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Engineers invent way for cars to harvest energy from bumps in the road

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Credit: Scott Meltzer/public domain

The 255 million cars on the road in the United States account for 40 percent of the country's fuel consumption. Most of that fuel is wasted.

Lei Zuo, an associate professor of mechanical engineering in Virginia Tech's College of Engineering, may have a partial solution: harvesting energy from the car's suspension.

Zuo explained that only 10 to 16 percent of the fuel a car consumes is actually used to drive—that is, to overcome road resistance and air drag. Most of the rest is lost to heat and other inefficiencies.

With clever engineering, however, that deficit can be reduced.

Three major opportunities exist for recovering or generating energy while driving: the waste heat given off by the engine, the kinetic energy absorbed during braking, and the vibrational energy dampened by the shock absorbers, he said.

Zuo estimates that a car's shock absorbers should be able to provide between 100 and 400 watts of energy on normal roads and even more on rougher roads. By comparison, the average cell phone call uses about 1 watt. That corresponds to an increase in fuel efficiency between 1 and 5 percent, which would add up to an annual fuel savings of $13 billion to $19 billion.

His energy-harvesting shock absorber works by translating the vertical vibrations of the suspension into rotational motion that turns a generator. The generator delivers electricity directly to the car's battery or electrical devices, reducing the demand on the alternator.

This system has solved a major challenge in harvesting vibrational energy: converting bidirectional, up-and-down motion into the unidirectional motion needed to drive a generator. A unique combination of gears allows motion in both directions to be converted into electricity, essentially doubling the amount of energy that can be recovered.

Zuo, who is affiliated with the Institute for Critical Technology and Applied Science, explains that this innovation allows the generator to work at a steady speed and reduces the load on the gear teeth, making the system more efficient and reliable. Moreover, the generator keeps rotating even after the vibration has stopped, maximizing the amount of energy recovered.

He and his students have tested the shock absorber on campus roads. Their current model, which the students have built using off-the-shelf components, can harvest about 60 percent of the available energy—a substantial improvement over other designs.

Zuo said he is confident that with precision components and manufacturing the system could reach 85 percent efficiency.

Moreover, he said, the device is entirely retrofittable in terms of space and function, and "can be integrated in the car directly without changing anything in the car." Zuo and his team have created other types of energy-harvesting shock absorbers, including linear electromagnetic and hydroelectric absorbers.

Zuo, who recently received an award for this work from the Governor's Commonwealth of Virginia Research Commercialization Fund, said he plans to focus next on the commercial viability of the energy-harvesting system.

He said he hopes to address the concerns of both drivers and automakers—who have different priorities.

"When we present this to drivers, they ask, how much can you improve the fuel efficiency? How soon can I get my money back?" Zuo said.

"From the car manufacturer's side, they ask another question: Can you replace my commercial shock absorbers? Can you give me better suspension performance?"

Zuo said he plans to tackle both cost and performance in the next round of development. Currently, the system wouldn't be cost-effective for car owners who drive less than an hour or so a day, so Zuo will focus on applications for large commercial vehicles while working to reduce the cost.

To improve performance, Zuo said he wants to adapt his design using a strategy called self-powered semi-active control: A microprocessor senses vehicle conditions and adjusts the suspension settings accordingly, delivering the smoothest ride while harvesting the greatest amount of energy.

Zuo also is working on the two others areas for energy recovery in cars: waste heat and regenerative braking. Regenerative braking is already in use for hybrid vehicles, but those make up only about 3 percent of the cars on the road; Zuo wants to develop a system that will work for conventional vehicles.

Energy-harvesting research often focuses on milliwatts and microwatts; Zuo focuses on systems that can yield hundreds or even thousands of watts. "I'm particularly excited about the opportunities in large-scale energy harvesting, which may help solve the global energy crisis," he said.

Provided by Virginia Tech

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