Ishmael the sheet metal fish



ENGR2330 Introduction to Mechanical Prototyping

Team Ishmael

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Executive summary

Our team designed and fabricated a sheet metal killer whale, named Ishmael (Figure 1). The preliminary shape of the whale came from images of the whale. Each person then took primary responsibility of a certain part of the whale (the author focused on the back six ribs). Patterns were later added to the orca imitating patterns of Native American whales. Unfortunately, due to miscommunication with the machine shop, not all the intricate patterns were cut out.

The resulting fish structure is powered by a wire-controlled motor actuating on two tendons which move the tail up and down in a motion similar to a real orca.



Figure 1 Isometric view of Ishmael's structural design

Design

Structure

Style



Figure 2 We mimicked the shape of our whale after the shape of real orca whales.

The overall structure of Ishmael came from realistic depictions of real orca whales (Figure 2). We added patterns to the whale structure imitating a Native American style of art (Figure 3)



Figure 3 Native American style artwork we imitated for Ishmael's design



Figure 4 Final structural design of Ishmael

Our final structural design of Ishmael was a combination of biomimicry and Native American art. Due to a miscommunication error with the machine shop however, we were unable to have the intricate interior designs cut on the ribs.

Structural elements

The basic structural elements of Ishmael are the ribs, backbone, and tail Figure 5. The head, dorsal fin, and side fins are purely aesthetic elements. The front four ribs serve no functional purpose except to provide the shape of the whale. Thus they were designed to be very intricate and with thin interior designs. The back three pair of ribs are less intricate because they serve as the attachment points for the tendons to move the backbone and the tail. All parts except the back portion of the backbone were fabricated using AL6061-T6 sheet metal.



Figure 5 The basic structure of Ishmael



Overlapping section between front and back portion of backbone

Figure 6 The ribs and backbone of the orca

The ribs are all bent sheet metal, forming an L structure on the base structure of the backbone (

Figure 6). The backbone is composed of two parts. The front part is stiff and made of AL6061-T6 sheet metal like the rest of the assembly. The back portion of the backbone is made of thin, flexible, blue spring steel. This allows the caudal end of the backbone and the tail to move up and down. The back portion of the backbone and the front portion share a common section that is sandwiched by two pairs of ribs. In that common section, a hole is cut out to provide room for the motor. Finally, the ribs attachments, like all other structural attachments on Ishmael were made using pop rivets (not shown).



Ishmael's head has a bent tab (L structures) that attaches to the bent tab on the front portion of the backbone to ensure proper head angle. The side fins also have bent tabs that attach via pop rivet to the front backbone. Finally, the tail attaches to the back portion of the backbone via three pop rivets.



Figure 8 Dorsal fin and gearbox tabs of Ishmael

Finally, the dorsal fins orient attach to the middle of the backbone through an L structure of bent tab ends (Figure 8). L brackets form tabs which attach the gearbox/motor (not shown) to the backbone. In a sense, the center two ribs sandwiched between the dorsal fin form a U structure to leave room for the gearbox/motor.

Power



Figure 9 A battery powered controller powers the gearbox motor.

Power is provided by two D cell batteries (3V total) which power a controller (Figure 9). The controller provides the power to Ishmael's gearbox motor (a permanent magnet DC brushed motor) thru two wires. The wiring is such that controller only turns the motor when the left control stick is pushed up or down.



Figure 10 The gearbox assembly is mounted into Ishmael via two support tabs and small screws.

The gearbox motor is mounted into Ishmael's backbone via the two gearbox support tabs and two screws (Figure 10).

Transmission



Figure 11 Tendons transmitted power into the movement of Ishmael

The motor turns an internal gearbox in the gearbox assembly to achieve an approximately 4:1 gearing ratio (

Figure 11). The output shaft turns two cranks- one on top and one on bottom- which attach to the top and bottom fishing line tendons (respectively). The cranks translate the rotary motion of the gearbox output shaft into linear motion to move the tail up and down. The cranks are offset such that one tendon is tightened as the other tendon is loosened.



Bottom tendon Crossing point (blue)

Figure 12 Side view of tendon-rib transmission system (tendons highlighted in color)

The tendons thread through the back three pairs of ribs through cut holes and are tied to the tail. In between the last and second to last pair of ribs, the tendons cross the backbone through a hole in the backbone (Figure 12). When the tendons are actuated, the entire back backbone is bent, while the crossing point allows the tail fin to be bent the opposite direction, thus giving Ishmael a more realistic tail motion.

Drawings

See attached. They are in the following order:

- 1. Full assembly drawing
- 2. Parts drawings