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SySTEM Alert!

Tomorrow is almost here.

Don't touch!
This water can cut!

Over eons, water has the power to reshape the surface of Earth. Streams of it moving over the land pick up and carry away dirt and minerals – carving riverbeds and even canyons into the planet's surface. The shaping power of water is incredible, but it is not always fast. Human engineers have developed a startling way of making this power work for them – at high speed.

At very high speed.

Imagine a thin stream of water molecules traveling at Mach 3. Mach 3 is three times the speed of sound, a speed that only a few airplanes can reach. This is no row-row-row-your-boat kind of stream. It is a raging torrent focused through the eye of a needle. Its force is so powerful that it is used in manufacturing as a cutting tool. These streams of ultra-fast water molecules literally slice through objects, tearing them apart on a microscopic level with great precision.

The technology is called waterjet cutting. The machines that make it possible have a special ability. They can do what engineers refer to as "intensifying" water. Water is stored in the machines. Hydraulic pumps apply pressure to water. The water molecules, seeking an escape from the high-pressure environment, rocket out of the only outlet available to them – a hole that leads out through a nozzle. The nozzle's thin opening aims the stream so that its cutting power is directed onto the target.

JUST WATER

What can plain old tap water be used to cut?

"We can cut with water items such as fiberglass, carpets, headliners in your car, rubber, paper, celery, cheesecakes, rice cakes, frozen pizzas," says Tom Sanders. Sanders is a representative for a company called KMT Waterjet in Baxter Springs, Kansas. KMT is a manufacturer of the waterjet cutting machines.

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Pressured to perform

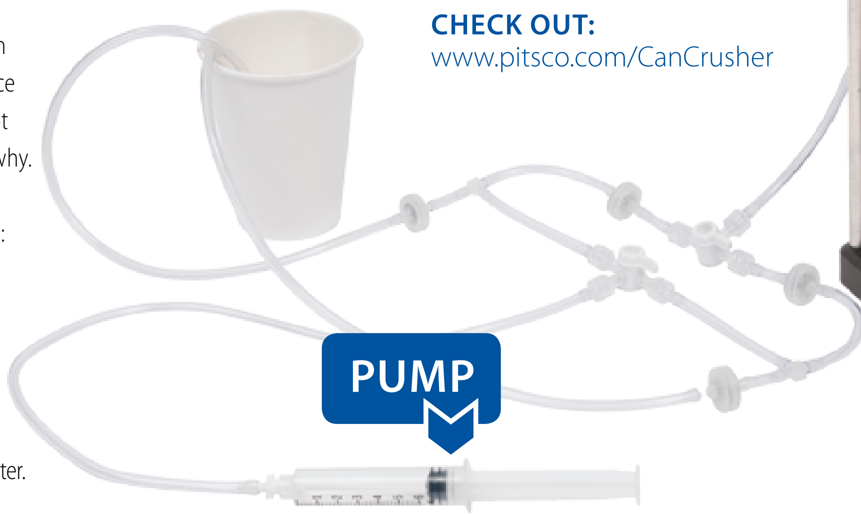
The waterjet cutting machines use hydraulic pumps to create pressure up to 90,000 pounds per square inch (or psi). To learn a little about hydraulics, read "Multiply your power" on the next page. To learn about psi, check out "To the sky or bust."

Waterjet cutting uses a stream of water to cut through materials. When abrasive minerals are added to the stream, the stream can even cut through super-hard materials such as this brass block. Photo courtesy of KMT Waterjet

Pull out and share *SySTEM Alert!* with your students!

SySTEM Alert! is published by Pitsco Education. Many of you reading this newsletter have Pitsco products in your classroom. In this and upcoming issues, we'll be taking a close look at science and math concepts in these products.

Multiply your power



CHECK OUT:
www.pitsco.com/CanCrusher

Pitsco's Can Crusher uses the power of hydraulics to turn an empty aluminum can into an aluminum pancake. Why would you use this device to smash a can when a swift stomp from your foot would do? Because hydraulics are so cool, that's why.

Hydraulic machines use fluid to do work. In particular, they use two special properties of fluid:

1. Fluid can change its shape.
2. Fluid resists being compressed into a smaller space.

FIRST, A PULL

In some systems, the fluid used is oil, but the Can Crusher uses water. Tubing goes into a reservoir of water. (In the picture, a cup is being used.) When the user draws back the pump plunger on the control syringe, the barrel of the syringe is emptied. Empty space is said to be a vacuum. There is an expression about this: "Nature abhors a vacuum." The water in the tubing rushes in to fill the barrel. As water from the tube is sucked into the syringe, water from the cup is pulled right in behind to ensure that no vacuum forms in the tube.

Water's ability to flow through the tubes comes courtesy of that first fluid property: the ability to change shape. The water molecules are not locked together into a rigid shape. They roll over and slide past one another.

THEN A LITTLE PUSH . . .

Now, the second property – incompressibility – comes into play. Technically, fluids can be compressed. But it takes so much force to do it that they are said to be incompressible. When water gets into a shoving match in very close quarters, it almost always wins.

In this case, when the user pushes the pump plunger, the water in the barrel still has a place to go: the tubes. So, the real shoving match hasn't started yet.

Because water is incompressible, none of the force that you used to press the control plunger down is wasted in pushing the water molecules together. The pressure applied by your thumb travels into the water. It acts with equal force against every surface the water touches. It pushes on the walls of the tubes, but the walls are strong enough to resist the pressure. Depending on how the valves in the tubes are set, the path back to the reservoir is blocked. So, the pressure can't be relieved that way either.

The only area with any give in the system is at the four syringes up top.

. . . BECOMES A BIG PUSH!

The displaced water pushes against the backs of the four plungers. Because the pump plunger is smaller than the four press plungers, the force acts across the greater surface area of the press plungers. The *force is multiplied* by that difference in surface area. In the Can Crusher, this comes out to 14 times as much force! When the press plungers are forced down, the little force that started in your thumb is now strong enough to crush a can!

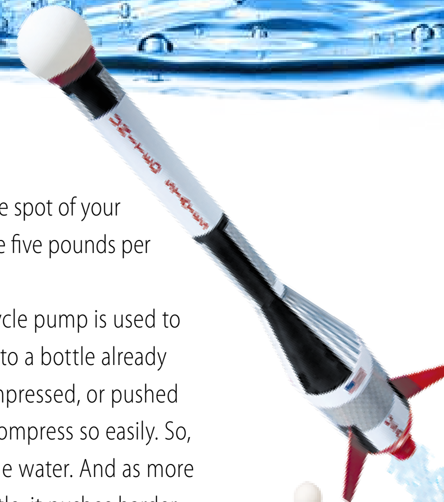
But this doesn't happen all in one push. The small volume of water ejected from the control syringe isn't enough to fill all four large syringes in one pump. It will take multiple pumps to do it.

This basic principle is used in all sorts of ways. Small but heavy-duty hydraulic machines can even be used to lift cars and houses.

Now, you've read an explanation of how the water crushes a can. What happens next? How does the water get out of the press syringes and back into the reservoir?

Has young inventor Boyan Slat found a way to clean up the oceans? He is shown here with a concept drawing of his vision. Images courtesy of www.theoceancleanup.com.

To the sky or bust



The AquaPort II Water Rocket Launcher from Pitsco uses water to provide thrust on a rocket made from a two-liter bottle. When the water is ejected from the downward-facing nozzle at the base of the rocket, an upward force propels the rocket high into the sky. But what makes the water shoot out with such force?

The secret is in a measurement called psi. That stands for "pounds per square inch." To understand psi, imagine your outstretched hand is lying on a table, your palm facing up. Now, imagine a plate is sitting on your hand and a five-pound weight is resting on the plate. You feel the weight pushing down on your hand though the plate. But the downward force is spread across the whole area where the plate touches your hand.

Now, imagine that the plate is lifted up and a one-inch cube is slid between it and your palm. Now, the plate is put to rest on that one-inch cube. All five pounds of force are channeled down through it. Because the pressure is transmitted through a smaller surface area, it is more intense on that one spot of your hand. You just increased the psi! There are five pounds per square inch of pressure in this setup.

Back to the AquaPort II. When a bicycle pump is used to pump air into the system, the air goes into a bottle already partially filled with water. Air can be compressed, or pushed into a smaller space. But water doesn't compress so easily. So, the air pushes down on the surface of the water. And as more and more air is compressed into the bottle, it pushes harder and harder across all the square inches of surface where it contacts the water.

The AquaPort can be pumped up to 75 psi before a safety valve starts letting out air.

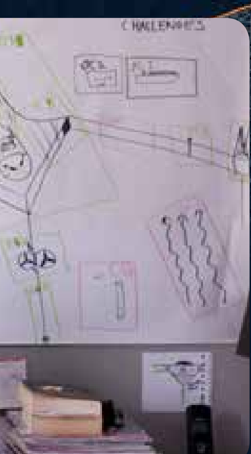
So, what happens when the water is allowed to escape? Those nearly 75 pounds of pressure on each square inch of water push the water out with great speed. And the bottle reacts by rushing upward to a great height.

What has psi done for you lately?

Psi, or pounds per square inch, is all about force being spread out or focused across a given amount of surface area which it acts upon. If you live in the Arctic, your snowshoes take advantage of this. Your body weight is spread across the broad surface of the shoe, and you don't sink as far into the snow. If you don't live in the Arctic, you've surely at least used a pushpin. The tiny point at the end of a pin focuses all the force being channeled through it. This is what lets it puncture hard surfaces.

CHECK OUT:
www.pitsco.com/Aquaport2

What's current in ocean news?



Boyan Slat. Remember that name because it might go down in history as the name of one of our world's greatest young visionaries. Then again, it might not. That likely depends on whether the 20-year-old Mr. Slat's big idea holds water. Er, make that plastic.

Let's zoom out for a moment. Did you know that there is an enormous swirl of plastic and trash in the northern Pacific Ocean called the Great Pacific Garbage Patch? (Think about that the next time you throw away a plastic bottle.)

Slat envisions creating a long series of floats strung end to end. These floating arms (that is essentially what they are) would stretch for 100 kilometers. And they would, in theory, gather up the small pieces of trash that float along or near the ocean's surface.

The currents that flow through the ocean would carry the trash right to the structure! From there it could be gathered and properly disposed of. This is why Slat's company, The Ocean Cleanup, refers to their system as a passive method for cleaning the ocean.

If the idea works, it will mean a cheap and elegant solution has been found to one of humanity's great environmental problems. And that would be worth a mention in the history books for its designer. But the idea is not certain to work. Skeptics argue the design can't withstand the pressures the trash and the ocean currents put on it. Also, they note that the design doesn't account for the way biological growth on the structure will affect its operation.

The idea is getting a test run in 2016. A two-kilometer version is being deployed off the coast of Tsushima Island, which is located near Japan. An enormous amount of plastic trash washes up on the island each year. If the small-scale test is successful (and that is a big if), then what? It proves the idea has merit. It sets the stage for the much larger version a few years later.

Career Fields

- Aeronautics machining
- Food processing

(continued from page 1)

Consider those last items in Sanders' list, all food. Food that is mass-produced for sale is prepared in a factory, and cutting is often part of the process. Cutting food with water offers advantages over cutting with blades. You might have heard of *E. coli*. It is a nasty bacteria that, if it contaminates food, can be a serious health risk for humans who eat it. Imagine a metal blade that is chopping, say, celery as it moves down a conveyor. If it touches any *E. coli* on one stalk of celery, the blade might pick up traces of it. As it chops the pieces that come after it, a little bit of the *E. coli* might rub off onto each one until it is all gone.

"But," says Sanders, "waterjet is contained to one piece of celery because the water has already passed through. It won't contaminate the piece behind it."

TEAM UP

Using water to cut food is one thing. Using it to cut the titanium that airplanes and spacecraft are made of is another. To cut titanium and other hard materials, a different technique is used: abrasive waterjet cutting. It is called abrasive because tiny pieces of hard material are mixed with the water stream as it exits the nozzle. Many machines, such as those KMT produces, use garnet, the same mineral that makes sandpaper rough. But other materials have been used as well.

Now, the water is a medium for carrying the hard mineral pieces. The abrasives ferociously but precisely bombard surfaces they strike. They can cut right through extremely hard materials such as metal, ceramic, and stone. Other tools such as lasers and plasma torches exist that can also cut hard materials. What is the advantage of waterjet cutting over these methods?

Sanders explains: "A torch or a laser is going to create heat. Waterjet does not create heat. So, you see waterjet in a lot of your airplane and aerospace applications. It will not heat up the part. If you are an engineer, you don't want to heat up the material. You want the structure of the material to remain constant."

HIDDEN POTENTIAL

Water is a very common substance, and it has its own set of properties. In nature, water doesn't normally cut through solid objects – at least not with such precision.

But in the right conditions, water will do just that. To know how to create these right conditions, engineers must have knowledge about the properties of water. Learning about the properties of materials is an important part of engineering. The everyday stuff of the world around us has the potential to do all kinds of work, to reshape our world. Seeing how this potential can be realized, however, takes knowledge and imagination.

Desal or not desal, that is the question

Are we forgetting something? Let's see. We use water to cut things, to crush and lift things, and even to launch rockets. Isn't there something else? Oh yeah! We drink it. Sometimes our personal need for this substance can lead to conflicts of interest. California, a desert state known for having droughts and water shortages, might have a solution.

The technology is called desalination. Salt water is drawn out of the ocean, and the salt is filtered out. Desalination can definitely produce a lot of fresh water. And the ocean can provide us with an extraordinary amount of water. But there are some drawbacks. First, it takes a lot of power. Second, pumping the water may kill a lot of sea life. (There are plans to pump water that is *below the ocean floor* – but these are pretty expensive.) Third, the waste. The process produces some brine – super salty water. This must be disposed of somehow.

Desalination plants exist already, but California is constructing a huge one in the city of Carlsbad. This has led to a lot of controversy. Even after the plant is operational, the question of whether desalination is worth its drawbacks may still not be answered. Ultimately, it is a question of values.

Image by James Grellier

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Student name: _______________________ **Class/Hour**: __________

SySTEM Alert! Quiz (Volume 4, Number 1)

This quiz covers the information in *SySTEM Alert!* volume 4, number 1. Circle the letter of the correct answer or write the letter by the question number.

1. What is the name for the giant swirl of plastic and trash in the Northern Pacific Ocean?
   A. Water Pollution Vortex
   B. Pacific Plastic Swirl
   C. Great Pacific Garbage Patch
   D. Northern Pacific Vortex

2. An old expression states that "Nature _______ a vacuum."
   A. creates
   B. abhors
   C. adores
   D. is

3. What does *psi* stand for?
   A. pressure surge intensification
   B. plastic seawater infusion
   C. percentage served increase
   D. pounds per square inch

4. Which of the following is **not** a drawback of desalination?
   A. It produces brine as a by-product.
   B. It might harm sea life.
   C. It takes a lot of power.
   D. It can produce only a little freshwater at a time.

5. Mach 3 is three times the speed of _______.
   A. sound
   B. light
   C. a jet airplane
   D. a falling object

6. What type of pump is used by a waterjet cutting machine?
   A. pressure pump
   B. vacuum pump
   C. hydraulic pump
   D. oil pump

7. Boyan Slat's idea for cleaning up waste in the ocean will be tested soon. How large is the test version of his invention?
   A. 600 meters
   B. one kilometer
   C. two kilometers
   D. 100 kilometers

8. What is it called when pieces of hard material are added to the stream of water in waterjet cutting?
   A. abrasive waterjet cutting
   B. corrosive waterjet cutting
   C. hard water cutting
   D. intensified waterjet cutting

9. What is the main reason waterjet cutters are often preferred over laser cutters for airplane manufacturing?
   A. Waterjet cutters are more precise.
   B. Waterjet cutters produce less heat.
   C. Waterjet cutters are smaller.
   D. Waterjet cutters are quicker.

10. Which material is very hard to compress?
   A. air
   B. water
   C. plant matter
   D. plastic waste

Bonus question:

We often clean with water. But sometimes water itself has to be cleaned. If you had a mixture of dirt and water (mud), what is a way that you could separate and contain just the water?