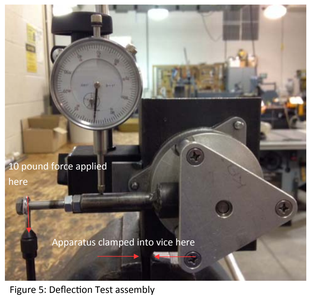

Figure 5: Deflection Test assembly

Deflection Testing Procedure: To measure wear after testing we did our deflection test. We measured how far the moment arm from Figure 6 deflects when a 10 pound force is applied to it using the fixture in Figure 4.

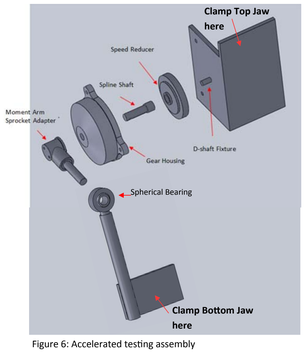

Figure 6: Accelerated testing assembly

Accelerated Testing Procedure: To perform accelerated testing we used a testing machine and the apparatus from Figure 3. The machine has two jaws that move apart cyclically, and it measures the force required to do so. The spherical bearing at the bottom of figure 3 slides onto the moment arm, and the flat stock and fixture are clamped into the jaws of the testing machine. The machine effectively applies an 80 pound load to the moment arm. Applied cyclically, this simulates the load applied to the splines of the planetary when the trike is in use.

Results

Shown in Figure 7 are the results of the deflection tests that we performed while the tricycle was being field tested. We saw a steady increase in deflection as more miles were put on the sintered metal planetary. We fit a line of best fit to the data and compared this to the data shown in Figure 8 from the accelerated testing of the sintered metal planetary. After comparing the two data sets, we found that the change in deflection test results from 1000 cycles of accelerated testing corresponds to the change in deflection test results from 1 mile of field testing. With that correlation, we were able to move forward to do accelerated testing on our alternative, the stronger steel planetary.

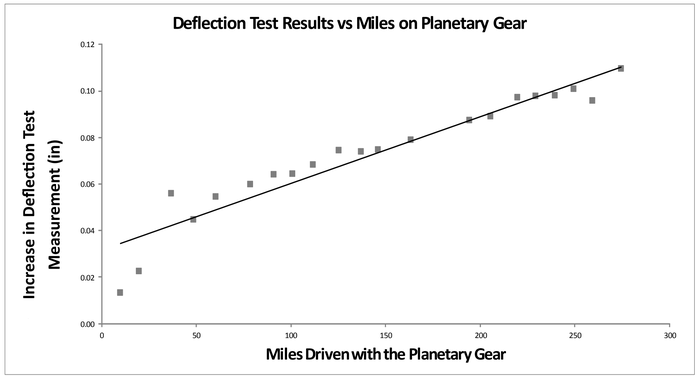

Figure 7: Field testing data on the sintered metal planetary

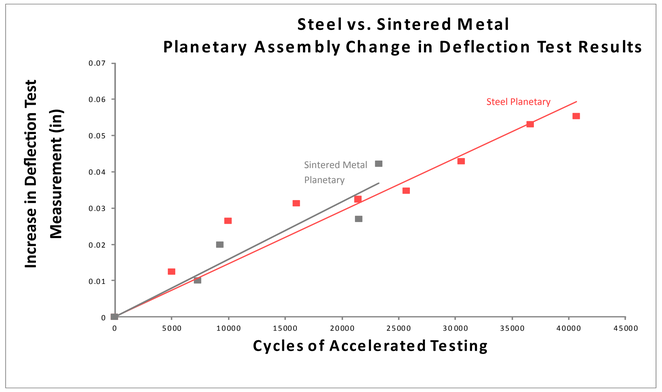

Figure 8: Deflection test data of the steel planetary during accelerated testing plotted with the data points from the sintered metal planetary during accelerated testing.

Figure 8 compares the results from deflection tests that were performed as the steel and the sintered metal planetaries were put through accelerated testing . It is clear from the linear best fit lines for the two data spreads that there is not a significant decrease in the rate of change of deflection test results from the sintered metal planetary to the steel planetary.

Conclusions

We saw very similar wear in the steel planetary set-up as we did the sintered metal one. We realized that the hardness of the steel protects the steel planetary from wearing but likely causes the drive shaft itself to wear. The sintered metal plantetary is softer which means that the sintered metal planetary itself wears but the drive shaft mated to it does not. Effectively, both set-ups wear at about the same rate. The steel planetary is not a feasible solution to prolong the useable life of the electric tricycles because the difference between it and the sintered metal planetary is not sufficient to justify the increased cost. Now that this possibility is effectively eliminated, other solutions will be researched in coming semesters to share with the Centre for the Advancement of the Handicapped.

Further Information

More information about this project and about Disability Resources' Mobility Group can be found on the Collaboratory Wiki by accessing this QR code or going to http://www.thecollaboratoryonline.org/wiki/Main_Page

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