Water on fire

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It is impossible to imagine our existence without water and fire. We rely on them to such a degree that in many cultures they are considered sacred elements. They are also like the opposites that attract, because one quenches or evaporates the other. Perhaps that's why it is so striking when human ingenuity devises ways for the two of them to cooperate in artful display.

Engineers and artists have teamed to create combinations of fire and water that have amazed people at tourist attractions, festivals, and the Olympic Games. Integrating flames into water fountains is an intriguing task, which designers of fountains have accomplished using both gaseous and liquid fuels.

Designing features with water and fire requires knowledge of fluid systems, control technology, and combustion. As such, mechanical engineers are in good position and can play an important role in designing the next generation of fountains with fire.

At the University of the Pacific in Stockton, Calif., mechanical engineering professor Ed Pejack and student Eric Eubanks designed a small-scale fountain for educational and demonstration purposes, adapting parts used in irrigation and a camping fuel can. The fountain has eight water outlets positioned in a circle with a propane jet at the center. A slight wind can cause the flame to fluctuate or separate. Fuel and water flows are regulated with manual valves.

Alan Robinson and Mark Fuller invented a fountain that illuminates water jets with colored flames. It is covered by U.S. Patent 4,858,826. The colors are produced by injecting pressurized solutions of metallic salts in atomized form into the main gas burner. Several injection points, each with a different salt, can produce different colors. A computer system controls the amount and timing of each colorant. The nozzles aimed outward keep the water jets separate from the flame. An ultraviolet sensor is used for safety, and the fuel flow is shut off when the main burner or the pilot is extinguished for any reason.

Safety is always an issue with water fountains. They combine water and electricity and, therefore, applicable safety measures must be followed when building fountains. Furthermore, fountains that incorporate fire pose additional considerations and thus require expertise and attention to appropriate safety details.

Kiki Pettit, a computer programmer who later turned to computer graphics and special effects, is an artist in blending fire with water. She has designed, built, and installed water fountains that incorporate liquid fuel to produce floating flames that flow with water. From her fountains, one can scoop up a handful of water with flames on top and hold it without being hurt.

One of her most challenging projects has been Egeria, which took six months from planning to installation. Egeria was a Roman goddess who wept so long after her lover died that she melted into a fountain. A filmmaker, Sandy Gentile, followed Egeria as it was being built and produced a feature documentary called “Firefall: The Road to Burning Man.”

Egeria is 12 feet tall with three tiers and was first installed at the 2002 Burning Man, a weeklong arts festival held yearly at Black Rock Desert in Nevada. More on Egeria and the festival can be found at www.burningideas.com and www.burningman.com, respectively.

The fountain uses 1,500 gallons per hour of water for each tier, cascading down so each tier adds to the one below. About 27 gallons of fuel are burned in a typical run of 1.5 hours, before the water gets too hot to hold.

Pettit emphasizes that engineering is as much a part of the beauty and art of the fountain as the look.

According to Pettit, the idea for combining fire with water came to her on a camping trip with a friend.

"His stove wouldn't light because we had filled it with fuel from a can that we later figured out had been returned to the store filled with water," she said. “We emptied it into a cup, and he lit it. The small amount of fuel left burned down to the level of the water. I thought, that's cool. Later, I did experiments to see if a..."
continual feed of fuel would flow over a fountain. It worked. And the firefall was born."

According to Pettit, "Fire provokes strong emotions in pretty much everyone—positive and sometimes negative—and strong emotion is what artists strive for in their art. I like the firefall because it is fire that is not scary. You can touch it and play with it. It’s the fire of campfires. It’s warm and comforting, and brings people together."

Pettit said that one of the big challenges with Egeria was in transporting it over 250 miles to its destination in the desert. The bowl of the bottom tier is 10 feet wide, and the legal maximum width for a load on the highway is 8 feet, so the bowl had to be transported on edge. The maximum legal height, to protect bridges and utility lines, is 14 feet, so she had to ship it on a flatbed truck less than 4 feet high. "I considered making the bowl split in half, but the seam had to be water- and fire-tight," she said.

Egeria uses naphtha as fuel because it has a high temperature flash point. It burns relatively slowly so flames could spill over more easily. "We like it because, unlike gasoline, it's simply pure fuel with no additives, and burns very cleanly," she said. "Naphtha is thought to be Greek fire, which was a weapon the Greeks used against the Roman navy. It was a terrifying weapon in its time because it could not be put out with water, and had the same effect in their society as the atom bomb did in ours."

Safety is another important challenge. But if you think of it not as a "water fountain on fire" but as "a fire pit made of water" you realize even though it’s unique, it’s also reasonably safe. There are no sparks to drift away, and there are only drops, not gallons, of fuel burning at a time: Only one ounce of fuel is burning every second, but it’s spread across more than 125 square feet in a very thin slick. However, since the fuel is liquid, spills are dangerous. "For this reason, we have avoided making any for permanent installation, and we currently only set up firefalls for performances," Pettit said.

She said her goal is to one day build the Olympic cauldron. She would like to allow people at the event to hold the Olympic flames in their own bare hands. "This would be the greatest and most powerful gift I could give to the world," Pettit said.

The Olympic cauldron is indeed the most visible symbol of the games. It holds the Olympic fire during the entire event. According to the Olympic Museum in Lausanne, Switzerland, fire symbolizes friendship among nations, as the flame is carried from Olympia in Greece, the birthplace of the games, to the final location where the games are to be held.

The cauldron design took a new turn when WET Design of Los Angeles was selected for the 2002 Olympic Winter Games in Salt Lake City. An illustrated book, Creating the Cauldron, published by WET Design in 2003, chronicles the Salt Lake cauldron from inception through the lighting ceremony. The Salt Lake Olympic Committee allocated $2 million for this symbolic project. Following the Games' theme of "Light the Fire Within," designers and builders created a beautiful structure made of steel and glass, towering 117 feet.

The cauldron at the Winter Olympic Games in Salt Lake City is a high-profile example of an emerging trend among fountain designers to make spectacles combining fire and water. The steel and glass tower, designed by WET Design of Los Angeles, stands 117 feet high.

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A fountain created as an educational project by Ed Pejack and Eric Eubanks at the University of the Pacific has eight water outlets circling a propane jet.

The bowl that holds the flame is a 12-foot-high prismatic frame covered with two layers of glass and supported on top of three main steel columns. Among major attributes that set this cauldron apart from any other in the past is the addition of water in the flame bowl itself. After all, WET Design’s specialty is water features. Its credits include the dancing fountains at the Bellagio in Las Vegas.

The water in the Olympic cauldron serves functional and esthetic purposes. Burning natural gas creates flames up to 30 feet high inside the glass fire enclosure. Water sprayed on the inside surface protects the glass from the heat and prevents buildup of the soot. The water film flowing down the glass creates random wave patterns that ripple the image of the fire inside. A computer system controls the water flow rate based on temperature of the return water.

Three helixes made of triangular elements wrap around the main columns. These elements are covered with specially laminated glass to harmonize with the snow-capped mountains around Salt Lake City. Intricate connections among triangular elements and columns required the expertise of a roller coaster manufacturer to cut and weld the steel. Transporting the cauldron 45 miles from the manufacturer to Salt Lake was another big challenge, as the maximum speed was limited to 12 mph and the cauldron was to be kept a secret until its unveiling.

Fundamental to the appeal of all these structures is the pairing of fire with water, two main props of life. We human beings don’t live long without either one. Water is the chief component of our bodies. It cleans and soothes us as well. Fire protects us from the cold, makes our food edible, and powers our civilization.

There is a fundamental rightness in an engineered artistry that brings them together.