An Easy Hero's Engine

Conservation of Energy

Introduction

Phase changes are taught at just about every level of science education, K–college. Rarely, however, is it emphasized what an important role they have played historically in our technological development. The boiling of water, after all, was what first allowed us to take significant advantage of chemical energy, enabling us to convert the heat given off during an exothermic reaction into useful work. How wonderful then that one of the earliest and most fundamental steam engines can be replicated with an aluminum soda can!

Concepts

- Energy conversion
- Gas laws
- Newton's third law of motion

Materials

Water
Bunsen burner
Fishing swivel
Pin
Soda can, unopened
String
Support stand with ring clamp

Safety Precautions

Caution should be taken whenever dealing with flame. Keep all flammable materials away from the demonstration. The can becomes quite hot during this demonstration. Keep hands and face away from the steam coming out of the can. Use heat resistant gloves or allow the can to cool completely before removing it from the swivel. Wear chemical splash goggles and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the laboratory. Follow all laboratory safety guidelines.

Preparation

1. Using an unopened soda can, gently slip a piece of string under the pull tab and pull it up so that it is wedged in over the rivet in the can's center.
2. Thread the string through a fishing swivel and tie the two loose ends of the string together (see Figure 1).
3. This step can get messy and should be done near a sink or even outdoors! Remove the soda can from the swivel and lay the soda can on its side. Push a pin in the side of the can about half-way up, and then withdraw the pin (see Figure 2). *Note:* If the can is kept horizontal and the hole is made on the very top of the curve, soda should not squirt out of the hole!
4. Empty as much of the soda as possible out of the can by shaking it with the pin-hole facing downward into a sink.
5. When shaking is no longer very effective, make a similar hole in the exact opposite side of the can—180° from the first slit (see Figure 3). Blow through this hole to force the remainder of the soda out of the can.
6. Insert the pin back into one of the holes, and then push the pin head to one side to make the hole tangential to the wall of the can (see Figure 4). Repeat this step for the second hole, pivoting the pin head to the same side as for the first. See Figure 5 for a top view cross-section of these tangential holes.
7. Add 20–30 mL of water to the can. This may be done by any of a number of ways. Perhaps the simplest is just to hold the can down

Figure 1.

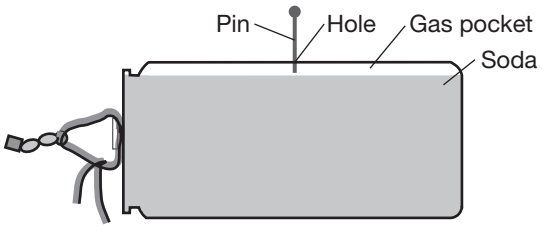

Figure 2.

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on its side at the bottom of a deep basin sink and let the water flow into one of the holes for about 10 seconds. Or, hold the can in a pan containing 3–4 cm of water, with one hole on bottom (submerged) and the other hole on top, and let the water leak in over the course of 5–10 minutes. Alternatively, if available, a hypodermic needle may be used to squirt water into the can.

8. Attach a ring clamp to a support stand, and tie a length of string to the outside edge of the ring. Tie the other end to the fishing swivel about 1 cm below the ring, and cut off any extra string (see Figure 6).

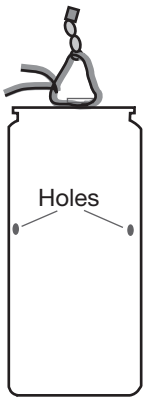

Figure 3.

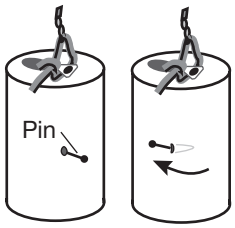

Figure 4.

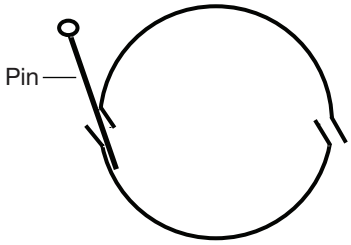

Figure 5.

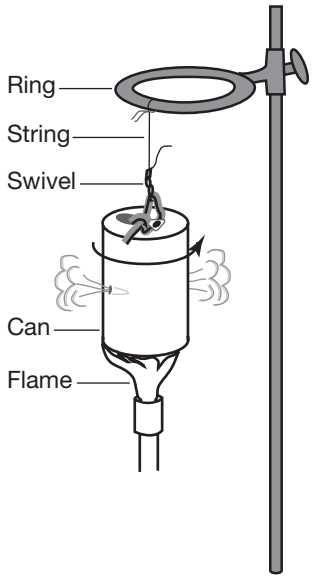

Figure 6.

Procedure

1. Establish a cool flame on a Bunsen burner and place it under the can, adjusting the ring height if necessary (see Figure 6).
2. Once the water inside starts boiling and the steam starts spurting out of the two slits, the can will begin spinning quite rapidly, and continue for several minutes.

Disposal

All materials may be saved for future use.

Tips

- Diet sodas are preferable if this activity is being done inside, since they have less potential to create a sticky mess.
- To increase the duration of the spin, use more water, but expect a proportionately longer heat-up period.
- To make an engine that spins the other way, repeat the above procedure, but orient the holes in the other direction. In other words, instead of having the holes angled to the right, have them angled to the left.
- If ring stands and/or Bunsen burners are not available, try the following less expensive alternative. Fold a coat hanger down the middle to form a tripod-like stand with a hook on top. Take the bottom 1/3 of another (empty) soda can, turn it upside down and place 10–15 mL of Sterno® in the concave bowl of the can's bottom. Place it beneath the hanging can and adjust the stand so that there is about 4–5 cm of clearance between the two cans. If Sterno is not available, or if you want to combine this demonstration with one that shows how to make a type of Sterno, mix 50 mL of 95% ethanol with 10 mL of saturated calcium acetate solution. The two will immediately stiffen into the familiar fuel.

Discussion

This activity demonstrates in a fun and very inexpensive way the conversion of chemical energy in the form of methane and oxygen (or ethanol and oxygen) into the thermal energy of the flame which in turn can be converted into the mechanical energy of the spinning can, thanks to the phase change of water boiling. This, in turn, might be used to do useful work—perhaps some sort of spool placed over the can could coil up a thread as it is spun, which in turn might lift an object off the floor. Or perhaps the spinning engine could be used to turn a generator to convert the mechanical energy into electrical. Inasmuch as the can always spins counter to the direction the holes are pointing, this engine could also be used in a physics class to illustrate that for every action force there is an equal and opposite reaction force.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Systems, order, and organization
Evidence, models, and explanation
Content Standards: Grades 5–8
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, properties and changes of properties in matter, understanding of motions and forces, transfer of energy
Content Standards: Grades 9–12
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, structure and properties of matter, motions and forces, conservation of energy and increase in disorder

Acknowledgments

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Reference

Shakhashiri, B. Z. *Chemical Demonstrations;* University of Wisconsin: Madison, WI, 1989; Vol. 3, pp 360–361.

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *An Easy Hero's Engine* activity, presented by Bob Becker, is available in *Conservation of Energy*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *An Easy Hero's Engine* are available from Flinn Scientific, Inc.

Materials required to perform this activity are available in the *Hero's Engine—Demonstration Kit* available from Flinn Scientific. Materials may also be purchased separately.

Catalog No.	Description
AP7115	Hero's Engine—Demonstration Kit
AP8228	Support Stand, 24" Rod
AP8232	Support Ring with Rod Clamp, 4"
AP4823	String, Ball, 75 g

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.