Purdue team creates high-tech torches for Indiana Bicentennial

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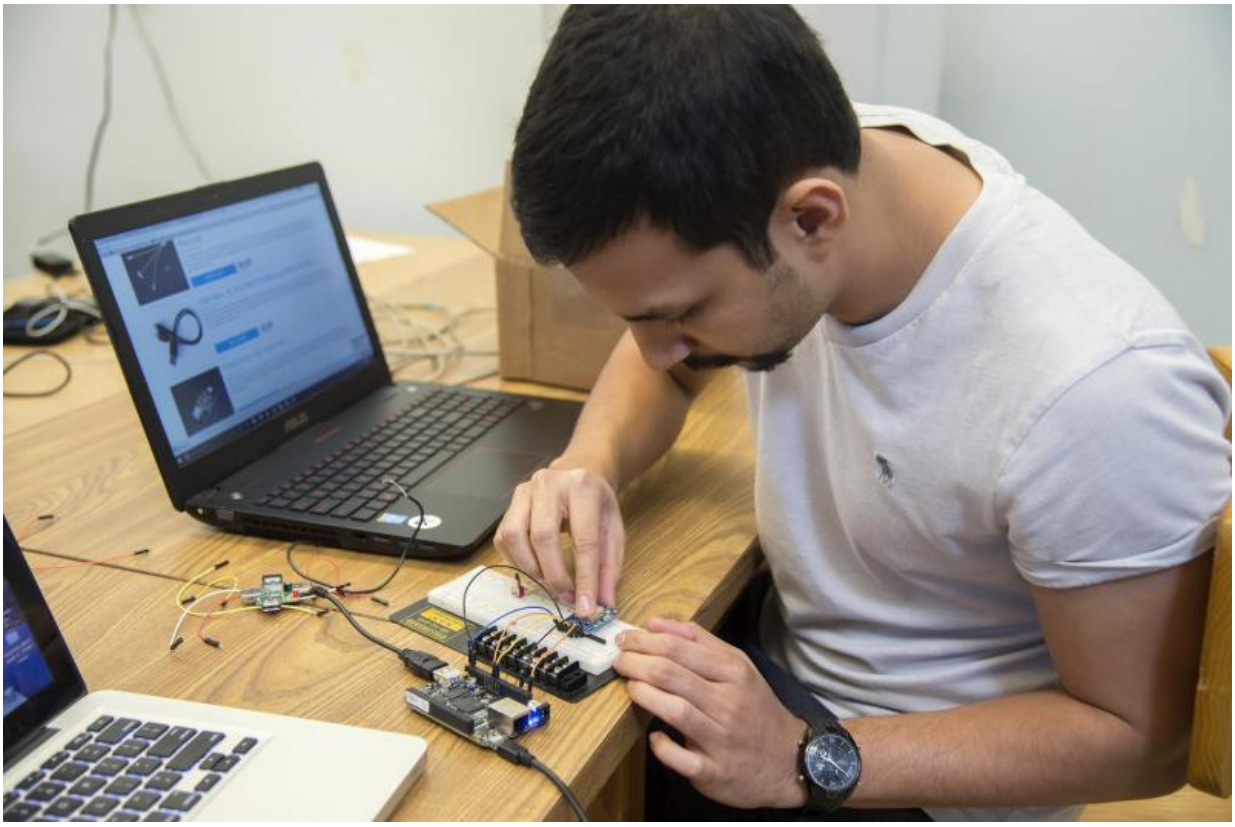

Engineering student Mrigank Jha experiments with an electronics board as part of work on the Bicentennial Torch. Credit: Purdue University photo/Mark Simons

An interdisciplinary team of students and faculty at Purdue University has designed and built three types of torches that will be central to

Indiana's bicentennial relay next year.

A workhorse "flagship" torch will dominate the relay, with 24 being manufactured; two high-speed torches capable of staying lit amid the turbulent winds of a roller coaster will see limited action; and a kinder, gentler children's torch will blaze using an array of LED lights.

The project involves eight faculty members, three research engineers and about 30 students this semester, although work has been ongoing for three semesters, said Timothée Pourpoint, the associate professor in the School of Aeronautics and Astronautics who is leading the effort.

The flagship torch burns an ethanol fuel blend known as E85, which is produced with agricultural products grown in Indiana. Using a liquid fuel poses various design challenges, said Pourpoint, whose resume includes research in rocket propulsion.

"A lot of torches use either a canister of gas like propane or butane, or a gel like Sterno," he said. "When we made the decision to go to E85, I knew it was opening up quite a few things that we need to be careful of. For one thing, you have a liquid fuel in something you hold in your hand, so obviously you don't want it to leak."

The flagship torch will be handled by about 1,800 people during the course of the relay.

"So safety is paramount, and robustness is paramount," Pourpoint said.

The torch includes various software, hardware and subsystems that have to mesh seamlessly. The electronic brain, designed by students in the School of Electrical and Computer Engineering (ECE), must communicate properly with devices including sensors, a camera, GPS module and mechanisms for controlling the flame. Six student teams

handled the electronics, materials, structural design and other aspects.

Two ECE teams informally competed on the project, submitting differing packages for the torch's electronics, said Mark Johnson, director of the ECE Instructional Laboratories.

The torch uses the same type of wick found in Tiki torches and is designed to maintain a flame 8 inches high. The fuel is pumped continuously at a slow rate to keep the wick saturated with E85.

"It pumps pretty slowly, 3 or 4 milliliters per minute," said Matthew Elliott, a senior from Independence, Kentucky, who is a member of a team of aeronautics and astronautics students coordinating the project.

Another fuel-related challenge stems from the color of E85's flame.

"The E85 burns too clean and produces a bluish flame that is not very visible in bright daylight," said Nathan Mosier, a professor in the Department of Agricultural and Biological Engineering. "So an additive was needed to make the flame brighter and more yellow."

The torch's internal scaffold structure, designed by students in the School of Materials Engineering, is held together with a series of connecting rods and metal rings. Students had to determine the best ways to join different parts and selected a mixture of adhesive and mechanical fasteners over welding for ease of flexibility in design. Materials-related elements are critical to the torch's success, from the thickness and color of the metal skin to issues related to weight and strength, said David Bahr, a professor and head of the School of Materials Engineering.

The design posed challenges in part because the point where the handle joins the crown must house a bevy of electronic components including a camera.

"The bearer will be able to click one button to take a picture, and if you hold the button you can shoot video, which will be uploaded to the Internet via Wi-Fi," Pourpoint said.

The camera will be capable of recording 10 minutes of high-definition video and 500 photographs. Data will be relayed via wireless signals to a nearby van, but when the signal is lost the data will be stored for transmission later. A GPS system tracks the relay's progress, and a USB port in the bottom of the handle allows for battery recharging.

"By the way, it has never been done before, as far as I know, creating a torch that knows where it is, a torch that takes photos, and so on," Pourpoint said.

The flagship torch is equipped with a sensor that detects when it tilts farther than 45 degrees, representing a potential burn hazard. Excessive tilt activates a mechanism that deploys a "snuff plate" to extinguish the flame while at the same time closing air inlets.

The torch can burn for at least 45 minutes and has enough battery power to last three hours.

Some of the components are produced using 3-D printing.

"A lot of aerospace companies use 3-D printing to make rocket engines, so for me to use it on the torch makes a lot of sense," Pourpoint said.

The teams operated under a tight timeline: to deliver a finished prototype by Dec. 11, coinciding with Indiana's statehood day.

The project has been a valuable experience for the students, in part because of the need to work with other teams.

"When you have to communicate with other teams it becomes a lot more interdisciplinary," said Archit Aggarwal, a senior from Mumbai, India. "My other projects were just related to working with people in my department, electrical and computer engineering, but this work involves communicating with other people, other teams and trying to come up with an optimized design that meets their needs as well as ours."

Most of the students are earning credit for the project.

The design of the flagship torch aesthetically matches the original Hadley torch on the Indiana state flag, adopted in 1917. It was important to retain the historic appeal of the original torch, said Mark Newman, executive director of the Indiana Office of Tourism Development.

The torch contains 19 stars, including five stars on a bottom ring, 13 stars on the top ring and one star on the top of the torch. The stars on the top ring have a practical function: they serve as air inlets for the flame. One star on the bottom ring serves as a viewport for the camera and the star on the top of the torch represents the 19th state in the union: Indiana.

The torch weighs 5 pounds. Its flame must withstand winds up to 35 mph and remain lit in a light rain. Ergonomic considerations include properly placing its center of mass so that it is easy to hold, and the handle was designed for bearers with various hand sizes.

"At the same time, you've created probably the most technologically advanced torch in the world, so that's a neat dichotomy," Newman said to the team during a briefing.

Provided by Purdue University