Some shock waves need a monocle

EGLIN AFB, FLORIDA – Though testing energetic materials used in weapons systems is absolutely crucial to the success of the Air Force, it is typically a lengthy and expensive process. One approach relies upon the use of large-scale gun systems to generate precision shocks, which are significant infrastructural investments. Unfortunately, there are only four such testing facilities equipped to test with explosives – the Air Force Research Laboratory (AFRL) Eglin Air Force Base Munitions Directorate (RW) in Florida, Sandia and Los Alamos National Laboratories in New Mexico, and Lawrence Livermore National Laboratory in California –which commonly means being on a waiting list to test a material.

A second approach to test energetic materials relies upon the use of a pressed explosive technology produced by Los Alamos National Laboratories. Although precise, those assets typically require long lead times to acquire. Then there's the expense of obtaining and storing those assets . Finally, as great as they are, each lab has limitations in terms of the scale of these tests due to gun barrel diameters or limitations of pressing large diameter explosives. Fortunately, one Air Force Research Laboratory (AFRL) engineer has patented a method -- **Lens for shaping an explosively generated shock** -- that proposes an answer to alleviate each of those issues.

Eric Welle, Ph.D., at AFRL/RW began thinking about ways to address the challenges using commercially available items, thus, accelerating the realization of DoD weapon's technology.

"This technology allows you to use off-the-shelf materials and machined items to generate this precision shock where (previously used) technologies require expensive material sets that are more hazardous by nature," Welle said.

Munitions labs typically use a Plane Wave Generator (PWG) to help them pinpoint the characteristics of any given explosive being tested. "There are different technologies that allow you to generate precision shocks. When I say a precision shock, I mean a shock that has a very specific, spatial, and temporal characteristic. By doing that, it allows us to describe equations of state and aspects of the chemistry of explosive being tested. Those properties are essential to design weapons systems," Welle explained.

He began making calculations and determined he could use a lens and a commonly found flammable liquid instead of pressed explosives to generate the precision shock. He says an additional benefit is that his method gets more precise results than the traditional PWGs.

"I'm using nitromethane. That's what the American Hot Rod Association uses," Welle said. "You can buy this in barrels from commercial chemical suppliers. It's an off-the-shelf item you can buy and store in a flammable liquids cabinet."

A contoured lens is also used to obtain these results. Similar to how eye glasses shape light waves fed into our eyes to enhance vision, the Liquid Plane Wave Shock Generator (LPWSG) lens reshapes a shockwave so it arrives at the same time.

"If I just detonated nitromethane (without the lens) and let the shock show up at a surface, the variation in timing across the surface is approximately a microsecond. It's approximately fifty times more variation than we want for precision experiments," Welle said.

Because this patented design relies upon readily available commercial materials and machined items, these tests can be done at most weapon's complex explosive sites rather than having to transport materials to any of the aforementioned facilities.

"Those facilities essentially have fixed link scales that they cannot go above because they use guns to throw projectiles," Welle began. "If you imagine having a gun, you can't just change the diameter of the barrel at will. A benefit of this technology is it's entirely scalable. You can scale it to a diameter of 20 inches if you want. Similarly, with the explosively-pressed lenses, there are certain diameters above which you just can't press those types of charges. This is because the pressures you have to achieve are not available with our conventional explosive manufacturing facilities."

Once Welle convinced himself his idea could work, through analysis, he leveraged his team of engineers to build the necessary hardware and test the LPWSG to discover every aspect of it, good or bad. Now, with patent in hand, his next step is to transition this technology to the warfighter, commercial entities and the British MOD, where the AFRL Midwest Regional Hub is one option to accomplish the transition.

"The point of these regional hubs is to transition technologies and to incentivize innovation. One of the things they do is send out a proposal for white papers (to fund technology)," he said. "The military will benefit by the low-cost nature of this tool that allows laboratories and industrial sites to collect data on materials that may be used for engineering design or government qualification. Also, this tool directly supports Digital Engineering approaches being embraced by the Department of Defense (DoD) which rely upon model-based engineering."

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