1. Introduction

The primary goal of the pedal power team is to retrofit a stationary exercise bike with an energy conversion system that transforms mechanical work into electrical work. Our team wants to use the stationary bike as an education tool at the Recreational Sports Facility (RSF) in order to ultimately power an iPad that would promote the benefits and potential of human power generation. In regards to this semester, the team has completely overhauled the designed developed during the Fall 2011 semester. In order to power the shaft-driven electric generator, the bike has been transitioned from a gear/chain system to an intermediate gear system driven by timing belts. In addition, we have ordered and machined all the necessary parts in order to fully assemble our design and completed over half of the total assembly.

2. Method

At the beginning of the semester, our team analyzed the mock-up of the gear-chain system that was on the recumbent bike. This system used to two bike gears in order to ramp-up the user’s input rpm to a faster rate. The output gear was connected directly to the shaft of the electric generator. When testing this design, our team realized that the electric generator was not receiving the necessary rpm to maintain a constant, steady charge. Another problem that was discovered was that this current system did not produce any resistance to the user. Therefore, when the user pedaled faster and faster, the pedals would start to slip and the user’s legs would spin out. Thus, our team set out to create new system that would generate the required rpm for the electric generator and offer an adjustable resistance feedback to the user.

In order to produce a constant voltage for powering the iPad, the electric generator required an input rpm of at least 2000 rpm to generate 12 volts. The user inputs about 60-65 rpm. To achieve the 2000 rpm, we needed a larger gear-up ratio. The input gear (large gear) of the current system had 53-teeth and to amplify the user input’s rpm of 65 rpm to 2000 rpm, the newly designed system would need an amplification ratio of input to output of 1 to 31. With the current input gear, this amplification ratio would be difficult to attain since small gears of 8 teeth or smaller are hard to find and not as robust for a recumbent bike. Hence, our team decided to use a intermediate pulley-belt system because the parts that were available would allow the system to produce the necessary 2000 rpm and were much more robust.

2.1 The intermediate Gear system

The intermediate pulley-belt system utilized two stages. At each stage, the rpm of the user would be multiplied by 6 and the rpm at the generator shaft would be, in theory, 2340 rpm which is more than enough to produce a constant voltage. The pulleys that could be purchased
(from McMaster Carr) allowed us to achieve this gear ratio and were robust parts that would be able to handle the high speeds and torque. Our implementation of this design will be discussed in more detail later in this report. Furthermore, the pulley-belt system provided additional benefits. Since we were using toothed-belts, the risk of the belts slipping off the pulleys was greatly reduced. Furthermore, the belts increased the safety of the system since there are no moving sharp edges like those in a chain-gear system. The parts that were purchased for this design are shown in table 1.

<table>
<thead>
<tr>
<th>Line</th>
<th>Part Number</th>
<th>Description</th>
<th>Quantity</th>
<th>Unit Price ($)</th>
<th>Purchased from:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6495K23</td>
<td>L and H Series Timing Belt Pulley, L-Series, Fit 1/2&quot; Belt Width, 1.438&quot; OD, 10 Teeth</td>
<td>2</td>
<td>16.65</td>
<td>McMaster Carr</td>
</tr>
<tr>
<td>2</td>
<td>6484K159</td>
<td>Trapezoidal Tooth Neoprene Timing Belt, 3/8&quot; Pitch, Trade Size 450L, 45&quot; Outer Circle, 1/2&quot; W</td>
<td>2</td>
<td>16.27</td>
<td>McMaster Carr</td>
</tr>
<tr>
<td>3</td>
<td>6495K222</td>
<td>L and H Series Timing Belt Pulley, L-Series, Fit 1 1/2&quot; Belt, 7.13&quot; OD, SD Bushing</td>
<td>2</td>
<td>87.62</td>
<td>McMaster Carr</td>
</tr>
<tr>
<td>4</td>
<td>7208K51</td>
<td>Steel Flange-Mounted Ball Bearing, for Shaft Diameter 3/8&quot;, Overall Length 2-1/2&quot;</td>
<td>2</td>
<td>22.23</td>
<td>McMaster Carr</td>
</tr>
</tbody>
</table>

Table1: Purchased parts for the intermediate gear system

Our team retained the original shaft-driven electric motor used during the Fall 2011 semester. Conventionally, we decided that the electric generator must sustain ~12 volts in order to effectively charge the battery of an iPad. In order to safely produce 12 volts from our electric motor, we experimentally determined that the shaft must rotate at ~2300 rpm. (See Appendix A).

3. Implementation

The team tried to use standard ready made parts bought through McMaster to minimize machining costs, if the product was sent to mass production. Also readymade parts reduce the maintenance costs. The part list is provided in Table 1. Figures 1-4 show the parts that were implemented to construct the intermediate gear system.

Figure 1 shows the primary crank. The steel wheel was removed from the bike and a aluminum plate was machined to attach the timing belt pulley to the crank.
Figure 2 shows the secondary gear system which consists of 2 separate pulleys. This serves as the main apparatus that boosts the RPM. Two flange mounted ball bearings were used to attach the axel to the frame as shown in figure 2. QD bushings were used to attach the timing belt pulley to the axel.

4. Conclusion

Our immediate next step is to finish the assembly of the bike. Our team projects to have the electric generator fully mounted to the bike and connected with the intermediate gear system by the end of Summer 2012. In order to accomplish this task, we will first need to place an idler in the primary gear system to reduce the slack that is in the current belt. This entails purchasing and installing a bearing that is designed to accommodate our idler pulley. This part will be found on McMaster. Another major task is to mount the motor to the bicycle. For this, we will need to have our design for the primary system set in stone so that we can position the motor accordingly. The mechanism for mounting the motor can be carried over from the fall 2011 bike design.

Once these two tasks have been accomplished we should have the physical components of the bike finished. What will be left to accomplish is the electronics system and perhaps additional features like adjustable resistance. For the electronics, most of the components which are currently used on the “Pedal A Watt” bicycle found in the lab will be brought over. This means that we will be wiring the motor to a power pack, which can then be rerouted to
the iPad charger. This task should be trivial, with the biggest concern being only that the system is contained and aesthetically pleasing. In terms of user resistance, this is a feature we would like to incorporate but have not yet designed. One idea for implementation is to use mechanical arm to increase the tension in the belts. A more sophisticated design suggestion would be to use a microcontroller with a variable resistor that can create a back EMF to slow the system. Our team hopes to showcase the pedal-powered iPad in late 2012 or early 2013.

Acknowledgements

Mick & Gordon of the Etcheverry Machine shop
Dr. Agogino
Maja Haji
Appendix A

Voltage vs. RPM

\[ y = 0.0065x + 0.064 \]

\[ R^2 = 0.9996 \]