HPVCP

Operation/Assembly Manual

Abdulh Alsabaie

Yen Clutter

Daniel Quezada

Connor Tolman

Yujie Zhang

2020

NORTHERN ARIZONA UNIVERSITY | College of Engineering, Forestry, and Natural Sciences

Project Sponsor: Dr. Perry, Machine Shop and Mechanical Engineering Department

Faculty Advisor: Dr. Perry

Sponsor Mentor: Dr. Willy

Instructor: Dr. Willy

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1 INTRODUCTION

The scope of this document is to guide how to operate and maintain the energy storage & regeneration system designed by the team. The energy regenerative propulsion system is designed by the team to improve the assembly parts of the existing human-powered car, which is mainly composed of a flywheel, a clutch, and electronic components. The flywheel will store the excess energy and release it when needed. Section 2 of the document will introduce how to make parts safely and correctly to ensure the consistency of product production and design. Section 3 will introduce the basic maintenance of the propulsion system to ensure the safety of the propulsion system during assembly and use. Section 4 will introduce how to assemble existing parts into a propulsion system designed by the team.

2 MANUFACTURING

This section discusses the correct procedures to be followed to manufacture the parts for the kinetic energy recovery system, including the flywheel, clutch plate fixture, and sprockets.

Flywheel:
The operative aspect of the team's regeneration system is the flywheel. The flywheel is what stores all of the energy regained from the system, and therefore has to be massive to retain the appropriate amount of energy.

1. The flywheel was machined from a ten-inch mild steel extrusion and therefore was not perfectly circular when received.
   The one-inch thick extrusion had to be faced, and the circumference had to be turned down in order to ensure concentricity.
2. With the outer circumference turned, and the mating surface faced, the center bore needed to be drilled at .75 inches to clear the shaft and return spring.
3. To carry the flywheel on the shaft the (2)bearing seats were then machined in at a 1.375-inch diameter.
4. In order to safely contain the bearing when under operation, a retaining plate was machined, and (4) holes were drilled and tapped into the flywheel to affix the plate using (4) 8-32 machine screws.

Clutch Plate Fixture:

1. The clutch plate fixture was also machined from a solid extrusion, however, it is aluminum. The extrusion was turned down on a lathe to ensure concentricity.
2. The center bore of the fixture was drilled out at one inch, to reduce weight and clear the center shaft.
3. The bearing seats were machined on a CNC mill to house the carrier bearings in the fixture
4. On the CNC mill, the clutch plate alignment tabs were machined into the face of the fixture and the friction plate journal was cut
5. After flipping the fixture 180 degrees, (6) mounting holes were bored into the back face of the fixture.
6. The (6) holes were then threaded to accept (6) ¼-20 screws
7. Finally, the (2) carrier bearings were pressed into the fixture plate

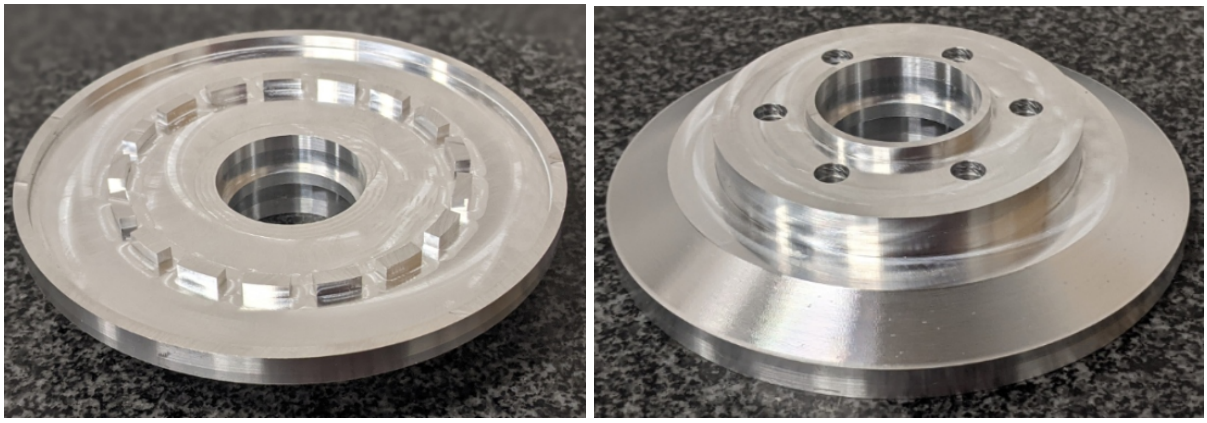


Figure 1: Friction Plate Fixture

Sprockets:
The (2) sprockets used on the vehicle are hardened carbon steel, however, the bore is too small.

1. To clear the retaining ring of the jaw clutch the center bore of the plate sprocket was widened from a .5 inch to 1.375 inch
2. To accommodate mounting to either the hub or the clutch plate fixture, (6) holes were bored and countersunk

3 MAINTENANCE

This section covers the maintenance and upkeep of the vehicle and energy recovery system. All moving components must be kept properly lubricated and clean in order to maximize longevity and ensure safe operation.

Prior to operation:

1. Shaft should be visually inspected to make sure that there are no cracks or deformation
2. All moving components should be free of obstruction
3. System should be properly retained between collars that are fastened appropriately

For cleaning and lubricating bearings:
The bearings used are double shielded in order to reduce particulate accumulation, however they need to be inspected prior to every use.

1. If found to be dirty, the bearings should be sprayed with a non residue degreaser to remove surface buildup.
2. If the dirt, or other contaminants have made it inside the bearing, the bearing should be removed and cleaned using high pressure air after following step (1).
3. after cleaning, the bearing should be left to dry, and then re lubricated using heavy oil before reinstallation

For cleaning and lubricating chains:

1. To clean the chains, it is recommended that brake cleaner be used for quick degreasing and dirt removal. To accomplish in depth cleaning after heavy buildup, the chain should be soaked in mineral spirits or acetone. Both methods will result in a clean chain, without any residuals left on the chain due to the cleaner.

2. To make sure that the components are ready for use after cleaning, the chain must be properly lubricated to return to service. Dry chain lubricants are recommended to reduce particulate buildup

Electronic System:

1. If the screen is not turning on, displaying metrics, or is too dim/bright:
    a. Open the housing lid and turn the potentiometer (located on the breadboard in the center of the Arduino) until you can read the screen.
    b. If the previous does not work, open the housing and replace the 9v battery.
2. If metrics are incorrect or not registering:
    a. Turn the system on, wait 5 seconds and repeat. If this does not work move on to the next step.
    b. Open the housing and *gently* press down on the wires to make sure they are connected. Excessive jostling of the HPV might cause wire disconnection. The digital input wires are the black ones inserted into the -3, and -5 digital read sockets- if the wires here are disconnected, the output from the HE sensors will not register.
    c. Lastly, inspect the wires and Hall Effect sensor to ensure no wire has been cut or the Hall Effect sensors have not been damaged. If they have been, replace the damaged parts.
        i. To test if the HE sensors are functioning take a strong magnet and pass it by the HE sensor (with north-facing towards the sensor) while the electronic system is on. If they are functioning a red LED will turn on when the magnet is in proximity.
3. Advice for Operation
    a. Turn off the system immediately after dismounting the HPV
    b. Avoid tinkering with wires
    c. Do not jostle the housing and avoid rough handling of the HPV to reduce risk of wires disconnecting, if wires disconnect refer to 2.
    d. Do not get housing wet.

4 ASSEMBLY

This section discusses how to assemble and mount the energy recovery and storage system and its corresponding electrical components as part of the HPV propulsion system.

Mechanical System:

collar, thrust bearing for the jaw actuator interface, jaw actuator, thrust bearing for clutch, retaining clip for jaw actuator, sprocket, clutch plate fixture, carrier berings, friction plate , return spring,flywheel, flywheel bearings, bering retaining plate, collar- all captured in mount

1. Connect the mounting system to the HPV using (2) bolts and corresponding nuts, inserting the bolts from the outer side of the vehicle as seen in figure #. Tighten until snug.

Figure 2: Mounting System and Flywheel

2. Carefully press the bearings into either side of the flywheel using a hydraulic press, ensuring that the bearings are level and flush with the surface of the flywheel, and outer race is supported. Use caution to not to impinge on inner bearing race directly.
3. Once both bearings have been pressed into the flywheel, connect the bearing retaining plate to one side of the flywheel using (4) machine screws per figure 2.
4. Ensure that the screw heads will clear the mounting system during operation.
5. Carefully press 2 bearings into either side of the friction plate fixture, ensuring that the bearings are level and flush with the surface. Do NOT press on the alignment used to hold the friction plate.
6. Insert the friction plate into the friction plate fixture, using high temperature epoxy to adhere them together. Insert the two combined parts into vice grips or C-clamps overnight to ensure proper bonding.
7. Connect the sprocket to the back of the friction plate fixture using (6) machine screws. If screw heads do not counter-sink safely level with the sprocket face, surface grind the tops of the screwheads to sit flush. Do not grind so much as to prohibit removal of bolts
8. Connect the remaining sprocket directly to the disk brake mounts of the bicycle hub using (6) M5 machine screws.
9. Begin system assembly. Slide the following components onto the shaft, left to right, in the order given. Do NOT tighten anything down yet.
    a. Collar
    b. Small thrust bearing
    c. Both sides of the spiral jaw actuator, putting the non-keyed half on first
    d. large Thrust bearing
    e. Retaining clip for jaw actuator. This is to keep the thrust bearing in place.
    f. Sprocket/Clutch Plate assembly, with the sprocket side being put on first
    g. Return spring
    h. Flywheel with bearings installed
    i. Spring or other available solid spacers such as washers.

    j. Collar
10. At this point, slide the shaft into the mounting system so that all components listed above sit between the mount arms, and to the left of the rear wheel (from the driver's perspective).
    a. Leave enough room on the outside of the mounting system, on the rightmost side, to attach another collar. Do not attach this collar yet.
11. Move all components except one collar to the leftmost position of the mounting system so that no more than ¼” remains between the flywheel and the clutch plate. Tighten the collar.
12. Add (1) collar to either side of the shaft on the outside of the mounting system and tighten. See figures 2 & 3.
13. Slide the remaining collar on the inside of the mounting brackets to the rightmost side of the mounting system and tighten.
14. Next, attach the sensor mount to the leftmost side of the shaft, so that it sits within ½” of the flywheel. Attach a flat magnet to the flywheel at the radius of the sensor mount.
15. Connect the chain from the sprocket on the wheel to the sprocket on the friction plate fixture.
16. Run cables from the right-hand brake actuator to the spiral jaw actuator.

Figure 3: Energy Recovery and Storage System Assembly

The following steps are for mounting and installing the electrical components of the design.

17. Mount the electrical box and mount on the front of the vehicle, directly below where the pedals are mounted.
18. Place the electronic system into the mounting box, with the sensors and their wires leaving the left side of the box.
19. Run wires along the frame, connecting them at intervals to the frame with electrical tape, zip ties, or any other available fastener. Run wires under the seat until the rear of the vehicle.
20. Run one wire up to the sensor mount to collect flywheel data. Secure the sensor in the mount using super glue, tape, or some other fastener. Ensure there is no tension in the wires and that they are not placed near any sharp parts or points of friction.
21. Run the other wire and sensor to a point on the frame next to the rim of the rear wheel. Connect a

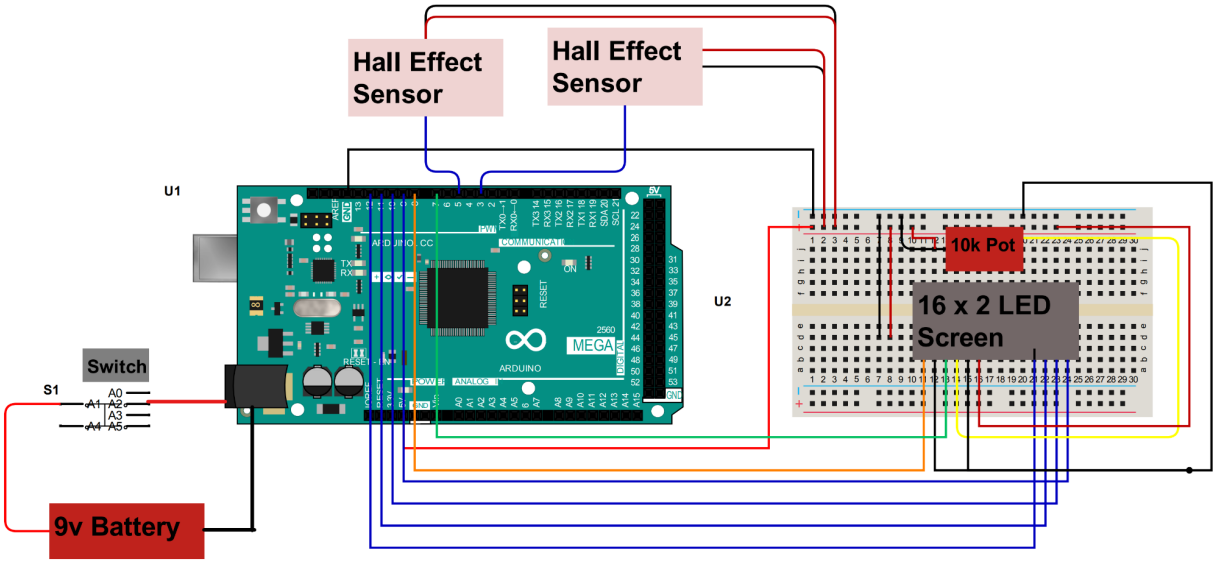
magnet to the rim using super glue. Fasten the sensor to the frame at this point using electrical tape.

The following steps are to ensure that the electronic equipment is working properly.

22. Spin the flywheel. If the sensor lights up, the magnet is mounted correctly. If not, check the polarity of the magnet and the proximity of the sensor to the magnet.
23. Spin the rear wheel. If the sensor lights up as the magnet passes, the magnet and sensor are mounted correctly. If it does not, check the polarity of the magnet and the proximity of the sensor to the magnet.

Electronic System:

1. Follow the wiring diagram below to correctly connect all the electrical components. Make sure all leads and ends are firmly inserted into the board and breadboard.
2. Place the mini breadboard in the center of the Arduino, making sure to take off the adhesive backing and stick it to the board- this prevents jostling and breakage.
3. Solder blue, red, and black wires to their respective digital output, power, and ground pins on the HE sensor. Connect the other ends of those wires to the board accordingly. Connect the digital output pin of the HE sensor on the wheel to digital pin 3 and the output pin of the HE sensor for the flywheel on digital pin 5.
4. Once the board is connected as shown in the diagram carefully place the components into their rightful place in the housing, refer to Figure 1 in the appendix. Do not insert the Arduino into the housing as shown in the appendix, instead place it flat on the floor of the housing and carefully screw the board down using very small screws. Lastly, place the switch into the right side of the LCD compartments and place the lid on top. Make sure the lid is not pinching any wires.
5. Plug the 9v battery into the battery port of the Arduino and flip the power switch to confirm the board and LCD screen turn on.
6. Give the wires on the board a very slight wiggle, if any wire disconnects it was not inserted firmly enough. Reconnect the wire.
7. Test the electronics system to ensure everything was installed correctly. Do this by turning on the system via the switch, wait for 5 seconds. First, spin the flywheel and then read the display to make sure it is registering. Second, lift the rear frame of the HPV and spin the rear tire. Read the screen to ensure that the speed is registering. If either of these testing procedures fail, refer to the maintenance section.


Hall Effect Sensor
Hall Effect Sensor
U1
U2
10k Pot
16 x 2 LED Screen
Switch
S1
A0
A1
A2
A3
A4
A5
9v Battery

5 APPENDIX

Appendix A: Electrical Components

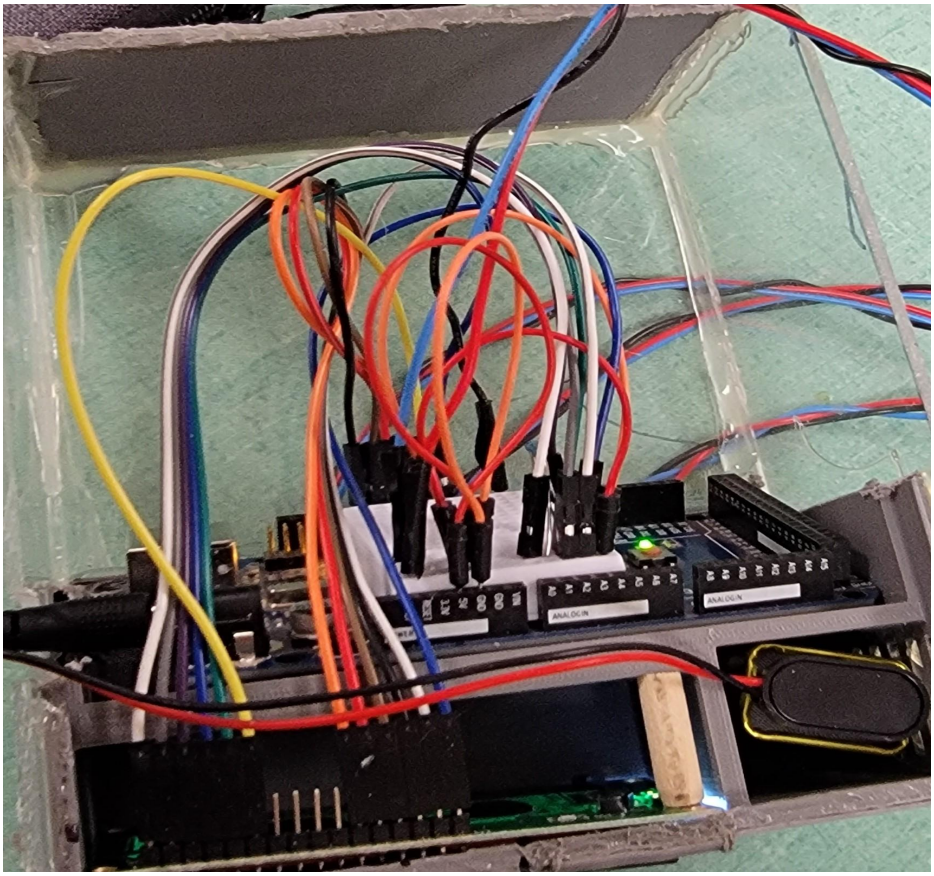


Figure A1: electrical components (Arduino, LCD, Battery)