

# Engineer focuses on the mechanics of better bullet proofing

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Body armor with greater ballistics resistance is the aim of the research being carried out by Youqi Wang, associate professor of mechanical engineering at Kansas State University, with support from two U.S. Department of Defense agencies.

The Army Research Lab and Army Research Office awarded Wang grants totaling \$350,000 for her new approach to how next-generation ballistic-resistant fabrics/textiles/materials might be designed. The three-year projects are "High-speed penetration failure mechanisms of textile fabrics and armor-grade textile composites" and "High-performance cluster for the simulation of ballistic penetrations."

An earlier composites design project sponsored by the Air Force brought Wang's unique design approach to the attention of the Army agencies. She is developing a computational model for the ballistics simulation of a fabric given its basic physical and mechanical properties.

"The important question for us is how can we determine the relationship between a material's properties and the ballistic resistance of any final product made of such material," she said.

"We're going to attack the basic mechanics of the problem," Wang said. "Thread is constructed of yarn; yarn has thousands of fibers; fibers have strands; and in between you have fiber-to-fiber interactions. Once we identify the mechanical properties, we'd like to analyze the fabric's behavior. Ours is the first computer model to attack this problem."

In October, Wang installed the cluster of computational computers for the project.

"We purchased a small cluster in order to demonstrate that our design approach is feasible," she said. "If we show that our design approach is a

sound one using only a few computers, we think our design tool has a better chance of being adopted."

Now in year two of the three-year projects, Wang has already designed sample materials that were tested for ballistics-resistance at the Army research facilities at Aberdeen, Md.

According to Wang, because there's a need for better body armor for the military, it's become extremely important to ask how protective materials will be designed in the future. The Army wants to reduce the weight, improve mobility and protect soldiers in combat or police officers and others, she said.

Wang's analysis begins with the properties of a single fiber and gains complexity: How much force can a thread withstand? If it is woven this way or that, what changes?

Next, she analyzes fabric properties: What should be the proper size of the yarn? What should be the structure of the yarn? Should it be twisted, plain or braided? What will be better? Then comes the textile-making process, weaving, braiding, yarn orientation. What orientation or interlock structure will be better for a ballistic-resistant fabric?

"How we answer the questions is going to be quite important in coming years," Wang said.

Since a single layer of a material will not stop a bullet, Wang said, the goal is to design thick layers of fabric, perhaps as many as five to 10 layers of fabric, or a 3-dimensional, woven fabric, in such a way that a bullet's energy dissipates along the fibers and the layers absorb the most possible energy.

"We don't want the impact energy to stay in one direction. We want it to go 3-dimensional," she said. "Our goal is to protect lives and defeat the bullet."

Source: Kansas State University

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