Water Activated Fly Fishing Lure

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Abstract
The recreational fishing industry lacks a fly lure that exhibits realistic insect-like motion. Existing lures move, however they do not necessarily move like an insect. The sponsor’s goal is to create an artificial fly lure which displays movement like a real fly without utilizing any external inputs. The team began by taking the sponsor’s qualitative requirements for the project and translating them into engineering design constraints. Based on these constraints the team then created a design concept. This concept consists of a tubular shaped body containing a power supply, electromechanical device, mechanical and electrical systems required to activate the lures motion. Prototype testing has been completed and the results show the current design concept is a valid and achievable one. While there has been success testing has shown that much lays ahead for the future of this lure. Although the current concept is valid there is still room for optimizing the fly lure’s power to weight ratio, wing actuation, wing material, and sealing.

Electrical wires and right body omitted for clarity
The Need for Project

A fly fishing lure that displays life like movement does not currently exist on the market. Currently no self powered fly fishing lures are on the market that exhibit lifelike movement. Lures are handmade to look like insects found in the fishing area. They remain still when they land on the water. Fish can easily tell the difference between live insects and poorly designed fly lures. A water reactive fly lure that displays life like movement will aid willing fisherman in catching more fish.

The Design Project Objectives and Requirements

To design and build a working proof of concept of a fly lure that displays life like movement by flapping its wings.

Design Objectives

The objective of this project is to provide amateur fly fisherman a fly lure that displays lifelike movement when it lands on water. This will be accomplished mainly with wings that oscillate. The fly lure will be fabricated to imitate (land, float, move) a dragonfly. Low cost will also be an objective since this is a commercial product and will have competition from standard fly lures. Finally the lure cannot produce any byproducts that would affect the fish or environment.

Design Requirements

For the fly lure to imitate a real dragonfly, it must first have a similar size (a wingspan of 50mm.) The weight of the fly lure must be small compared to the weight of the fly line used for casting. To produce life like movement, wings will be designed to oscillate at a similar frequency to a real dragonfly’s (30 beats per second.) The lure system must be activated when it lands on water. For the fly lure to be competitive in the market it must cost less then $2.00 each to make.

Design Concepts considered

Many concepts were explored including mechanical, electric and chemical energy. Initial ideas and concepts were discussed during brainstorming sessions. From these sessions the following primary design categories were defined: energy, motion and support structure. The energy category is subdivided into: source, storage and conversion. The following subsections highlight the concepts in each category.

Energy Source

Three methods of adding energy to the system were considered: Human, environmental and chemical. Human interaction concepts included compressing a spring by hand or winding memory materials. These were dismissed because of user time constraints. Environmental concepts included solar power, wind power and utilizing the current in
rivers and were dismissed due to lack of reliability. Chemical reaction concepts included utilizing effervescence or a battery. Effervescence was dismissed because it could not be properly harnessed.

**Energy Storage**

Two concepts were considered for energy storage: mechanical and electrical. Mechanical storage concepts were based on storing potential energy in a spring or memory material. The electrical storage concept utilized a battery to store electrical energy.

**Energy Conversion**

The energy created in the previous sections were classified as ‘raw energy’ to be converted into ‘useful energy’ that will move the wings of the fly lure. A battery is a method to convert chemical energy into electrical energy. Both rotational and linear electronic motors are a means to convert electrical energy to kinetic energy. A spring or memory material is a method for converting mechanical potential energy to kinetic energy. No feasible method could be derived to convert chemical energy directly to mechanical energy.

**Motion**

Flapping wings is the motion to be exhibited by the lure. Two concepts were considered for creating this motion from raw mechanical oscillation: rigid linkage and flexible actuator. A rigid linkage involved a two force member to be attached to the wings and the device creating motion, either a linear or rotational motor. The flexible actuator concept utilizes a string attached between the wings on either side of the fly. As the motor turns it actuates the string and wings.

**Support Structure**

All the previously discussed components need to be secured to a hook and sealed from water. Three main concepts were considered for this task. The first concept was a sheet metal housing that would be stamped and formed into a cylinder for strength and uniformity. The second concept was a molded or extruded plastic housing also in the shape of a cylinder. The plastic housing concept could be single- or two-piece. A third concept with a spine and heat shrink to secure and seal components was also considered.

**Recommended Design Concept**
The recommended design concept utilizes a button cell battery to power a DC motor that actuates a cam which in turn actuates a string attached to wings supported by a 2 piece plastic body.

**Design Descriptions**

The recommended design concept has a 2-piece molded plastic body to house 2 button batteries, a water activated switch and a motor with a cam. Attached to the outside of the body is a thin wing that is actuated by a string passing through the body and underneath the cam.

**Energy Creation & Storage**

Of the energy concepts discussed, battery power (2x1.4V is recommended due to advantages over other sources discussed. The batteries chosen are able to power a motor that can produce the rotational frequency to replicate the beat of a dragonfly’s wings. The 1.4V batteries are lightweight, low cost and readily available.

**Energy Conversion**

The energy conversion method must convert the electrical energy to mechanical energy. Thus, a miniature DC motor is selected.

**Motion**

The recommended method for converting the rotational motion of the motor into the motion of the flapping wings is a flexible actuator. The flexible actuator will be made from monofilament line that is low cost, lightweight and readily available. The line attaches to the wings with epoxy, and passes through small holes in the body. The close fit between the monofilament line and the holes in the body will prevent water from entering the body. The monofilament line passes underneath the cam and between alignment ribs to keep engaged. The monofilament line is not secured to the cam, reducing friction and wear on the line. This also simplifies the manufacturing process.

**Support Structure**

The recommended support structure is a two piece custom molded plastic body. The two pieces are nearly symmetrical, fit into each other and will be held together with epoxy for the proof of concept. Energy directors can easily be added to the body so that the 2 halves can be ultrasonically welded together for production volumes. The advantage of a two piece body over a one piece body is the ability to mold the compartments needed to house the interior components.

**Analytical Investigations**

Research was performed on the energy usage of insects and small flying mammals in order to derive a baseline energy usage value. This energy usage was used to determine what energy sources would
feasibly be able to power the system. Calculations were performed that utilized the conductivity of water to determine the correct dimensions for the water activated switch. The size and spacing of the conductors of the water activated switch is key and was derived from precise analytical calculations.

**Experimental Investigations**

The first experimental investigation was the initial prototype of the current recommended concept. It used a pen tube as the body, along with a pager motor with an eccentric. Monofilament line was used as the actuator, and it was secured to the wings with a knot. This exercise proved that the concept could generate the desired flapping wings. The second investigation tested the concept of the water switch. Plastic test housing was used with copper conductors to show that a water switch could be used to activate the system.

**Key Advantages of the Recommended Concept**

The primary advantage of the recommended concept is that it visually displays wing movement nearly identical to that of a dragonfly. Additionally the life of the product is based solely on the time it spends in the water because the device is water activated. There is no standby or idle time for the battery life to be wasted.

**Financial Issues**

The biggest financial concern is the tooling cost for the custom molded plastic body halves. The majority of the components used in the design are off the shelf components that are low cost and readily available. The custom molded plastic housing is the biggest cost. The piece price to mold in high volume is estimated to be approximately $0.20 each. However the tool cost is estimated to be between $5k - $10k. If the fly lure body is ultrasonically welded together there would be an additional investment of approximately $20k.

**Recommended Improvements**

The standard batteries can be replaced with rechargeable batteries. One recommended improvement is to replace the standard button cell batteries with rechargeable batteries. The rechargeable batteries could be charged inside of the body, or be removable. If the batteries cannot be removed due to sealing concerns, extra leads could be added that could be connected to a charging base. The second recommended improvement is to add energy directors to the plastic body halves so they can be ultrasonically welded together. This would improve sealing and the manufacturing process.