Researchers at the University of Wisconsin-Madison have developed a nanogenerator that can harvest friction energy from rolling tyres, which will have huge impact on fuel efficiency efforts. The nanogenerator concept has been broadened to the principle of the triboelectric effect (i.e. triboelectric generator), where the contact between two dissimilar surfaces creates charge distribution, and thus inducing current flow externally, ***Xudong Wang****, Associate Professor of materials science and engineering at UW-Madison, told* ***Polymers & Tyre Asia***

Xudong Wang (Picture courtesy: College of Engineering)

POWER FROM FRICTION

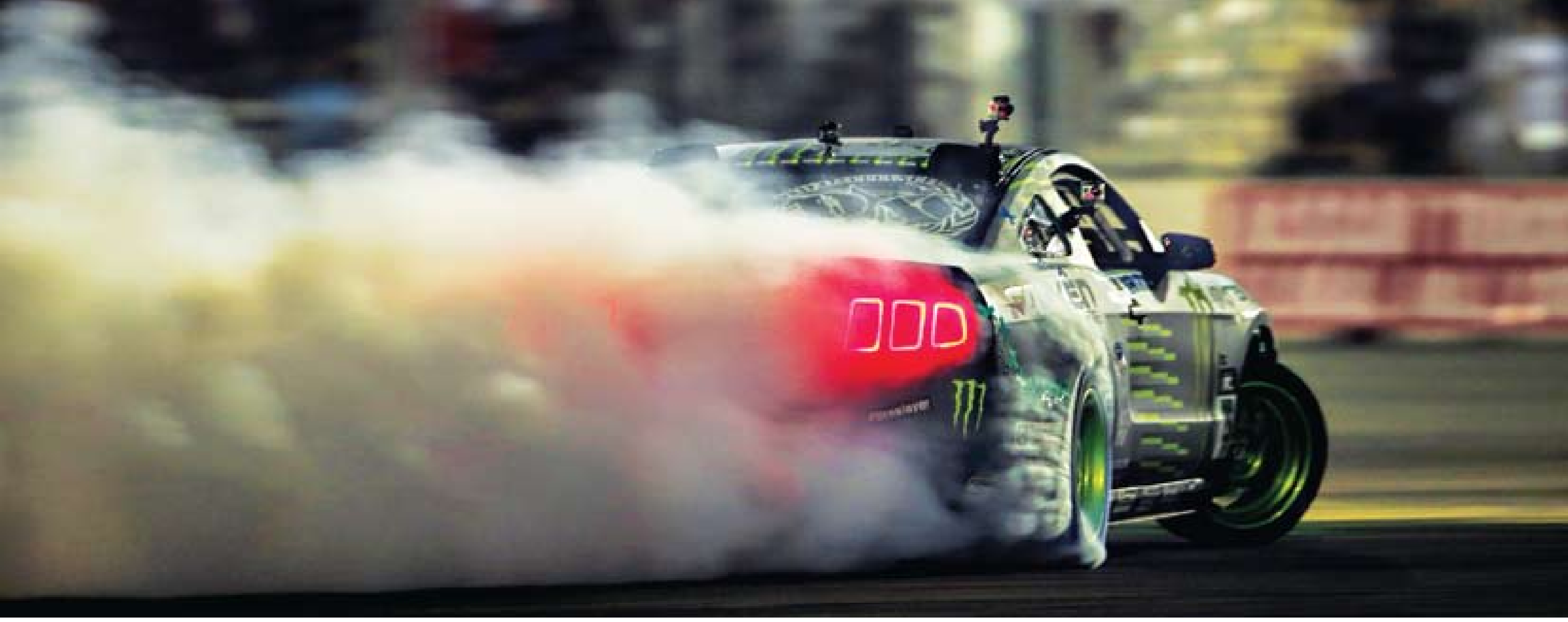
PTA News Bureau

Harvesting energy from rolling tyres to provide power to the battery in electric vehicles is a concept that excites tyre engineers ever since Goodyear developed its concept tyre BH-03 that can generate electricity to charge the car battery. The idea was to take advantage of piezoelectricity, the electric charge that builds up in certain materials as they are squeezed or pressed. Tyres, as they roll, get deformed constantly and Goodyear engineers worked on generating power from this action.

The idea of scavenging friction energy from rolling tyres has evolved further. Researchers at the University of Wisconsin-Madison recently came up with a nanogenerator that could make vehicles more efficient by deriving power from the friction of rolling tyres. Xudong Wang, the Harvey D. Spangler fellow and an Associate Professor of materials science and engineering at UW-Madison, and his PhD student Yanchao Mao have been working on this device for about a year. The team, which also includes Dalong Genga and Erjun Liang, was able to demonstrate the device using a miniature remote-controlled Jeep.

"Nanogenerator was first developed in 2007 using piezoelectric nanostructures to harvest low-level mechanical energy," Wang told ***Polymers & Tyre Asia*** in an exclusive e-mail interview. "Its nanoscale building blocks enable higher sensitivity and higher efficiency compared to bulk structures. Now, the nanogenerator concept has been broadened to the principle of the triboelectric effect (i.e. triboelectric generator), where the contact between two dissimilar surfaces creates charge distribution, and thus inducing current flow externally," he said.

Wang explained: "The triboelectric effect is applied in our energy harvesting strategy from the tyre friction. In our design, we take the advantage of the contact between the tyre and ground, which are regarded as two dissimilar materials to create charge separation. Our design allows immediate draining



POWERHOUSE: Friction generates power (Photo courtesy: http://driftcarsforsale.com)

of the induced charge once the tyre surface moves away from the ground. Continuously rolling of tyres will continuously produce charge to the tyre surface, which can thus generating continuous current pulses."

Wang and his colleagues did their trials using a toy jeep with LED lights. They attached an electrode to the wheels of the car, and as it rolled across the ground, the LED lights flashed on and off. The movement of electrons caused by friction was able to generate enough energy to power the lights,

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supporting the idea that energy lost to friction can actually be collected and reused.

This is different from the technology Goodyear developed where its concept BH-03 generates electricity from the heat and motion of the tyre using a fishnet pattern of thermo/piezoelectric material. BH-03 is ultra black in texture and absorbs heat and light. The tread pattern is also designed to absorb heat. The tyre gets hotter while rolling and also while resting in the sun. It is this thermo energy that Goodyear engineers used to generate power.

The UW-Madison concept will have tremendous impact on automobile sector, where electric vehicles are becoming more and more popular, but their scope currently remains constrained as the power that can be retained is low. Cars may never be able to run on power generated excusively from wheels, but the UW-Madison team's work has suddenly given the much needed thrust to the efforts to achieve optimum fuel efficiency.

Bigger the better

How much of energy can be converted like this from tyre friction? "We don't have a specific answer for this question. At this point, we know that about 10 per cent fuel consumption goes to overcome the tyre friction. This type of energy is absolutely and inevitably wasted. If we can recover part of it, it will be a net gain of energy consumed," Wang told PTA.

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"The friction energy of the tyre turns into heat and electrical energy. But we don't know the ratio between these two paths of energy conversion. We still need more fundamental study of this type of energy conversion process in order to better understand the energy conversion efficiency.

"Our design is not optimised at this point. We have shown that the electric output increases with the weight applied to the wheel, i.e. the weight of the vehicle. It is intuitive to think that the electric output increases follows the frication.

There are definitely room for furthertake advantage of piezoelectricity, the electric charge that builds up in certain materials as they're squeezed or pressed improvement of the efficiency. For example, the size of the electrode, the position of electrode, the electric property of the tyre surface. We don't know their contributions to the efficiency yet, but we are working on the optimisation right now," Wang said. He is still woking on the implementation part and design of the nanogenerator.

Wang's research interests include studying the growth and assembly of oxide nanowire arrays, understanding the coupling effect of semiconductor properties and piezoelectric charge displacement, and developing nanogenerator that uses piezoelectric nanomaterials to convert low level mechanical energy into electricity.

He has published 80 papers in peer reviewed scientific journals, contributed seven book chapters in his research field, and holds five patents/ provisional patents on oxide nanostructures and nanomaterial-enhanced energy harvesting. His publications have been cited over 6,000 times by peers.