Keeping Hybrid & Electric Cars Cool

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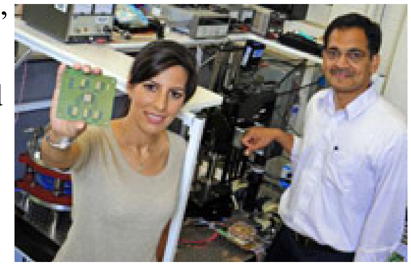

When scientists unveiled the mystery of boiling of fluids in the form of tiny "microchannels" they cracked various formulas and models to keep the high-power electronic gadgets cool. These high power electronics generally are electric and hybrid cars, aircrafts, computers and other devices. Suresh Garimella – the R. Eugene and Susie E. Goodson Professor of Mechanical Engineering at Purdue University – tells us that if we heat a liquid in cooling systems then we can analyze how much heat can be removed, compared to simply heating a liquid to below its boiling point.

Doctoral student Tannaz Harirchian addresses a valid question, "One big question has always been, where is the transition from macroscale boiling to microscale boiling? How do you define a microchannel versus a macrochannel, and at what point do we need to apply different models to design systems? Now we have an answer."

If we are boiling liquid in smallest channels they behave differently from boiling liquid in larger cooling systems. Boiling liquid in smallest channels don't form spherical bubbles. They create one long continuous "liquid annulus," or oblong "slugs" of vapor in liquid form. Harirchian developed formulas that assisted engineers to differentiate among various kinds of flows. They had more clear concept about how to design the systems accordingly. The unambiguous "flow regimes" — whether the fluid is bubbly, annular or in slugs — must be known before the proper formulas can be used to predict the performance of certain channel designs. She also found out that the cross sectional area of each channel determine and influence the boiling behavior of a liquid. "I am very proud of this work," Garimella said. "We have come a long way."

This innovative cooling system will be helpful in preventing the overheating of devices such as insulated gate bipolar transistors and high-power switching transistors fitted in clean and green hybrid and electric vehicles. When we accelerate a vehicle from zero to 60 mph in ten seconds or even less, we need chips. These chips are helpful in driving electric motors, switching large amounts of power from the battery pack to electrical coils etc. Same devices are required for "regenerative braking." Now the electric motors work as generators to brake the vehicle, producing power to recharge the battery pack; to convert electrical current to run accessories in the vehicle; and to convert alternating current to direct current to charge the battery from a plug-in line. It is true that these high-power devices generate about four times as much heat as a normal computer chip.

Now the researchers have to find an escape route from the above process. A "dielectric liquid," came to their rescue. "dielectric liquid" is a fluid that doesn't conduct electricity which allows it to be used directly in circuits without causing electrical shorts.

Garimella, who is the director of the NSF Cooling Technologies Research Center, says, "We have finally made sense of boiling in small-scale channels and now have a nice understanding of the physics." Researchers used special test chips by Delphi. They are about a half-inch on each side fitted with 25 temperature sensors. He elaborates further, "Right under each of these sensors is a little heater, so we can adjust the amount of heat we apply to specific locations on the chip and simulate what happens in a real chip," We know that extra heating lowers the performance of electronic chips or damages the tiny circuitry, especially in small "hot spots." Garimella explained about their strategy further, "In order to design these systems properly you need to be able to predict the heat-transfer rate and how much cooling you will get."

Small fans are used in traditional chips for cooling. They also fit finned metal plates known as heat sinks, which are attached to computer chips to dissipate heat. But conventional air-cooled methods are not quite effective. They are unable to remove adequate heat for the advanced automotive electronics, especially because of hot air under a car's hood.

Now they engraved microchannels directly on top of the silicon chips. The good thing is since both the channels and the chip are made of silicon, there is not much difference in expansion from heating. It was easy to allow chips to be stacked on top of each other with the cooling channels between each chip. If we want a more compact system, we can follow this stacking method. “We can fit a lot more chips in much less real estate using this approach,” Garimella said.

Researchers also utilized the benefits of a high-speed camera to capture the behavior of the circulating fluid. This made life easier for the researchers because they can study channels as small as 100 by 100 microns and as large as 100 microns deep by about 6 millimeters wide. “We wanted to test a wide range of channel sizes,” Harirchian said.

Delphi has advanced their project further. They generated prototypes and commercialize the cooling technology. The researchers have a database of movies at their disposal. They can avail it on the NSF center’s Web site to demonstrate the boiling behavior in microchannels. They also have generated a “complete test matrix.” This matrix assist the engineers to find out how a particular system would perform given a range of channel dimensions, amount of heating and fluid flow. “You can basically mix and match different design specifics and see the result,” Garimella said.

The cooling systems also are being developed to cool the electronic controls in aircraft, military systems and for other applications.

Hal Strumpf, senior technology fellow and chief engineer for thermal systems at Honeywell International Incorporation says, “We hope to be able to use the new models to help us in designing vapor cycle system evaporators for aircraft thermal management. These evaporators typically operate over the full range of flow regimes studied by Garimella’s team, and each individual flow regime must be accurately modeled to predict evaporator performance.”

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2 Responses to “Keeping Hybrid & Electric Cars Cool”

1. 1

   Shelby Raymond:
   September 29th, 2009

   The trouble with electric cars is that in 10, 15, 20 years…what do we do will all of the toxins present in the batteries. How will we actually mediate the harm and ethically recycle them? We can’t send everything to China and assume it’s out of the system as we do with computers, televisions and cell phones (we really don’t need to change cell phones every year – think of the waste folks!). The main solution will be reduced consumption, more walking and bicycles. IMHO It isn’t progress to exchange one harm for another. We as individuals and the companies that run our economies don’t like that, but, that is what it will take to make a true difference, not just a feel-good marketing campaign.

2. 2

   Bob Gabriels:
   September 29th, 2009